

Larry K. Golightly · Isaac Teitelbaum · Tyree H. Kiser  
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# Renal Pharmacotherapy

Dosage Adjustment of  
Medications Eliminated  
by the Kidneys

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# Renal Pharmacotherapy

Dosage Adjustment of Medications  
Eliminated by the Kidneys

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## Preface

For optimal effectiveness and safety, medications used to manage both acute and chronic diseases must be administered in dosages carefully tailored according to patient-specific metabolic and excretory functional capacity. Due to variably compromised ability to eliminate certain drugs from the body, patients with kidney disease often present with complex and potentially challenging clinical issues related to adjustment of drug dosages. In these patients, provision of effective and safe pharmacotherapy depends upon not only understanding the pharmacokinetic and pharmacodynamic actions of all prescribed medications but also comprehensive appreciation of each patient's current clinical status.

In this regard, additional challenges have been recently realized. As of 2009, clinical laboratories in North America and elsewhere are expected to report serum creatinine (SCr) concentrations that are consistent with reference values obtained by isotope dilution mass spectrometry [1]. For most laboratories, this has necessitated recalibration of autoanalyzers. Depending on analyzer manufacturer and model, recalibrated SCr levels are known to be 5–20 % lower than values reported prior to recalibration [2]. Use of recalibrated SCr values with the Cockcroft-Gault equation [3] to calculate estimated creatinine clearance (CrCL) often results in a compounded error leading to a numerically exaggerated estimate of excretory kidney function. If this CrCL value is used as currently recommended by the US Food and Drug Administration [4] for the purpose of determining drug dosages for persons with renal impairment, risk for medication error and drug overdose is increased.

In order to improve the accuracy of measures of kidney function used for staging severity of kidney disease, clinical laboratories now are encouraged to utilize recalibrated SCr concentrations with the 4-variable Modification of Diet in Renal Disease (MDRD) equation [5] or the Chronic Kidney Disease Epidemiological (CKD<sub>epi</sub>) equation [6] to calculate estimated glomerular filtration rate (eGFR) in mL/min/1.73 m<sup>2</sup> and to report this number along with the SCr value to clinicians [1, 7]. Although this measure of excretory kidney function often is readily available, it is not fully compatible with FDA-mandated product labeling related to drug dosage adjustment in patients with renal insufficiency. These inconsistencies may lead to further confusion and additional potential errors.

Available resources for adjustment of dosages of drugs in patients with renal insufficiency have been found to be broadly inconsistent and imprecise. A systematic review of dosage recommendations for 100 commonly prescribed medications listed in four widely used compendia found disparities in all of these resources in their recommendations for adjustments of dosage and dosage interval [8]. These differences ranged from minor disagreement regarding suggested dosage amount for a specific medication to divergence as broad and conflicting as no adjustment needed versus contraindicated. The four sources varied in their definitions of renal impairment, and some were found to be qualitative and unclear. In response, authorities conceded that “despite numerous secondary sources of drug dosing information, drug prescribing in renal failure remains imprecise and relies on interpolation, extrapolation, and estimation” [9]. In similar fashion, frequent inconsistencies have been found not only among FDA-approved prescribing information concerning recommended dose adjustments for recently marketed medications but also clinicians' methods for interpretation and application of these recommendations [10].

Additional resource-related issues may be problematic concerning efforts to provide optimal drug therapy for patients with abnormal or rapidly changing renal function. At least as important as use of inconsistent or discrepant information concerning drug dosing is inability or failure to recognize disparate dosage recommendations. Clinicians should be provided with convenient access to at least two reputable, reliable, and evidence-based sources of information on renal drug dosing, thereby allowing individualized selection of the most relevant regimen based on clinical judgment in light of pharmacological concerns weighted for safety and effectiveness. We sought to satisfy this requirement by compiling a listing of dosing suggestions comprised of official and alternative recommendations.

## Methods

Conduct oversight for this project was provided by the Colorado Multiple Institutional Review Board (COMIRB, Protocol № 10-1105). Our objective, based on a review of available resources, was to compile a comprehensive tabular listing of dosage recommendations for patients with compromised renal function.

Information concerning adjustment of selected drug dosages that is compatible with conventional and revised measures of kidney function was obtained from available tertiary, secondary, and primary literature sources. This information was compiled into an alphabetical listing according to the approved generic drug name. Information on drug dosage adjustment was included in the listing if, in the opinion of the authors, such adjustment is necessary.

For all medications included in the listing, FDA-mandated product information was obtained from the package insert. In every instance, careful attempt was made to directly quote or to remain entirely faithful to the actual language and/or meaning within the product information. Alternative dosage adjustment information routinely was obtained from commonly used compendia. Most often, this consisted of GFR-based adjustment recommendations taken from the professional standard *Drug Prescribing in Renal Failure* [11] (with permission) or any of its various derivatives [12–15]. In most cases, other tertiary [16–21], secondary [22–25], and primary references (or available Internet-based counterparts of these print media) were used. Use of these alternatives often was necessary to supply or, more commonly, to corroborate and/or expand evidence-based dosing information for antimicrobials, newly marketed medications, and drugs used in patients receiving renal replacement therapy. Specialized alternative resources also were used for certain drugs for which information other than that provided in standard compendia was considered preferable.

The primary literature related to drug dosing in kidney disease was reviewed for all renally eliminated medications. In the event that alternative dose recommendations differed from those provided by the manufacturer, information selected and subsequently included in the listing was believed to be the most clinically relevant based on original clinical research and experience. The primary literature also was utilized for all medications for which proprietary dosing information was believed to be inadequate or outmoded and in need of change. This was most often necessary for dose adjustment of medications used for patients receiving renal replacement therapy. Searches for information contained in the primary literature were performed with the US National Library of Medicine's PubMed indexing system and Elsevier's Embase using nonproprietary or preferred drug names.

## Results

A review of available resources disclosed 349 medications that require or suggest need for dosage adjustment when administered to patients with acute or chronic kidney disease and 769 drug entities that normally do not require dose adjustment for renal impairment. From this review, salient data for each medication was extracted and incorporated into a pre-formatted computer file. This file comprises the listings shown below.

## Discussion

To promote effectiveness and minimize possible toxicity, the dosage of certain medications must be adjusted in persons with compromised kidney function. Convenient and comprehensive evidence-based resources are needed to enable consistent application of such adjustments.

Failure to enjoin appropriate dosage adjustments in patients with abnormal or rapidly changing kidney function continues to lead to reports of drug toxicity involving a broad array of renally eliminated medications [26–37]. Better resources clearly are needed to facilitate dose optimization. Means to ensure that patients whose current medications need adjustment are consistently identified also are vitally necessary.

Computerized assessment and consequent-directed recommendations concerning drug dosage have proven capable of improving prescribing patterns. A recent meta-analysis that evaluated 26 controlled comparisons of behavioral prescriber changes and/or health outcomes of patients associated with computerized interventions targeted to affect prescribing documented significant benefit of computerized advice by increasing the initial dose, increasing serum drug concentrations, reducing the time to therapeutic stabilization, reducing the risk of toxic drug levels, and reducing the length of hospital stay [38]. In patients with renal insufficiency, automated clinical decision support (CDS) systems have proven capable of detecting potentially dangerous and costly exposure to excess dosages of antimicrobial and other drugs that occurs frequently despite the intensive monitoring afforded to critically ill patients [39] and those attended in the emergency department [40]. Perhaps most convincing of the value of CDS are data showing that, as compared with pre-implementation figures, implementation of a CDS system was associated with a statistically and clinically significant 39 % increase in the fraction of delivered prescriptions for renally eliminated or nephrotoxic medications deemed appropriate according to previously published and/or expert evaluation standards when the system was applied to approximately 100,000 orders for these medications in hospitalized patients with renal insufficiency [41]. CDS systems for renally eliminated medications may be most effective if supplemented with academic detailing [42].

The appendant listing was designed to close some identified gaps in information concerning dosage adjustment of medications eliminated by the kidneys. More importantly, it was composed with the intent that this was to be adapted and used as part of an automated system that would display each patient's identification, location, and kidney function. Ultimately, the listing is to be used with CDS as described above, thereby enabling provider alerting to need for attention based on determination of specific clinically relevant dosing cusps or breakpoints for prescribed medications with individualized information displayed concerning suggested dose modifications and recommended actions.

This resource listing displays several strengths including alphabetical format, completeness, referencing, and, when available, dosage recommendations based on eGFR [43]. In glaring contrast, it also has significant weaknesses and limitations. First and foremost, we fully understand and appreciate that no single reference related to medication management in patients with kidney disease can provide truly comprehensive, completely accurate, totally unbiased, and thoroughly evidence-based recommendations. Secondly, our information was largely compiled with use of secondary or tertiary data sources with corroboration of the primary literature. Thirdly, alternative dosage adjustment recommendations that include breakpoints set in terms of eGFR often are listed in our information. The authors of the original guidelines in which this standard was established concede that calculated CrCL, an approximation useful in clinical dosimetry, may be used to simulate GFR [44]. These measures of kidney function thusly were considered essentially interchangeable, as demonstrated in earlier clinical investigations [45], and this bias currently persists in the dosing guidelines used as our foremost source of alternative dosage adjustment recommendations [11]. This relationship likely will not hold true if currently available measures of SCr are used to calculate CrCL or if eGFR is not corrected for body surface area in unusually small or large adults. Lastly, other than an



informal acceptability survey of clinicians at the University of Colorado Hospital, the utility of this resource has not been clinically tested. Nonetheless, the appendant listing is believed to satisfy some, if not most, of the dosing information needs of busy clinicians involved in pharmacotherapy for patients with kidney disease.

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## Disclaimer

Information presented is designed to facilitate clinical assessment of drug therapy and to enable discernment and determination of optimal drug dosing in persons with kidney disease. This information is intended to aid clinical decision making. This information must not be substituted for sound clinical judgment. Rather, it should be used with comprehensive understanding of pathological, pharmacological, and patient-specific clinical issues in order to provide the best treatment for seriously ill patients.

This document was originally designed for use by those who are competent healthcare professionals employed by or directly connected and having privileges with University of Colorado Hospital who rely on their clinical judgment and discretion. User assumes full responsibility for ensuring the appropriate use and reliance upon the information in view of all attendant circumstances, indications, and contraindications.



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## Abbreviations and Keys

CAPD	Chronic ambulatory peritoneal dialysis
CrCL	Creatinine clearance (mL/min)
CRRT	Continuous renal replacement therapy
CVVH	Continuous venovenous hemofiltration
CVVHD	Continuous venovenous hemodialysis
CVVHDF	Continuous venovenous hemodiafiltration
dL	Deciliter
doi	Digital object identifier
eCrCL	Estimated CrCL in mL/min using the Cockcroft-Gault equation $CrCL = (140 - \text{age}) \times \text{Weight} / (72 \times SCr)$ for males and $0.85 \times CrCL$ for females where SCr is derived from rSCr in our hospital as follows: $SCr = (rSCr + 0.07) / 0.99$ ; alternatively, this value may be approximated by increasing rSCr by 8 %. This may facilitate use of CrCL equations that were developed prior to availability and reporting of rSCr by clinical laboratories. In many patients, this may be closely approximated by eGFR with correction for body surface area [ $eGFR \times (1.73 \text{ m}^2 / BSA)$ ]. Other laboratories differ.
eGFR	Estimated GFR as calculated by the clinical laboratory using the 4-variable MDRD equation
ESRD	End-stage renal disease
FDA	United States Food and Drug Administration
g	Gram
GFR	Glomerular filtration rate in mL/min, usually determined by iohexol or <sup>125</sup> I-iothalamate clearance
IM	Intramuscular
IV	Intravenous
kg	Kilogram (actual body weight unless otherwise specified)
L	Liter
mg	Milligram
mL	Milliliter
NR	Non-renal
PRN	Pro re nata (as occasion requires; as necessary)
rSCr	Recalibrated serum creatinine (traceable to IDMS reference standard, mg/dL)
℞	Treatment
SCr	Serum creatinine (mg/dL)





**Common systemic medications that normally do not require significant downward dose adjustment in the presence of renal impairment in adults (NR). Cautions are described if present in proprietary information.**

Abacavir/Ziagen <sup>®</sup>	Amphotericin B/Fungizone <sup>®</sup>	Barium sulfate/Barobag <sup>™</sup> ,
Abatacept/Orencia <sup>®</sup>	Amphotericin B liposome/Ambisome <sup>®</sup>	Barosperse <sup>™</sup> , Cheetah <sup>™</sup> ,
Abciximab/ReoPro <sup>®</sup>	Amyl nitrate	Enhancer <sup>™</sup> , Entrobar <sup>™</sup> , HD
Abiraterone/Zytiga <sup>™</sup>	Anagrelide/Agrylin <sup>®</sup>	85 <sup>™</sup> , HD <sup>™</sup> 200 Plus,
AbobotulinumtoxinA/Dysport <sup>™</sup>	Anastrozole/Arimidex <sup>®</sup>	Intropaste <sup>™</sup> , Prepcat <sup>™</sup> , Scan
Acetylcysteine/Acetadote <sup>®</sup>	Anidulafungin/Eraxis <sup>™</sup>	C <sup>™</sup> , Tonojug <sup>™</sup> , Tonopaque <sup>™</sup>
Adalimumab/Humira <sup>®</sup>	Antihemophilic factor, human/ Monoclolate P <sup>®</sup> , Koate DVI <sup>®</sup>	Basiliximab/Simulect <sup>®</sup>
Adenosine/Adenocard <sup>®</sup> , Adenoscan <sup>®</sup>	Antihemophilic factor, recombinant/ Recombinate <sup>®</sup> , Hexilate <sup>®</sup>	Beclomethasone/QVAR <sup>®</sup> , Beconase <sup>®</sup>
Aflibercept (intravitreal)/Eylea <sup>™</sup>	Antihemophilic factor/von Willebrand factor complex/Humate-P <sup>®</sup>	Belatacept/Nulojix <sup>®</sup>
Agalsidase beta/Fabrazyme <sup>®</sup>	Anti-inhibitor coagulant complex/ Feiba NF	Belimumab/Benlysta <sup>®</sup>
Albendazole/Albenza <sup>®</sup>	Antithrombin III/Thrombate III <sup>®</sup>	Belladonna and opium/B&O <sup>®</sup>
Albumin/Albuminar <sup>®</sup>	Antithymocyte globulin, equine/ Atgam <sup>®</sup>	Benzphetamine/Didrex <sup>®</sup>
Albuterol/Proventil <sup>®</sup>	Antithymocyte globulin, rabbit/ Thymoglobulin <sup>®</sup>	Benzonatate/Tessalon <sup>®</sup>
Aldesleukin/Proleukin <sup>®</sup>	Antivenin lactrodectus mactans	Benztropine/Cogentin <sup>®</sup>
Alefacept/Amevive <sup>®</sup>	Aprepitant/Emend <sup>®</sup>	Beta-carotene
Alemtuzumab/Campath <sup>®</sup>	Argatroban	Betamethasone/Celestone <sup>®</sup>
Alfentanil/Alfenta <sup>®</sup>	Arginine/R-gene <sup>®</sup>	Betaxolol/Kerlone <sup>®</sup> —Caution, reduce dose in severe renal impairment
Alglucerase/Ceredase <sup>®</sup>	Aripiprazole/Abilify <sup>®</sup>	Bethanechol/Urecholine <sup>®</sup>
Alglucosidase alfa/Lumizyme <sup>™</sup> , Myozyme <sup>®</sup>	Artemether and lumefantrine/ Coartem <sup>®</sup> —Caution in severe renal impairment	Bevacizumab/Avastin <sup>®</sup>
Alosetron/Lotronex <sup>®</sup>	Articaine 4 % and epinephrine/ Orabloc <sup>™</sup> , Septocaine <sup>®</sup>	Bexarotene/Targetin <sup>®</sup> —Caution in severe renal impairment
Alpha <sub>1</sub> -Proteinase Inhibitor (Alpha <sub>1</sub> Antitripsin)/Prolastin <sup>®</sup> C	Ascorbic acid/Vitamin C	Bicalutamide/Casodex <sup>®</sup>
Alpha galactosidase/Beano <sup>®</sup>	Asenapine/Saphris <sup>®</sup>	Bisacodyl/Dulcolax <sup>®</sup>
Alprazolam/Xanax <sup>®</sup>	Asparaginase/Elspar <sup>®</sup>	Boceprevir/Victrelis <sup>™</sup>
Alprostadil/Caverject <sup>®</sup>	Asparaginase <i>Erwinia chrysanthemil</i> Erwinase <sup>™</sup>	Bortezomib/Velcade <sup>®</sup>
Alteplase/Activase <sup>®</sup>	Atomoxetine/Strattera <sup>®</sup>	Bosentan/Tracleer <sup>®</sup>
Altretamine/Hexalen <sup>®</sup>	Atorvastatin/Lipitor <sup>®</sup>	Brentuximab/Adcetris <sup>™</sup> —Caution, the effects or risks imposed by renal impairment have not been determined
Aluminum hydroxide/Amphogel <sup>®</sup> , Alternagel <sup>®</sup>	Atovaquone/Mepron <sup>®</sup>	Bromocriptine/Cycloset <sup>®</sup> , Parlodel <sup>®</sup>
Aluminum hydroxide and magnesium trisilicate or carbonate and alginic acid/Gaviscon <sup>®</sup> —Caution, contains small amounts of magnesium	Atracurium	Brompheniramine/Brovex <sup>™</sup>
Alvimopan/Entereg <sup>®</sup>	Atropine	Budesonide/Entocort <sup>®</sup>
Ambenonium/Mytelase <sup>®</sup>	Avanafil/Stendra <sup>™</sup>	Bumetanide/Bumex <sup>®</sup>
Ambrisentan/Letairis <sup>®</sup>	Axitinib/Inlyta <sup>®</sup>	Bupivacaine/Marcaine <sup>®</sup>
Amifostine/Ethyol <sup>®</sup>	Azficel-T/LaViv <sup>®</sup>	Buprenorphine/Buprenex <sup>®</sup>
Aminobenzoate potassium/Potaba <sup>®</sup>	Azilsartan/Edarbi <sup>™</sup>	Bupropion/Wellbutrin <sup>®</sup> —Caution in severe renal impairment
Aminocaproic acid/Amicar <sup>®</sup>	Azithromycin/Zithromax <sup>®</sup> —Caution in severe renal impairment (GFR < 10 mL/min)	Busulfan/Myleran <sup>®</sup>
Aminohippurate sodium	Baclofen/Lioresal <sup>®</sup> —Caution in severe renal impairment	Butabarbital/Butisol <sup>®</sup>
Aminolevulinic acid/Levulan <sup>®</sup> , Kerastick <sup>®</sup>	Balsalazide/Colazal <sup>®</sup> —Caution in severe renal impairment	C1 esterase inhibitor/Beriner <sup>®</sup> , Cinryze <sup>™</sup>
Aminophylline		Cabazitaxel/Jevtana <sup>®</sup> —Caution in severe renal impairment
Amiodarone/Cordarone <sup>®</sup> , Nexterone <sup>®</sup>		Cabergoline/Dostinex <sup>®</sup>
Amitriptyline/Elavil <sup>®</sup>		Caffeine sodium benzoate
Amlodipine/Norvasc <sup>®</sup>		Calcitonin/Miacalcin <sup>®</sup>
Amobarbital/Amytal <sup>®</sup>		Calcitriol/Rocaltrol <sup>®</sup>
Amoxapine/Asendin <sup>®</sup>		Calcium acetate/PhosLo <sup>®</sup>

Calcium carbonate/Tums <sup>®</sup>	Clonazepam/Klonopin <sup>®</sup>	Desloratadine/Clarinet <sup>®</sup> —Caution in renal impairment, consider initiation with 5 mg every 48 h
Calcium citrate/Citracal <sup>®</sup>	Clonidine/Catapres <sup>®</sup>	Dexamethasone/Decadron <sup>®</sup>
Calcium polycarbophil/FiberCon <sup>®</sup>	Clopidogrel/Plavix <sup>®</sup>	Dexlansoprazole/Kapidex <sup>™</sup>
Candesartan/Atacand <sup>®</sup>	Clorazepate/Tranxene <sup>®</sup>	Dexmedetomidine/Precedex <sup>®</sup>
Carbamazepine/Tegretol <sup>®</sup>	Cocaine	Dexmethylphenidate/Focalin <sup>®</sup>
Carbidopa/Lodosyn <sup>®</sup>	Collagenase <i>Clostridium histolyticum</i> injection/Xiaflex <sup>™</sup>	Dextran 40/Gentran <sup>®</sup> —Caution in renal impairment
Carbinoxamine/Palgic <sup>®</sup>	Colesevelam/Welchol <sup>®</sup>	Dextroamphetamine/Dexedrine <sup>®</sup>
Carboprost/Hemabate <sup>®</sup>	Colestipol/Colestid <sup>®</sup>	Dextroamphetamine and amphetamine/Adderall <sup>®</sup>
Carisoprodol/Soma <sup>®</sup>	Corticotropin/Acthrel <sup>®</sup>	Dextromethorphan/Robitussin DM <sup>®</sup>
Carvedilol/Coreg <sup>®</sup>	Cortisone acetate	Diatrizoate/Gastrografin <sup>™</sup> , MD-Gastroview <sup>®</sup>
Cascara sagrada	Cosyntropin/Cortrosyn <sup>®</sup>	Diazepam/Valium <sup>®</sup>
Caspofungin/Cancidas <sup>®</sup>	Crizotinib/Xalkori <sup>®</sup>	Diazoxide/Proglycem <sup>®</sup> —Caution, consider reduced dosage in renal impairment
Castor oil	Cromolyn/Gastrocrom <sup>®</sup> —Caution, consider dose reduction	Dicloxacillin/Pathocil <sup>®</sup>
Cefaclor/Ceclor <sup>®</sup>	Cyanocobalamin/Vitamin B <sub>12</sub>	Dicyclomine/Bentyl <sup>®</sup>
Ceftriaxone/Rocephin <sup>®</sup>	Cyclobenzaprine/Flexeril <sup>®</sup>	Diethylpropion/Tenuate <sup>®</sup>
Certolizumab/Cimzia <sup>®</sup> —Caution, inadequate data to recommend dose in renal impairment	Cyclophosphamide/Cytoxan <sup>®</sup> —Caution, consider dose reduction in severe renal impairment (GFR < 10 mL/min) and/or chronic oral administration	Diflunisal—Caution, no data in renal impairment
Cetorelix/Cetrotide <sup>®</sup>	Cyclosporine/Gengraf <sup>®</sup> , Neoral <sup>®</sup> , Sandimmune <sup>®</sup>	Digoxin immune Fab/Digibind <sup>®</sup>
Cetuximab/Erbix <sup>®</sup>	Cyproheptadine/Periactin <sup>®</sup>	Dihydroxyacetone/DHT <sup>™</sup>
Cevimeline/Evoxac <sup>®</sup>	Cytarabine/Cytosar <sup>®</sup>	Diltiazem/Cardizem <sup>®</sup> , Cartia <sup>®</sup> , Dilacor <sup>®</sup> , Taztia <sup>®</sup> , Tiazac <sup>®</sup>
Chloramphenicol/Chloromycetin <sup>®</sup> —Caution in severe renal impairment	Cytomegalovirus immune globulin/Cytogam <sup>®</sup>	Dimenhydrinate/Dramamine <sup>®</sup>
Chlordiazepoxide/Librium <sup>®</sup>	Dacarbazine/DTIC <sup>®</sup>	Dimercaprol/BAL <sup>®</sup>
Chloroprocaine/Nesacaine <sup>®</sup>	Daclizumab/Zenapax <sup>®</sup>	Dinoprostone/Cervidil <sup>®</sup> , Prepidil <sup>®</sup> , Prostin E <sub>2</sub> <sup>®</sup>
Chloroquine/Aralen <sup>®</sup>	Dactinomycin/Cosmegen <sup>®</sup>	Diphenhydramine/Benadryl <sup>®</sup>
Chlorpheniramine/Chlor-trimeton <sup>®</sup>	Danazol/Cyclomen <sup>®</sup>	Diphenoxin and atropine/Motofen <sup>®</sup>
Chlorpromazine/Thorazine <sup>®</sup>	Dantrolene/Dantrium <sup>®</sup>	Diphenoxylate and atropine/Lomotil <sup>®</sup>
Chlorzoxazone/Parafon <sup>®</sup>	Dapsone	Diphtheria and tetanus toxoids and acellular pertussis vaccine/Adacel <sup>®</sup> , Boostrix <sup>®</sup>
Cholecalciferol/Vitamin D <sub>3</sub>	Darbepoetin alfa/Aranesp <sup>®</sup>	Dipyridamole/Persantine <sup>®</sup>
Cholestyramine/Questran <sup>®</sup>	Darifenacin/Enablex <sup>®</sup>	Disulfiram/Antabuse <sup>®</sup>
Choline magnesium trisalicylate/Trilisate <sup>®</sup> —Caution, monitor salicylate levels	Darunavir/Prezista <sup>®</sup>	Divalproex/Depakote <sup>®</sup>
Cilostazol/Pletal <sup>®</sup> —Caution in severe renal impairment (GFR < 25 mL/min)	Dasatinib/Sprycel <sup>®</sup>	Dobutamine/Dobutrex <sup>®</sup>
Cinacalcet/Sensipar <sup>®</sup>	Decitabine/Dacogen <sup>™</sup>	Docetaxel/Taxotere <sup>®</sup>
Cisatracurium/Nimbex <sup>®</sup>	Deferiprone/Ferriprox <sup>®</sup> —Caution, not evaluated in patients with kidney disease	Docusate/Colace <sup>®</sup>
Citalopram/Celexa <sup>®</sup>	Degarelix/Firmagon <sup>®</sup> —Caution in severe renal impairment	Dolasetron/Anzemet <sup>®</sup>
Citric acid, sodium, and potassium citrate/Polycitra <sup>®</sup> —Caution with low urine output	Delavirdine/Rescriptor <sup>®</sup>	Donepezil/Aricept <sup>®</sup>
Clemastine/Tavist <sup>®</sup>	Denileukin/Ontak <sup>®</sup>	Dopamine/Intropin <sup>®</sup>
Clevidipine/Cleviprex <sup>™</sup>	Denosumab/Prolia <sup>™</sup> , Xgeva <sup>™</sup> —Caution, patients with CrCL < 30 mL/min or on hemodialysis are at increased risk for hypocalcemia	Doxapram/Dopram <sup>®</sup>
Clidinium and chlordiazepoxide/Librax <sup>®</sup>	Desflurane/Suprane <sup>®</sup>	Doxazosin/Cardura <sup>®</sup>
Clindamycin/Cleocin <sup>®</sup>	Desipramine/Norpramin <sup>®</sup>	Doxepin/Sinequan <sup>®</sup>
Clobazam/Onfi <sup>™</sup> —Caution, no experience in severe renal impairment		Doxercalciferol/Hectorol <sup>®</sup>
Clomiphene/Clomid <sup>®</sup> , Serophene <sup>®</sup>		Doxorubicin/Adriamycin <sup>®</sup>
		Doxylamine/Unisom <sup>®</sup>

Doxycycline/Vibramycin <sup>®</sup>	Etravirine/Intelence <sup>™</sup>	Furosemide/Lasix <sup>®</sup>
Dronabinol/Marinol <sup>®</sup>	Everolimus/Afinitor <sup>®</sup> , Zortress <sup>®</sup>	Galsulfase/Naglazyme <sup>®</sup>
Dronedarone/Multaq <sup>®</sup>	Exemestane/Aromasin <sup>®</sup>	Ganirelix
Droperidol/Inapsine <sup>®</sup>	Ezetemibe/Zetia <sup>®</sup>	Gefitinib/Iressa <sup>®</sup>
Drotrecogin alfa/Xigris <sup>®</sup>	Ezogabine/Potiga <sup>™</sup> —Caution, dose initiation should follow a conservative approach	Gemcitabine/Gemzar <sup>®</sup> —Caution, no data in severe renal impairment
Dutasteride/Avodart <sup>®</sup>	Factor VIIa (recombinant)/ NovoSeven <sup>®</sup>	Gemtuzumab/Mylotarg <sup>®</sup> —Caution, no data in renal impairment
Ecallantide/Kalbitor <sup>®</sup> —Caution, no data in renal impairment	Factor IX complex, human/Profilnine <sup>®</sup>	Glatiramer/Copaxone <sup>®</sup> —Caution, no data in renal impairment
Ecuzumab/Soliris <sup>®</sup>	Fat emulsion/Intralipid <sup>®</sup>	Glimepiride/Amaryl <sup>®</sup>
Edrophonium/Enlon <sup>®</sup>	Fat emulsion/Intralipid <sup>®</sup>	Glucagon
Efalizumab/Raptiva <sup>®</sup>	Febuxostat/Uloric <sup>®</sup> —Caution in severe renal impairment	Glucarpidase/Voraxaze <sup>®</sup>
Eletriptan/Relpax <sup>®</sup>	Felodipine/Plendil <sup>®</sup>	Glutamine/Sympt-X <sup>®</sup>
Eltrombopag/Promacta <sup>®</sup> —Caution, no data in renal impairment; monitor closely	Fenoldopam/Corlopan <sup>®</sup>	Glycerin
Enflurane/Ethrane <sup>®</sup>	Fentanyl/Sublimaze <sup>®</sup> , Subsys <sup>™</sup>	Glycopyrrolate/Robinul <sup>®</sup>
Enfuvirtide/Fuzeon <sup>®</sup>	Ferric gluconate/Ferrlecit <sup>®</sup>	Golimumab/Simponi <sup>™</sup> —Caution, no data in renal impairment
Entacapone/Comtan <sup>®</sup>	Ferrous sulfate/Feosol <sup>®</sup>	Goserelin/Zoladex <sup>®</sup>
Ephedrine	Ferumoxsil/GastroMARK <sup>™</sup>	Granisetron/Kytril <sup>®</sup>
Epinephrine/Adrenalin <sup>®</sup>	Ferumoxytol/Feraheme <sup>™</sup>	Griseofulvin/Grifulvin <sup>®</sup>
Epirubicin/Ellence <sup>®</sup>	Fesoterodine/Toviaz <sup>™</sup> —Caution, in severe renal impairment (CrCL < 30 mL/min) max dose = 4 mg/day	Guaifenesin/Robitussin <sup>®</sup>
Epoetin alfa/Epogen <sup>®</sup> , Procrit <sup>®</sup>	Fidaxomicin/Dificid <sup>™</sup>	Guanabenz/Wytensin <sup>®</sup>
Epoprostenol/Flolan <sup>®</sup>	Filgrastim/Neupogen <sup>®</sup>	Guanfacine/Tenex <sup>®</sup>
Eprosartan/Teveten <sup>®</sup>	Finasteride/Proscar <sup>®</sup>	Haloperidol/Haldol <sup>®</sup>
Ergocalciferol/Drisdol <sup>®</sup>	Fingolimod/Gilenya <sup>™</sup>	Hemin/Panhematin <sup>®</sup>
Ergoloid mesylates	Flavoxate/Urispas <sup>®</sup>	Heparin—Caution, monitor carefully; renal dysfunction may reduce clearance
Ergonovine/Ergotrate <sup>®</sup>	Floxuridine/FUDR <sup>®</sup>	Hepatitis B immune globulin/ HepaGam B <sup>™</sup>
Ergotamine/Ergotrate <sup>®</sup>	Fludrocortisone/Florinef <sup>®</sup>	Hepatitis B vaccine (recombinant)/ Engerix-B <sup>®</sup>
Erlotinib/Tarceva <sup>™</sup> —Caution, no data in renal impairment	Flumazenil/Romazicon <sup>®</sup>	Histreltin/Vantas <sup>™</sup>
Erythromycin/EES <sup>®</sup> , Erythrocin <sup>®</sup>	Fluorescein/AK-Fluor <sup>®</sup> , Fluorescite <sup>®</sup>	Human chorionic gonadotropin/Pregnyl <sup>®</sup>
Escitalopram/Lexapro <sup>®</sup> —Caution in severe renal impairment	Fluorouracil/Adrucil <sup>®</sup> —Caution in severe renal impairment	Hyaluronate/Hylaform <sup>®</sup> , Juvederm <sup>®</sup> , Orthovisc <sup>®</sup> , Restylane <sup>®</sup> , Supartz <sup>™</sup> , Synvisc <sup>®</sup>
Esmolol/Brevibloc <sup>®</sup>	Fluoxetine/Prozac <sup>®</sup>	Hydralazine/Apresoline <sup>®</sup>
Esomeprazole/Nexium <sup>®</sup>	Fluoxymesterone/Androxy <sup>®</sup>	Hydrocodone and acetaminophen/ Vicodin <sup>®</sup>
Estazolam/ProSom <sup>®</sup>	Fluphenazine/Prolixin <sup>®</sup>	Hydrocortisone/Cortef <sup>®</sup> , Solu-Cortef <sup>®</sup>
Estradiol/Estrace <sup>®</sup>	Flurazepam/Dalmane <sup>®</sup>	Hydromorphone/Dilaudid <sup>®</sup>
Estramustine/Emcyt <sup>®</sup>	Flurbiprofen/Ansaid <sup>®</sup>	Hydroxocobalamin/Cyanokit <sup>®</sup>
Estrogens, conjugated/Premarin <sup>®</sup>	Fluvastatin/Lescol <sup>®</sup> —Caution in severe renal impairment	Hydroxychloroquine/Plaquenil <sup>®</sup>
Estrogens, esterified/Menest <sup>®</sup>	Fulvestrant/Faslodex <sup>®</sup>	Hydroxyzine/Atarax <sup>®</sup> , Vistaril <sup>®</sup>
Estropipate/Ogen <sup>®</sup>	Fluvoxamine/Luvox <sup>®</sup>	Hyoscyamine/Levsin <sup>®</sup>
Eszopiclone/Lunesta <sup>®</sup>	Folic acid/Folvite <sup>®</sup>	Hyoscyamine, atropine, scopolamine, and phenobarbital/Donnatal <sup>®</sup>
Etanercept/Enbrel <sup>®</sup>	Follitropin alfa/Gonal-f <sup>®</sup>	Ibritumomab/Zevalin <sup>®</sup>
Ethanolamine/Ethamolin <sup>®</sup>	Fosamprenavir/Lexiva <sup>®</sup>	Ibuprofen/Motrin <sup>®</sup> , Advil <sup>®</sup> —Caution, no data in advanced renal disease; not recommended
Ethinyl estradiol/Estinyl <sup>®</sup>	Fosaprepitant/Emend <sup>®</sup>	
Ethosuximide/Zarontin <sup>®</sup>	Fosinopril/Monopril <sup>®</sup>	
Ethotoin/Peganone <sup>®</sup>	Fosphenytoin/Cerebyx <sup>®</sup> —Caution, see phenytoin	
Ethosuximide/Zarontin <sup>®</sup> —Caution in patients with known renal disease	Fospropofol/Lusedra <sup>™</sup>	
Etidronate/Didronel <sup>®</sup> —Caution, consider dosage decrease with reduction in GFR	Frovatriptan/Frova <sup>®</sup>	
Etomidate/Amidate <sup>®</sup>		

Ibutilide/Corvert <sup>®</sup>	Ivacaftor/Kalydeco <sup>™</sup>	Mebendazole/Vermox <sup>®</sup>
Icatibant/Firazyr <sup>®</sup>	Ivermectin/Stromectol <sup>®</sup>	Mechlorethamine/Mustargen <sup>®</sup>
Iloperidone/Fanapt <sup>™</sup>	Ixabepilone/Ixempra <sup>®</sup>	Meclizine/Antivert <sup>®</sup>
Iloprost/Ventavis <sup>®</sup>	Japanese encephalitis virus vaccine/ JE-Vax <sup>®</sup>	Medroxyprogesterone/Provera <sup>®</sup>
Imiglucerase/Cerezyme <sup>®</sup>	Ketamine/Ketalar <sup>®</sup>	Mefloquine/Lariam <sup>®</sup>
Imipramine/Tofranil <sup>®</sup>	Ketoconazole/Nizoral <sup>®</sup>	Megestrol/Megace <sup>®</sup> —Caution, no data in renal impairment
Immune globulin/Gamastan <sup>®</sup> , Flebogamma <sup>®</sup> , Gammagard <sup>®</sup> , Gamunex <sup>®</sup> , Octagam <sup>®</sup> , Vivaglobin <sup>®</sup>	Labetalol/Trandate <sup>®</sup>	Menotropins/Repronex <sup>®</sup>
Indinavir/Crixivan <sup>®</sup>	Lactulose/Enulose <sup>®</sup>	Mephobarbital/Mebaral <sup>®</sup> —Caution, reduce dose in renal impairment
Indocyanine green	Lamotrigine/Lamictal <sup>®</sup> —Caution, minimal data available in patients with renal impairment	Mepivacaine/Carbocaine <sup>®</sup>
Indigo Carmine	Lansoprazole/Prevacid <sup>®</sup>	Mesalamine/Asacol <sup>®</sup> , Pentasa <sup>®</sup> , Rowasa <sup>™</sup> —Caution, renal impairment may increase risk for blood and kidney problems;
Infliximab/Remicade <sup>®</sup>	Lanthanum/Fosrenol <sup>®</sup>	monitor blood counts and renal function
Influenza virus vaccine (inactivated)/ Fluarix <sup>®</sup> , Fluzone <sup>®</sup>	Lapatinib/Tykerb <sup>®</sup>	Mesna/Mesnex <sup>®</sup> —Caution, no data in renal impairment
Interferon alfa-2B/Intron <sup>®</sup> A	Leflunomide/Arava <sup>®</sup> —Caution in renal impairment	Metaproterenol/Alupent <sup>®</sup>
Interferon alfacon-1/Infergen <sup>®</sup> — Caution, no data available in patients with renal impairment	Letrozole/Femara <sup>®</sup> —No dosage adjustment required if CrCL ≥10 mL/min	Methamphetamine/Desoxyn <sup>®</sup> — Caution in renal impairment
Interferon beta-1a/Avonex <sup>®</sup> , Rebif <sup>®</sup>	Leucovorin calcium	Methimazole/Tapazole <sup>®</sup>
Interferon beta-1b/Betaseron <sup>®</sup>	Leuprolide/Lupron <sup>®</sup>	Methocarbamol (oral)/Robaxin <sup>®</sup>
Interferon beta-1b/Extavia <sup>®</sup>	Levodopa/Larodopa <sup>®</sup>	Methoxsalen/Oxsoralen <sup>®</sup>
Interferon gamma-1b/Actimmune <sup>®</sup>	Levoleucovorin/Fusilev <sup>™</sup>	Methsuximide/Celontin <sup>®</sup>
Iodipamide meglumine/Cholografin <sup>™</sup>	Levonorgestrel/Plan B <sup>®</sup>	Methyclothiazide/Enduron <sup>®</sup>
Iodixanol/Visipaque <sup>®</sup> —Caution, possible contrast induced nephropathy	Levorphanol/Levo-Dromoran <sup>®</sup>	Methylene blue
Iodoquinol/Yodoxin <sup>®</sup>	Levothyroxine/Synthroid <sup>®</sup>	Methylergonovine/Methergine <sup>®</sup>
Iopamidol/Isovue <sup>®</sup> —Caution, possible contrast induced nephropathy	Lidocaine/Xylocaine <sup>®</sup>	Methylphenidate/Methylin <sup>™</sup> , Ritalin <sup>®</sup>
Iothalamate <sup>125</sup> I/Glofil <sup>®</sup> -125	Linagliptin/Tradjenta <sup>™</sup>	Methylprednisolone/Solu-Medrol <sup>®</sup> , Depo-Medrol <sup>®</sup>
Iothalamate meglumine/Conray <sup>®</sup> , Cysto-Conray <sup>™</sup> —Caution, possible contrast induced nephropathy	Linezolid/Zyvox <sup>®</sup>	Metolazone/Zaroxolyn <sup>®</sup>
Ipecac	Liothyronine/Cytomel <sup>®</sup>	Metoprolol/Lopressor <sup>®</sup> , Toprol-XL <sup>®</sup>
Ipilimumab/Yervoy <sup>™</sup>	Liotrix/Thyrolar <sup>®</sup>	Metronidazole/Flagyl <sup>®</sup>
Irbesartan/Avapro <sup>®</sup>	Liraglutide/Victoza <sup>®</sup>	Metyrosine/Demser <sup>®</sup>
Irinotecan/Camptosar <sup>®</sup> —Caution, no data in renal impairment; not recommended in hemodialysis	Lisdexamfetamine/Vyvanse <sup>™</sup>	Mexiletine/Mexitol <sup>®</sup>
Iron dextran/Dexferrum <sup>®</sup> , INFed <sup>®</sup>	Loperamide/Imodium <sup>®</sup>	Micafungin/Mycamine <sup>®</sup>
Iron sucrose/Venofer <sup>®</sup>	Lopinavir and ritonavir/Kaletra <sup>®</sup>	Midazolam/Versed <sup>®</sup>
Isoniazid/Nydrazid <sup>®</sup>	Loratadine/Claritin <sup>®</sup> —Caution, if GFR < 30 mL/min starting dose is 10 mg every other day	Mifepristone/Mifeprex <sup>®</sup> , Korlym <sup>™</sup>
Isoflurane/Forane <sup>®</sup>	Lorazepam/Ativan <sup>®</sup> —Caution, renal impairment contributes to risk of propylene glycol accumulation in patients receiving high-dose continuous infusion	Minocycline/Minocin <sup>®</sup>
Isoproterenol/Isuprel <sup>®</sup>	Losartan/Cozaar <sup>®</sup>	Minoxidil/Loniten <sup>®</sup>
Isosorbide dinitrate/Isordil <sup>®</sup>	Lovastatin/Mevacor <sup>®</sup>	Mirtazapine/Remeron <sup>®</sup> —Caution, consider dose reduction in renal impairment; clearance is decreased 50 % if CrCL is <10 mL/min
Isosorbide mononitrate/Imdur <sup>®</sup>	Loxapine/Loxitane <sup>®</sup>	Misoprostol/Cytotec <sup>®</sup>
Isotretinoin/Accutane <sup>®</sup>	Lubiprostone/Amitiza <sup>®</sup> —Caution, no data in renal impairment	Mitotane/Lysodren <sup>®</sup>
Isradipine/DynaCirc <sup>®</sup> —Caution, in renal impairment; starting dose is 5 mg daily	Maprotiline/Ludiomil <sup>®</sup>	Mitoxantrone/Novantrone <sup>®</sup> —Caution, no data in renal impairment
	Measles, mumps, and rubella virus vaccine/MMR <sup>®</sup> II	Modafinil/Provigil <sup>®</sup> —Safety not established in renal impairment

Molindone/Moban <sup>®</sup>	Omeprazole and sodium bicarbonate/ Zegerid <sup>®</sup>	Phentermine/Ionamin <sup>®</sup>
Montelukast/Singulair <sup>®</sup>	OnabotulinumtoxinA/Botox <sup>®</sup>	Phentolamine/Regitine <sup>®</sup>
Moxifloxacin/Avelox <sup>®</sup>	Ondansetron/Zofran <sup>®</sup>	Phenylephrine/Neo-Synephrine <sup>®</sup>
Multivitamins/Hexavitamin	Opium tincture	Phosphorated carbohydrate solution/Emetrol <sup>(c)</sup>
Muromonab-CD3/Orthoclone OKT3 <sup>®</sup>	Orlistat/Xenical <sup>®</sup> , Alli <sup>™</sup>	Physostigmine
Nabilone/Cesamet <sup>™</sup> —Caution, no data in renal impairment	Orphenadrine/Norflex <sup>™</sup>	Phytonadione/AquaMephyton <sup>®</sup> , Mephyton <sup>®</sup>
Nafarelin/Synarel <sup>®</sup>	Oxaliplatin/Eloxatin <sup>®</sup> —Caution in renal impairment; safety not established	Pilocarpine/Salagen <sup>®</sup>
Nafcillin/Unipen <sup>®</sup>	Oxandrolone/Oxandrin <sup>®</sup>	Pimozide/Orap <sup>®</sup>
Nalbuphine/Nubain <sup>®</sup> —Caution in renal impairment; consider use of reduced doses	Oxazepam/Serax <sup>®</sup>	Pindolol/Visken <sup>®</sup>
Nalmefene/Revox <sup>®</sup>	Oxybutynin/Ditropan <sup>®</sup>	Pioglitazone/Actos <sup>®</sup>
Naloxone/Narcan <sup>®</sup>	Oxycodone/Roxicodone <sup>®</sup> , Oxecta <sup>™</sup> , OxyContin <sup>®</sup>	Perflutren/Definity <sup>®</sup>
Naltrexone/ReVia <sup>®</sup>	Oxymetholone/Anadrol <sup>®</sup> -50	Pneumococcal conjugate vaccine (7-valent)/Prevnar <sup>®</sup>
Natalizumab/Tysabri <sup>®</sup>	Oxytocin/Pitocin <sup>®</sup>	Pneumococcal polysaccharide vaccine/ Pneumovax 23 <sup>®</sup>
Nateglinide/Starlix <sup>®</sup>	Paclitaxel/Taxol <sup>®</sup>	Polidocanol/Asclera <sup>®</sup>
Nefazodone/Serzone <sup>®</sup>	Palifermin/Kepivance <sup>®</sup>	Poliovirus vaccine (inactivated)/IPOL <sup>®</sup>
Nelarabine/Arranon <sup>®</sup>	Palivizumab/Synagis <sup>®</sup>	Polyethylene glycol 3350/Miralax <sup>®</sup> , MoviPrep <sup>®</sup>
Nelfinavir/Viracept <sup>®</sup>	Palonosetron/Aloxi <sup>®</sup>	Polyethylene glycol-electrolyte solution/Colyte <sup>®</sup> , Golytely <sup>®</sup> , Nulytely <sup>®</sup>
Nesiritide/Natrecor <sup>®</sup>	Pancrelipase/Creon <sup>®</sup> , Zenpep <sup>®</sup>	Porfimer/Photofrin <sup>®</sup>
Nevirapine/Viramune <sup>®</sup>	Panitumumab/Vectibix <sup>®</sup> —Caution, no data in renal impairment	Posaconazole/Noxafil <sup>®</sup>
Niacin/Niaspan <sup>®</sup> —Caution in renal disease	Pantoprazole/Protonix <sup>®</sup>	Potassium iodide/SSKI <sup>®</sup>
Nicardipine/Cardene <sup>®</sup> —Caution, in renal insufficiency initiate oral therapy with 20 mg three times daily or extended release 30 mg twice daily	Papaverine	Pralatrexate/Folotylin <sup>®</sup>
Nicotine/Nicorette <sup>®</sup> , Nicoderm <sup>®</sup>	Papillomavirus vaccine, human, recombinant/Gardasil <sup>®</sup>	Pramlintide/Symlin <sup>®</sup> —Caution, no data in hemodialysis
Nifedipine/Procardia <sup>®</sup> , Adalat <sup>®</sup>	Paregoric	Prasugrel/Effient <sup>™</sup>
Nilotinib/Tasigna <sup>®</sup>	Paricalcitol/Zemlar <sup>®</sup>	Pravastatin/Pravachol <sup>®</sup> —Caution, with history of significant renal dysfunction, starting dose is 10 mg daily
Nilutamide/Nilandron <sup>®</sup>	Paromomycin/Humatin <sup>®</sup>	Praziquantel/Biltricide <sup>®</sup>
Nimodipine/Nimotop <sup>®</sup>	Pazopanib/Votrient <sup>™</sup>	Prazosin/Minipress <sup>®</sup>
Nisoldipine/Sular <sup>®</sup>	Pegaptanib/Macugen <sup>®</sup>	Prednisolone/Orapred <sup>®</sup> , Prelone <sup>®</sup>
Nitazoxanide/Alinia <sup>®</sup> —Caution, no data in renal impairment	Pegaspargase/Oncaspar <sup>®</sup>	Prednisone/Deltasone <sup>®</sup>
Nitroglycerin/Nitrostat <sup>®</sup>	Pegfilgrastim/Neulasta <sup>®</sup>	Prilocaine/Citanest <sup>®</sup>
Nitroprusside/Nitropress <sup>®</sup>	Peginesatide/Omontys <sup>®</sup> —Caution, not indicated in patients with chronic kidney disease not on dialysis	Primaquine
Norepinephrine/Levophed <sup>®</sup>	Pegloticase/Krystexxa <sup>™</sup>	Procaine/Novocain <sup>®</sup>
Norethindrone/Aygestin <sup>®</sup>	Pegvisomant/Somavert <sup>®</sup> —Caution, no data in renal impairment	Procarbazine/Matulane <sup>®</sup>
Nortriptyline/Pamelor <sup>®</sup>	Penbutolol/Levatol <sup>®</sup>	Prochlorperazine/Compazine <sup>®</sup>
Nystatin/Nilstat <sup>®</sup> , Mycostatin <sup>®</sup>	Penicillin G benzathine/Bicillin LA <sup>®</sup>	Progesterone/Prometrium <sup>®</sup>
Octreotide/Sandostatin <sup>®</sup>	Penicillin G procaine/Wycillin <sup>®</sup>	Promethazine/Phenergan <sup>®</sup>
Ofatumumab/Arzerra <sup>™</sup>	Penicillin V potassium/Pen VK <sup>®</sup>	Propafenone/Rythmol <sup>®</sup>
Olanzapine/Zyprexa <sup>®</sup>	Pentamidine (inhaled)/Nebupent <sup>®</sup>	Propantheline/Pro-Banthine <sup>®</sup>
Olmесartan/Benicar <sup>®</sup>	Pentobarbital/Nembutal <sup>®</sup>	Propofol/Diprivan <sup>®</sup>
Olsalazine/Dipentum <sup>®</sup> —Caution, monitor renal function	Pentosan polysulfate/Elmiron <sup>®</sup>	Propranolol/Inderal <sup>®</sup>
Omalizumab/Xolair <sup>®</sup>	Perphenazine/Trilafon <sup>®</sup>	Propylthiouracil
Omega-3-acid esters/Lovaza <sup>®</sup>	Pertuzumab/Perjeta <sup>™</sup>	Protamine
Omeprazole/Prilosec <sup>®</sup>	Phenelzine/Nardil <sup>®</sup>	Protriptyline/Vivactil <sup>®</sup>
	Phenol	
	Phenoxybenzamine/Dibenzylamine <sup>®</sup>	

Pseudoephedrine/Sudafed <sup>®</sup>	Scopolamine/Transderm Scōp <sup>®</sup>	Terazosin/Hytrin <sup>®</sup>
Psyllium/Metamucil <sup>®</sup>	Secobarbital/Seconal <sup>®</sup>	Teriparatide/Forteo <sup>®</sup>
Pyrantel pamoate/Combantrin <sup>™</sup>	Selegiline/Eldepryl <sup>®</sup>	Tesamorelin/Egrifta <sup>™</sup> —Caution, safety not established in renal impairment
Pyrazinamide	Selenium (homeopathic)/Male Libido <sup>™</sup>	Testosterone/Delatestryl <sup>®</sup> , Depo-Testosterone <sup>®</sup>
Pyrethrins and piperonyl butoxide/ Rid <sup>®</sup>	Sertraline/Zoloft <sup>®</sup>	Tetanus immune globulin/ HyperTet <sup>™</sup>
Pyridoxine	Sevelamer/Renagel <sup>®</sup>	Tetrabenzazine/Xenazine <sup>®</sup>
Pyrimethamine/Daraprim <sup>®</sup>	Sevoflurane/Ultane <sup>®</sup>	Tetracaine/Pontocaine <sup>®</sup>
Quazepam/Doral <sup>®</sup>	Sildenafil/Revatio <sup>®</sup> , Viagra <sup>®</sup> —Caution, if CrCL < 30 mL/min, consider starting dose at Viagra 25 mg	Thalidomide/Thalomid <sup>®</sup>
Quetiapine/Seroquel <sup>®</sup>	Simethicone/Mylicon <sup>®</sup>	Theophylline/Elixophyllin <sup>®</sup> , Uniphyll <sup>®</sup>
Quinupristin and dalfopristin/ Synercid <sup>®</sup>	Simvastatin/Zocor <sup>®</sup>	Thiabendazole/Mintezol <sup>®</sup> —Caution in renal impairment
Rabeprazole/AcipHex <sup>®</sup>	Sipuleucel-T/Provenge <sup>®</sup>	Thiamine
Rabies immune globulin/HyperRab <sup>®</sup>	Sirolimus/Rapamune <sup>®</sup>	Thioguanine/Tabloid <sup>®</sup>
Raloxifene/Evista <sup>®</sup>	Sodium bicarbonate	Thioridazine/Mellaril <sup>®</sup>
Raltegravir/Isentress <sup>®</sup>	Sodium bicarbonate/Alka Seltzer <sup>®</sup>	Thiotepa—Caution, use in low dosage, monitor carefully
Ramelteon/Rozemer <sup>®</sup>	Heartburn and Acid Indigestion Relief	Thiothixene/Navane <sup>®</sup>
Ranibizumab/Lucentis <sup>®</sup>	Sodium citrate and citric acid/Bicitra <sup>®</sup>	Thyroid/Armour Thyroid <sup>®</sup>
Rasagiline/Azilect <sup>®</sup> —Caution, no data in severe renal impairment	Sodium oxybate/Xyrem <sup>®</sup>	Thyrotropin alfa/Thyrogen <sup>®</sup>
Rasburicase/Elitek <sup>®</sup>	Sodium polystyrene sulfonate/ Kayexalate <sup>®</sup>	Tiagabine/Gabitril <sup>®</sup>
Regadenoson/Lexiscan <sup>®</sup>	Sodium tetradecyl sulfate/Sotradecol <sup>®</sup>	Ticagrelor/Brilinta <sup>™</sup>
Remifentanyl/Ultiva <sup>®</sup> —Caution, in patients >65 years, decrease starting dose by 50 %	Somatropin/Humatrope <sup>®</sup>	Ticlopidine/Ticlid <sup>®</sup>
Retepase/Retavase <sup>®</sup>	Sorbitol	Tigecycline/Tygacil <sup>®</sup>
Rh <sub>0</sub> (D) immune globulin/RhoGam <sup>®</sup>	Succimer/Chemet <sup>®</sup> —Caution in renal impairment	Timolol/Blocadren <sup>®</sup>
Ribavirin (inhaled)/Virazole <sup>®</sup>	Succinylcholine/Anectine <sup>®</sup>	Tinidazole/Tindamax <sup>®</sup>
Rilpivirine/Endurant <sup>™</sup>	Sucralfate/Carafate <sup>®</sup>	Tipranavir/Aptivus <sup>®</sup>
Riboflavin	Sufentanil/Sufenta <sup>®</sup>	Tocilizumab/Actemra <sup>®</sup>
Rifapentine/Priftin <sup>®</sup>	Sulfadiazine	Tolazamide/Tolinase <sup>®</sup>
Rifaximin/Xifaxan <sup>™</sup>	Sulfasalazine/Azulfidine <sup>®</sup> —Caution, 37 % cleared renally	Tolbutamide/Orinase <sup>®</sup>
Rilpivirine/Edurant <sup>™</sup>	Sulindac/Clinoril <sup>®</sup> —Caution, not recommended in advanced renal disease	Tolcapone/Tasmar <sup>®</sup> —Caution in severe renal impairment (CrCL < 25 mL/min)
Riluzole/Rilutek <sup>®</sup>	Sumatriptan/Imitrex <sup>®</sup>	Tolvaptan/Samsca <sup>™</sup>
RimabotulinumtoxinB/Myobloc <sup>®</sup>	Tacrine/Cognex <sup>®</sup>	Toremifene/Fareston <sup>®</sup>
Risperidone injection/Risperdal <sup>®</sup> Consta <sup>®</sup>	Tacrolimus/Prograf <sup>®</sup> —Caution, careful monitoring indicated in renal dysfunction	Torsemide/Demadex <sup>®</sup>
Ritonavir/Norvir <sup>®</sup>	Tamoxifen/Nolvadex <sup>®</sup>	Tranlycypromine/Parnate <sup>®</sup>
Rituximab/Rituxan <sup>®</sup> —Caution, minimal data in renal impairment	Telaprevir/Incivek <sup>™</sup>	Trastuzumab/Herceptin <sup>®</sup>
Rivastigmine/Exelon <sup>®</sup>	Telmisartan/Micardis <sup>®</sup>	Trazodone/Desyrel <sup>®</sup>
Rizatriptan/Maxalt <sup>®</sup>	Temazepam/Restoril <sup>™</sup>	Treprostinil/Remodulin <sup>®</sup>
Rocuronium/Zemuron <sup>®</sup>	Temozolomide/Temodar <sup>®</sup> —Caution in severely impaired renal function (CrCL < 36 mL/min); no data in hemodialysis	Tretinoin/Vesanoid <sup>®</sup> —Caution, no data in renal impairment
Roflumilast/Daliresp <sup>™</sup>	Tenecteplase/TNKase <sup>®</sup>	Triamcinolone/Kenalog <sup>®</sup> , Aristospan <sup>®</sup>
Romidepsin/Istodax <sup>®</sup>	Teniposide/Vumon <sup>®</sup>	Triazolam/Halcion <sup>®</sup>
Romiplostim/Nplate <sup>™</sup>		Trientine/Syprine <sup>®</sup>
Ropinirole/Requip <sup>®</sup>		Trifluoperazine/Stelazine <sup>®</sup>
Ropivacaine/Naropin <sup>®</sup>		Trihexyphenidyl/Artane <sup>®</sup>
Rosiglitazone/Avandia <sup>®</sup>		Trimethobenzamide/Tigan <sup>®</sup>
Rufinamide/Banzel <sup>™</sup>		Trimipramine/Surmontil <sup>®</sup>
Sacrosidase/Sucraid <sup>®</sup>		
Saquinavir/Invirase <sup>®</sup>		
Sargramostim/Leukine <sup>®</sup>		

Tripolidine and pseudoephedrine/ Actifed <sup>®</sup>	Varicella virus vaccine/Varivax <sup>®</sup>	Vitamin A/Aquasol A <sup>®</sup>
Triptorelin/Trelstar <sup>®</sup> —Caution, rate of elimination is diminished in renal impairment	Varicella-zoster immune globulin/ VariZIG <sup>™</sup>	Vitamin E/Aquasol E <sup>®</sup>
Typhoid Vaccine/Vivotif <sup>®</sup>	Vasopressin/Pitressin <sup>®</sup>	Vorinostat/Zolinza <sup>®</sup>
Urofollitropin/Bravelle <sup>®</sup>	Vecuronium/Norcuron <sup>®</sup>	Warfarin/Coumadin <sup>®</sup>
Ursodiol/Actigall <sup>®</sup> , Urso <sup>®</sup>	Vemurafenib/Zelboraf <sup>™</sup>	Yohimbine/Yocon <sup>®</sup>
Ustekinumab/Stelara <sup>®</sup> —Caution, minimal data in renal impairment	Verapamil/Calan <sup>®</sup> , Isoptin <sup>®</sup> —Caution in renal impairment	Zafirlukast/Accolate <sup>®</sup>
Valproic acid/Depacon <sup>®</sup> , Depakene <sup>®</sup>	Verteporfin/Visudyne <sup>®</sup>	Zaleplon/Sonata <sup>®</sup>
Valsartan/Diovan <sup>®</sup>	Vilazodone/Viibryd <sup>™</sup>	Zanamivir/Relenza <sup>®</sup>
Vancomycin (oral)/Vancocin <sup>®</sup>	Vinblastine/Velban <sup>®</sup>	Zileuton/Zyflo <sup>®</sup>
Vardenafil/Levitra <sup>®</sup>	Vincristine/Oncovin <sup>®</sup>	Zinc sulfate/Zincate <sup>®</sup>
	Vinorelbine/Navelbine <sup>®</sup>	Ziprasidone/Geodon <sup>®</sup>
	Vismodegib/Erivedge <sup>™</sup>	Zolmitriptan/Zomig <sup>®</sup>
		Zolpidem/Ambien <sup>®</sup> , Intermezzo <sup>®</sup>
		Zoster vaccine/Zostavax <sup>®</sup>



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## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Acamprosate - Selected References**

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Acamprosate/Campral®** {Alcohol deterrent; putative glutamate/GABA receptor modifier}

**Usual initial dose:** 666 mg orally

**Usual maintenance dose:** 666 mg (two 333 mg tablets) orally three times daily

**Typical maximum dose:** 1,998 mg/day

**Proportion eliminated unchanged:** ~90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL >50 mL/min* 666 mg orally three times daily

*CrCL 30–50 mL/min* 333 mg orally three times daily

*CrCL <30 mL/min* Contraindicated

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acarbose - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acarbose/Precose®

{Antidiabetic;  $\alpha$ -glucosidase inhibitor}

<b>Usual initial dose:</b>	25 mg orally one to three times daily with meals
<b>Usual maintenance dose:</b>	50–100 mg orally three times daily with meals
<b>Typical maximum dose:</b>	50 mg orally three times daily (weight $\leq$ 60 kg); 100 mg orally three times daily (weight >60 kg)
<b>Proportion eliminated unchanged:</b>	35 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>SCr &gt;2.0 mg/dL</i>	<i>Clinical trials in diabetic patients with significant renal dysfunction (SCr &gt;2.0 mg/dL) have not been conducted; therefore, treatment of these patients with (acarbose) is not recommended.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>50 mg orally three times daily with meals</i>
	<i>GFR 10–50 mL/min</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>Hemodialysis</i>	<i>Data not available. Avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>CAPD</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid unless no suitable alternative exists.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acebutolol - Selected References

- Acebutolol hydrochloride capsule [package insert]. Morgantown: Mylan Pharmaceuticals Inc; 2006.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Acebutolol/Sectral**<sup>®</sup> {Antihypertensive; antianginal;  $\beta$ -adrenergic receptor blocker}

**Usual initial dose:** 200 mg orally twice daily

**Usual maintenance dose:** 400–800 mg/day orally

**Typical maximum dose:** 1,200 mg/day

**Proportion eliminated unchanged:** 55 % (acebutolol 18 %, primary active metabolite >90 %)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL <50 mL/min 100 mg orally twice daily (50 % decrease)*

*CrCL <25 mL/min 100 mg orally once daily (75 % decrease)*

**Alternative adjustment:** *GFR >50 mL/min 200 mg orally twice daily; titrate.*

*GFR 10–50 mL/min 100 mg orally twice daily; titrate (50 % decrease).*

*GFR <10 mL/min 100 mg orally once daily; titrate (75 % decrease).*

*Hemodialysis 100 mg orally once daily; titrate; administer after hemodialysis on dialysis days.*

*CAPD Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.*

*CRRT 100 mg enterally twice daily; titrate.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acetaminophen - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Tylenol® Regular Strength Tablet [package insert]. Fort Washington: McNeil Consumer Healthcare; 2011.



## Dosage Adjustment of Medications Eliminated by the Kidneys

**Acetaminophen/Tylenol®, Ofirmev™** {Antipyretic; analgesic}

**Usual initial dose:** 650 mg orally or rectally or 1,000 mg IV  
**Usual maintenance dose:** 650 mg orally or rectally or 1,000 mg IV every 6 h (PRN)  
**Typical maximum dose:** 4,000 mg/day (3,250 mg/day in persons with evidence of liver disease)  
**Proportion eliminated unchanged:** 4 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal impairment</i>	<i>Longer dosing intervals and a reduced total daily dose of acetaminophen may be warranted.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>650 mg orally or rectally or 1,000 mg IV every 6 h (PRN)</i>
	<i>GFR 10–50 mL/min</i>	<i>650 mg orally or rectally or 1,000 mg IV every 6 h (PRN) (no change)</i>
	<i>GFR &lt;10 mL/min</i>	<i>650 mg orally or rectally or 1,000 mg IV every 8 h (PRN)</i>
	<i>Hemodialysis</i>	<i>650 mg orally or rectally or 1,000 mg IV every 8 h (PRN)</i>
	<i>CAPD</i>	<i>650 mg orally or rectally or 1,000 mg IV every 8 h (PRN)</i>
	<i>CRRT</i>	<i>650 mg orally or rectally or 1,000 mg IV every 6 h (PRN)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acetazolamide - Selected References

- Acetazolamide injection USP [package insert]. Big Flats: X-GEN Pharmaceuticals Inc; 2009.
- Acetazolamide tablet USP [package insert]. Hawthorne: Taro Pharmaceuticals USA Inc; 2005.
- Alm A, Berggren L, Hartvig P, Roosdorp M. Monitoring acetazolamide treatment. *Acta Ophthalmol (Copenh)*. 1982;60:24–34.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Acetazolamide/Diamox®** {Diuretic; antiepileptic; carbonic anhydrase inhibitor}

**Usual initial dose:** 250–500 mg orally or IV  
**Usual maintenance dose:** 250–500 mg (approx 5 mg/kg) orally or IV every 6–12 h  
**Typical maximum dose:** 1,000 mg/day  
**Proportion eliminated unchanged:** 95 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Marked kidney disease or dysfunction</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>250 mg orally or IV every 6 h</i>
	<i>GFR 10–50 mL/min</i>	<i>125 mg orally or IV every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>Hemodialysis</i>	<i>Minimal data available. Preferably avoid or use in reduced doses of 62.5–125 mg orally or IV every 24 h with careful clinical and serum level monitoring.*</i>
	<i>CAPD</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>CRRT</i>	<i>250 mg orally or IV every 12 h</i>

### *\*Therapeutic Drug Monitoring*

**Therapeutic Plasma Levels:** *Mid-interval to trough concentration: 4–10 mg/L*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acetohydroxamic Acid - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- McIntyre CW, Owen PJ. Prescribing drugs in kidney disease. In: Brenner BM, editor. *Brenner & Rector's the kidney*. 8th ed. Philadelphia: Saunders Elsevier; 2008. p. 1930–55.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Acetohydroxamic Acid/Lithostat®** {Antibacterial for chronic urea-splitting urinary infection; urease inhibitor}

**Usual initial dose:** 12 mg/kg/day total (e.g., one tablet [250 mg] three to four times a day)  
**Usual maintenance dose:** 10–15 mg/kg/day  
**Typical maximum dose:** 1.5 g/day  
**Proportion eliminated unchanged:** 19–48 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>SCr ≥1.8–2.5 mg/dL</i>	<i>Maximum dose 500 mg orally twice daily</i>
	<i>SCr &gt;2.5 mg/dL</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>10–15 mg/kg/day orally in three to four divided doses</i>
	<i>GFR 10–50 mL/min</i>	<i>10–15 mg/kg/day in orally three to four divided doses</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risks of drug and metabolite accumulation, bone marrow depression, hypercoagulability, hypercarbia, and electrolyte derangements.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risks of drug and metabolite accumulation, bone marrow depression, hypercoagulability, hypercarbia, and electrolyte derangements.</i>
	<i>CAPD</i>	<i>Preferably avoid due to risks of drug and metabolite accumulation, bone marrow depression, hypercoagulability, hypercarbia, and electrolyte derangements.</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acitretin - Selected References

- Bavinck JNB, Tieben LM, Van Der Woude FJ, et al. Prevention of skin cancer and reduction of keratotic skin lesions during acitretin therapy in renal transplant recipients: a double-blind, placebo-controlled study. *J Clin Oncol*. 1995;13:1933–8.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Acitretin/Soriatane®** {Antipsoriatic; retinol (vitamin A) derivative}

**Usual initial dose:** 25 mg orally once daily with the main meal  
**Usual maintenance dose:** 25–50 mg orally once daily with the main meal, depending on response and tolerance  
**Typical maximum dose:** 100 mg/day  
**Proportion eliminated unchanged:** Nil (approx 20 % as minimally active oxidative and glucuronide metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL >~30 mL/min* 25–50 mg orally once daily with the main meal  
*Severely impaired kidney function* Contraindicated

**Alternative adjustment:** *Data not available*

*Note: Reasons for the above contraindication are not clear and this categorization is apparently unsupported. Single and multiple dose investigations in patients with ESRD either receiving or not receiving hemodialysis revealed that total acitretin exposure was approximately 50 % lower than in matched patients without renal impairment and comparative elimination characteristics showed little or no change. Substantial clinical experience in kidney transplant recipients shows successful use of acitretin in usual or slightly reduced (0.2–0.4 mg/kg) daily dosages.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acyclovir (IV) - Selected References

- Acyclovir injection [package insert]. Bedford: Bedford Laboratories; 2005.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Bean B, Braun C, Balfour HH Jr. Acyclovir therapy for acute herpes zoster. *Lancet*. 1982;2:118–21.
- Boelaert J, Schurgers M, Daneels R, Van Landuyt HW, Weatherley BC. Multiple dose pharmacokinetics of intravenous acyclovir in patients on continuous ambulatory peritoneal dialysis. *J Antimicrob Chemother*. 1987;20:69–76.
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- Shah GM, Winer RL, Krasny HC. Acyclovir pharmacokinetics in a patient on continuous ambulatory peritoneal dialysis. *Am J Kidney Dis*. 1986;7:507–10.
- Trotman RL, Williamson JC, Shoemaker M, Salzer WL. Antibiotic dosing in critically ill adult patients receiving continuous renal replacement therapy. *Clin Infect Dis*. 2005;41:1159–66.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Acyclovir/Zovirax® (IV)** {Antiviral; nucleoside analog; viral DNA polymerase inhibitor}

**Usual initial dose:** 10 mg/kg (ideal body weight or lean body mass)

**Usual maintenance dose:** 5 mg/kg IV every 8 h for 7 days (mucosal and cutaneous herpes simplex [HSV-1 and HSV-2] infections in immunocompromised patients);  
5 mg/kg IV every 8 h for 5 days (severe initial episodes of herpes genitalis);  
10 mg/kg IV every 8 h for 7–10 days (herpes simplex encephalitis);  
10 mg/kg IV every 8 h for 7 days (varicella zoster infections in immunocompromised patients)

**Typical maximum dose:** 20 mg/kg IV every 8 h

**Proportion eliminated unchanged:** 77–99 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Acyclovir dosage adjustments in renal impairment*

<i>CrCL (mL/min)</i>	<i>Percent of recommended dose (%)</i>	<i>Dosing interval (h)</i>
<i>&gt;50</i>	<i>100</i>	<i>8</i>
<i>25–50</i>	<i>100</i>	<i>12</i>
<i>10–25</i>	<i>100</i>	<i>24</i>
<i>0–10</i>	<i>50</i>	<i>24</i>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>5–10 mg/kg IV every 8 h</i>
<i>GFR 10–50 mL/min</i>	<i>5–10 mg/kg IV every 12–24 h</i>
<i>GFR &lt;10 mL/min</i>	<i>2.5–5 mg/kg IV every 24 h</i>
<i>Hemodialysis</i>	<i>2.5–5 mg/kg IV every 24 h, dose after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>2.5–5 mg/kg IV every 24 h</i>
<i>CVVH</i>	<i>2.5–7.5 mg/kg IV every 24 h</i>
<i>CVVHD or CVVHDF</i>	<i>5–7.5 mg/kg IV every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Acyclovir (Enteral) - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Acyclovir/Zovirax® (Enteral)** {Antiviral; nucleoside analog}

**Usual initial dose:** 200–800 mg enterally

**Usual maintenance dose:** 800 mg enterally every 4 h, five times daily (acute treatment of herpes zoster); 200 mg orally every 4 h, five times daily (treatment of initial genital herpes); 400 mg orally two times daily for up to 12 months (chronic suppressive therapy for recurrent disease); 200 mg orally every 4 h, five times daily for 5 days (intermittent therapy, at the earliest sign or symptom [prodrome] of recurrence); 800 mg orally four times daily for 5 days (chickenpox)

**Typical maximum dose:** 800 mg five times daily (enteral)

**Proportion eliminated unchanged:** 50–90 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Acyclovir dosage modification for renal impairment (enteral)*

Normal dosage regimen	CrCL (mL/min/ 1.73 m <sup>2</sup> )	Adjusted dosage regimen	
		Dose	Dosing interval
200 mg every 4 h	>10	200 mg	Every 4 h, 5× daily
	0–10	200 mg	Every 12 h
400 mg every 12 h	>10	400 mg	Every 12 h
	0–10	200 mg	Every 12 h
800 mg every 4 h	>25	800 mg	Every 4 h, 5× daily
	10–25	800 mg	Every 8 h
	0–10	800 mg	Every 12 h

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>200–800 mg orally or enterally five times daily</i>
<i>GFR 10–50 mL/min</i>	<i>200–800 mg orally or enterally every 8 h</i>
<i>GFR &lt;10 mL/min</i>	<i>200–800 mg orally or enterally every 12 h</i>
<i>Hemodialysis</i>	<i>200–800 mg orally or enterally every 12 h; administer after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>200–800 mg orally or enterally every 12 h</i>
<i>CRRT</i>	<i>Not applicable (consider IV acyclovir)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Adefovir - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Adefovir/Hepsera™** {Antiviral; anti-hepatitis B nucleotide analog}

**Usual initial dose:** 10 mg orally once daily

**Usual maintenance dose:** 10 mg orally once daily

**Typical maximum dose:** 10 mg orally once daily

**Proportion eliminated unchanged:** >90 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Adefovir dosing interval adjustment in adults with impaired renal function*

	CrCL (mL/min) <sup>a</sup>			
	≥50	30–49	10–29	Hemodialysis
<i>Recommended dosage and dosing interval</i>	<i>10 mg orally every 24 h</i>	<i>10 mg orally every 48 h</i>	<i>10 mg orally every 72 h</i>	<i>10 mg orally every 7 days following dialysis</i>

<sup>a</sup>CrCL calculated by Cockcroft-Gault method using lean or ideal body weight

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>10 mg orally every 24 h</i>
<i>GFR 20–50 mL/min</i>	<i>10 mg orally every 48 h</i>
<i>GFR &lt;20 mL/min</i>	<i>10 mg orally every 72 h</i>
<i>Intermittent hemodialysis</i>	<i>10 mg orally once weekly after dialysis</i>
<i>CAPD</i>	<i>Data not available. Preferably avoid or, if indeed necessary, administer 10 mg orally every 72 h and monitor carefully.</i>
<i>CRRT</i>	<i>Data not available. Preferably avoid or, if indeed necessary, administer 10 mg enterally every 48–72 h and monitor carefully.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Alendronate - Selected References

Black DM, Cummings SR, Karpf DB, et al. Randomised trial of effect of alendronate on risk of fracture in women with existing vertebral fractures. *Lancet*. 1996;348:1535–41.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Alendronate/Fosamax®

{Anti-osteoporotic; bisphosphonate}

<b>Usual initial dose:</b>	10 mg orally once daily or 35–70 mg orally once weekly
<b>Usual maintenance dose:</b>	10 mg orally once daily or 35–70 mg orally once weekly
<b>Typical maximum dose:</b>	70 mg/week
<b>Proportion eliminated unchanged:</b>	40–60 % of an assimilated dose; ~100 % of drug in plasma

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;60 mL/min</i>	<i>No adjustment needed: 10 mg orally once daily or 35–70 mg orally once weekly</i>
	<i>CrCL 35–60 mL/min</i>	<i>No adjustment needed: 10 mg orally once daily or 35–70 mg orally once weekly</i>
	<i>CrCL &lt;35 mL/min</i>	<i>Not recommended due to lack of experience</i>
<b>Alternative adjustment:</b>	<i>eCrCL ≥60 mL/min</i>	<i>10 mg orally once daily or 35–70 mg orally once weekly</i>
	<i>eCrCL 35–59 mL/min</i>	<i>10 mg orally once daily (no adjustment needed)</i>
	<i>eCrCL &lt;35 mL/min</i>	<i>10 mg orally once daily (no adjustment needed); only minimal clinical experience supports safety.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Alfuzosin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Alfuzosin/Uroxatral**<sup>®</sup> { $\alpha_1$ -Adrenergic receptor blocker; R for benign prostatic hyperplasia}

**Usual initial dose:** 10 mg orally  
**Usual maintenance dose:** 10 mg orally once daily with food/after a meal at the same time each day  
**Typical maximum dose:** 10 mg/day  
**Proportion eliminated unchanged:** 24 % (11 % as unchanged drug)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;30 mL/min</i>	<i>10 mg orally once daily after a meal</i>
	<i>CrCL ≤30 mL/min</i>	<i>Safety not determined—Drug exposure (maximum blood levels and area under the plasma concentration time curve) are increased by 50 % as compared to patients with normal renal function.</i>
<b>Alternative adjustment:</b>	<i>eCrCL ≥60 mL/min</i>	<i>10 mg orally once daily after a meal</i>
	<i>eCrCL 30–59 mL/min</i>	<i>10 mg orally once daily after a meal</i>
	<i>eCrCL &lt;30 mL/min</i>	<i>5 mg orally once daily after a meal</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Aliskiren - Selected References

- Ali AK. Pharmacovigilance analysis of adverse event reports for aliskiren hemifumarate, a first-in-class direct renin inhibitor. *Ther Clin Risk Manag.* 2011;7:337–44.
- Azizi M, Ménard J. Renin inhibitors and cardiovascular and renal protection: an endless quest? *Cardiovasc Drugs Ther.* 2010. Epub ahead of print. doi:[10.1007/s10557-012-6380-6](https://doi.org/10.1007/s10557-012-6380-6).
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- Vaidyanathan S, Bigler H, Jarugula V, et al. Pharmacokinetics of the oral direct renin inhibitor aliskiren alone and in combination with irbesartan in renal impairment. *Clin Pharmacokinet.* 2007;46:661–75.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Aliskiren/Tekturna**<sup>®</sup> {Antihypertensive; direct renin inhibitor}

**Usual initial dose:** 150 mg orally  
**Usual maintenance dose:** 150–300 mg orally once daily  
**Typical maximum dose:** 300 mg/day  
**Proportion eliminated unchanged:** 25 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal impairment (GFR &lt;60 mL/min)</i>	<i>Avoid. Safety and effectiveness not established (patients with CrCL &lt;30 mL/min were excluded from controlled trials); monitor renal function—Patients with renal artery stenosis, heart failure, volume depletion, and those receiving an angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) may be at particular risk for developing acute renal failure. Contraindicated in patients with diabetes who are receiving ARBs or ACE inhibitors because of the increased risk of renal impairment, hyperkalemia, and hypotension</i>
<b>Alternative adjustment:</b>	<i>eCrCL 31–59 mL/min</i>	<i>Preferably avoid. If indeed necessary, 150–300 mg orally once daily (no adjustment necessary); monitor carefully—Be aware of contraindications and markedly increased risk of acute kidney injury, hyperkalemia, and hypotension in patients receiving ARBs and/or ACE inhibitors.</i>
	<i>eCrCL ≤30 mL/min</i>	<i>Preferably avoid. If indeed necessary, 150–300 mg orally once daily (no adjustment necessary); monitor carefully—Be aware of contraindications and markedly increased risk of acute kidney injury, hyperkalemia, and hypotension in patients receiving ARBs and/or ACE inhibitors.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid. Minimal data available; if indeed necessary, initiate therapy with 150 mg orally once daily with careful clinical and biochemical monitoring.</i>
	<i>CRRT</i>	<i>Preferably avoid. No published data available; if indeed necessary, initiate with 150 mg enterally once daily with careful monitoring.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Allopurinol - Selected References

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- Zyloprim® tablet [package insert]. San Diego CA: Prometheus Laboratories Inc; 2003.

## Dosage Adjustment of Medications Eliminated by the Kidneys

<b><u>Allopurinol/Zyloprim®</u>, Aloprim®</b>	<b>{Anti-gout; xanthine oxidase inhibitor}</b>
<b>Usual initial dose:</b>	200 mg/m <sup>2</sup> orally or IV
<b>Usual maintenance dose:</b>	200–400 mg/m <sup>2</sup> /day orally or IV
<b>Typical maximum dose:</b>	600 mg/day
<b>Proportion eliminated unchanged:</b>	10 % (plus 80 % of each dose as pharmacologically active primary metabolite, oxypurinol)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 10–20 mL/min</i>	<i>200 mg orally or IV once daily</i>
	<i>CrCL 3–10 mL/min</i>	<i>100 mg orally or IV once daily</i>
	<i>CrCL &lt;3 mL/min</i>	<i>100 mg/day orally or IV at extended intervals</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>200 mg orally or IV once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>150 mg orally or IV once daily</i>
	<i>GFR &lt;10 mL/min</i>	<i>100 mg orally or IV once daily or 150 mg orally every 48 h</i>
	<i>Hemodialysis</i>	<i>100 mg orally or IV once daily or 150 mg orally every 48 h; administer supplemental half dose (50 %) after dialysis</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>150 mg enterally or IV once daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Almotriptan - Selected References

Axert® tablet [package insert]. Titusville: Ortho-McNeil Neurologics; 2009.

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Gras J, Llupià J, Llenas J, Palacios JM. Safety profile of almotriptan, a new antimigraine agent. *Arzneimittelforschung*. 2001;51:726–32.

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Keam SJ, Goa KL, Figgitt DP. Almotriptan: a review of its use in migraine. *Drugs*. 2002;62:387–414.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Almotriptan/Axert®

{Anti-migraine; serotonin 5-HT<sub>3</sub> receptor antagonist}

<b>Usual initial dose:</b>	12.5 mg orally
<b>Usual maintenance dose:</b>	6.25–12.5 mg orally; may be repeated once in 2 h if necessary
<b>Typical maximum dose:</b>	25 mg/day
<b>Proportion eliminated unchanged:</b>	45 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal impairment</i>	<i>6.25 mg orally; maximum daily dose should not exceed 12.5 mg over a 24-h period.</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Amantadine - Selected References

- Aoki FY, Sitar DS. Clinical pharmacokinetics of amantadine hydrochloride. *Clin Pharmacokinet.* 1988;14:35–51.
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- Olyaei AJ, Bennett WM. Drug dosing in elderly patients with chronic kidney disease. *Clin Geriatr Med.* 2009;25:459–527.
- Olyaei AJ, DeMattos AM, Bennett WM. Use of drugs in patients with renal failure. In: Schrier RW, editor. *Diseases of the kidney and urinary tract.* 8th ed. Philadelphia: Lippincott Williams & Wilkins; 2007. p. 2765–807.
- Soung L-S, Ing TS, Daugirdas JT, et al. Amantadine hydrochloride pharmacokinetics in hemodialysis patients. *Ann Intern Med.* 1980;93:46–9.
- Symmetrel® tablet and syrup [package insert]. Chadds Ford: Endo Pharmaceuticals Inc; 2009.
- Wu MJ, Ing TS, Soung LS, Daugirdas JT, Hang JE, Gandhi VC. Amantadine hydrochloride pharmacokinetics in patients with impaired renal function. *Clin Nephrol.* 1982;17:19–23.



## Dosage Adjustment of Medications Eliminated by the Kidneys

**Amantadine/Symmetrel®** {Antiviral; anti-Parkinsonian; viral M2 protein transmembrane blocker; dopaminergic}

**Usual initial dose:** 100 mg orally  
**Usual maintenance dose:** 100 mg orally twice daily  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Amantadine dosage in renal function impairment*

<i>CrCL (mL/min)</i>	<i>Dosage</i>
30–50	200 mg orally first day followed by 100 mg orally each day thereafter
15–29	200 mg orally first day followed by 100 mg on alternate days
<15	200 mg orally every 7 days
<i>Hemodialysis: 200 mg orally every 7 days</i>	

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>100 mg orally every 12 h (1.4 mg/kg/day)</i>
<i>GFR 10–50 mL/min</i>	<i>100 mg orally every 24–48 h</i>
<i>GFR &lt;10 mL/min</i>	<i>100 mg orally every 7 days</i>
<i>Hemodialysis</i>	<i>200 mg orally every 7 days (no supplemental dose after dialysis)</i>
<i>CRRT</i>	<i>100–200 mg orally every 48–60 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Amikacin - Selected References

- Amikacin sulfate injection USP [package insert]. Lake Forest: Hospira Inc; 2004.
- Armstrong DK, Hodgman T, Visconti JA, Reilley TE, Garner WL, Dasta JF. Hemodialysis of amikacin in critically ill patients. *Crit Care Med*. 1988;16:517–20.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Amikacin/Amikin®

{Antibacterial; aminoglycoside}

<b>Usual initial dose:</b>	7.5 mg/kg
<b>Usual maintenance dose:</b>	15 mg/kg/day IV once daily or divided into two or three equal doses (monitor <sup>a</sup> , adjust)
<b>Typical maximum dose:</b>	20 (to 30) mg/kg/day not to exceed 1.5 g/day
<b>Proportion eliminated unchanged:</b>	95 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	7.5 mg/kg every (nine times SCr in mg/dL) h	
<b>Alternative adjustment:</b>	<i>eCrCL &gt;80 mL/min</i>	7.5–20 mg/kg (up to 25–30 mg/kg in burn and cystic fibrosis patients) IV loading dose over 1 h followed by 7.5 mg/kg IV over 1 h every 12 h or 15–20 mg/kg IV over 1 h every 24 h <sup>a</sup>
	<i>eCrCL 30–80 mL/min</i>	5–7.5 mg/kg every 24 h <sup>a</sup>
	<i>eCrCL 10–30 mL/min</i>	5–7.5 mg/kg every 48 h <sup>a</sup>
	<i>eCrCL &lt;10 mL/min</i>	3.75 mg/kg every 48–72 h <sup>a</sup>
	<i>Hemodialysis</i>	3.75 mg/kg after dialysis <sup>a</sup>
	<i>CAPD</i>	7.5 mg/kg IV followed by amikacin instilled in peritoneal dialysate at a (peak) concentration desired in plasma, usually 15–20 mg/L <sup>a</sup>
	<i>CVVH</i>	15 mg/kg followed by 7.5 mg/kg every 24–48 h according to plasma concentrations <sup>a</sup>
	<i>CVVHD</i>	15–25 mg/kg followed by 7.5 mg/kg every 24–48 h according to plasma concentrations <sup>a</sup>
	<i>CVVHDF</i>	15–25 mg/kg followed by 7.5 mg/kg every 24–48 h according to plasma concentrations <sup>a</sup>

### <sup>a</sup>*Therapeutic drug monitoring*

<b>Therapeutic plasma levels:</b>	<i>Peak</i>	20–30 mg/L (conventional, multiple daily dosing)
	<i>Trough</i>	<10 mg/L; patients on extended-interval dosing generally should be re-dosed when levels fall below 5 mg/L.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Amiloride - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- George CF. Amiloride handling in renal failure. *Br J Clin Pharmacol.* 1980;9:94–5.
- McIntyre CW, Owen PJ. Prescribing drugs in kidney disease. In: Brenner BM, editor. *Brenner & Rector's the kidney.* 8th ed. Philadelphia: Saunders Elsevier; 2008. p. 1930–55.
- Midamor® tablet [package insert]. Minneapolis: Paddock Laboratories Inc; 2008.
- Olyaei AJ, Bennett WM. Pharmacologic approach to renal insufficiency. In: Dale DC, Federman DD, Antman K, editors. *ACP medicine, WebMD June 2007 update.* Hamilton: BC Decker; 2007; NEPHROLOGY IX: Appendix A1–25.
- Olyaei AJ, Bennett WM. Drug dosing in elderly patients with chronic kidney disease. *Clin Geriatr Med.* 2009;25:459–527.
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- Schwartz A, Sellar R, Onesti G, Kim K, Swartz C, Brest AN. Pharmacodynamic effects of a new potassium-sparing diuretic, amiloride. *J Clin Pharmacol.* 1969;9:217–23.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Amiloride/Midamor**<sup>®</sup> {Diuretic; potassium-sparing agent}

**Usual initial dose:** 5 mg orally daily  
**Usual maintenance dose:** 5–10 mg orally once daily  
**Typical maximum dose:** 20 mg/day  
**Proportion eliminated unchanged:** ~50 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>SCr &gt;1.5 mg/dL or BUN &gt;30 mg/dL</i>	<i>Use only with careful, frequent, and continuing monitoring of serum electrolytes, creatinine, and BUN levels.</i>
	<i>Anuria, acute or chronic renal insufficiency and evidence of diabetic nephropathy</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>5 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>2.5 mg orally once daily or 5 mg orally every 48 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk for hyperkalemia and cardiac irregularities.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risk for hyperkalemia and cardiac irregularities.</i>
	<i>CAPD</i>	<i>Preferably avoid due to risk for hyperkalemia and cardiac irregularities.</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid due to risk for hyperkalemia and cardiac irregularities.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### *p*-Aminosalicylic Acid - Selected References

Abramowicz M, Zuccotti G, Pflomm J-M, et al. Handbook of antimicrobial therapy. 19th ed. New Rochelle: The Medical Letter; 2011.

Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.

Held H, Fried F. Elimination of para-aminosalicylic acid in patients with liver disease and renal insufficiency. *Chemotherapy*. 1977;23:405–15.

Holdiness MR. Clinical pharmacokinetics of the antituberculosis drugs. *Clin Pharmacokinet*. 1984;9:511–44.

Hong L, Jiang W, Pan H, Jiang Y, Zeng S, Zheng W. Brain regional pharmacokinetics of *p*-aminosalicylic acid and its N-acetylated metabolite: effectiveness in chelating brain manganese. *Drug Metab Dispos*. 2011;39:1904–9.

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Paser® delayed release granules [package insert]. Princeton: Jacobus Pharmaceutical Co Inc; 1996.

Peloquin CA, Berning SE, Huitt GA, Childs JM, Singleton MD, James GT. Once-daily and twice-daily dosing of *p*-aminosalicylic acid granules. *Am J Respir Crit Care Med*. 1999;159:932–4.

Peloquin CA, Zhu M, Adam RD, Singleton MD, Nix DE. Pharmacokinetics of *para*-aminosalicylic acid granules under four dosing conditions. *Ann Pharmacother*. 2001;35:1332–8.

Pentikäinen PJ, Wan SH, Azarnoff DL. Bioavailability of aminosalicylic acid and its various salts in humans. IV: comparison of four brands of the sodium salt. *J Pharm Sci*. 1974;63:1431–4.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

***p*-Aminosalicylic Acid/Paser<sup>®</sup>, PAS** {Antitubercular; folic acid synthesis inhibitor}

**Usual initial dose:** 50 mg/kg orally  
**Usual maintenance dose:** 4 g orally three times daily or 150 mg/kg/day orally in two to three equally divided doses  
**Typical maximum dose:** 300 mg/kg/day  
**Proportion eliminated unchanged:** 35 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal disease</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>50 mg/kg (approximately 4 g [1 granule packet]) orally every 8 h</i>
	<i>GFR 10–50 mL/min</i>	<i>25–35 mg/kg orally every 8 h (25–50 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>25 mg/kg orally every 8 h (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>25 mg/kg orally every 8 h; dose after dialysis (50 % decrease)</i>
	<i>CAPD</i>	<i>25 mg/kg orally every 8 h (50 % decrease)</i>
	<i>CRRT</i>	<i>25–35 mg/kg orally every 8 h (25–50 % decrease)</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Ammonium Chloride - Selected References**

- Ammonium chloride injection concentrate (5 mEq/mL) [package insert]. Lake Forest: Hospira Inc; 2009.
- Bear R, Goldstein M, Phillipson E, et al. Effect of metabolic alkalosis on respiratory function in patients with chronic obstructive lung disease. *Can Med Assoc J.* 1977;117:900–3.
- Brenes LG, Sanchez MI. Impaired urinary ammonium excretion in patients with isolated proximal renal tubular acidosis. *J Am Soc Nephrol.* 1993;4:1073–8.
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- Stein TP, Leskiw MJ, Wallace HW. Metabolism of parenterally administered ammonia. *J Surg Res.* 1976;21:17–20.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ammonium Chloride

{Systemic acidifier; electrolyte replenisher}

<b>Usual initial dose:</b>	100–200 mEq IV in 500–1,000 mL 0.9 % sodium chloride IV over 3 h (not to exceed 5 mL/h)
<b>Usual maintenance dose:</b>	As required by repeated sodium bicarbonate determinations
<b>Typical maximum dose:</b>	200 mEq/day
<b>Proportion eliminated unchanged:</b>	Nil

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal function impairment</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Amoxicillin - Selected References**

- Abramowicz M, Zuccotti G, Pflomm J-M, et al. Handbook of antimicrobial therapy. 19th ed. New Rochelle: The Medical Letter; 2011.
- Amoxicillin powder for suspension [package insert]. Jacksonville: Ranbaxy Laboratories Inc; 2008.
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- Moxatag<sup>®</sup> tablet extended release [package insert]. San Diego: Victory Pharma Inc; 2008.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Amoxicillin/Amoxil®, Moxatag™** {Antibacterial; aminopenicillin}

**Usual initial dose:** 500 mg orally  
**Usual maintenance dose:** 250–500 mg orally every 8–12 h  
**Typical maximum dose:** 3,000 mg single dose or 2,000 mg/day  
**Proportion eliminated unchanged:** 60–80 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 10–30 mL/min</i>	<i>250–500 mg orally or enterally every 12 h</i>
	<i>CrCL &lt;10 mL/min</i>	<i>250–500 mg orally or enterally every 24 h</i>
	<i>Hemodialysis</i>	<i>250–500 mg orally or enterally every 24 h + additional dose both during and after dialysis</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>250–500 mg orally or enterally every 8 h</i>
	<i>GFR 10–50 mL/min</i>	<i>250–500 mg orally or enterally every 8–12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>250–500 mg orally or enterally every 12–24 h</i>
	<i>Hemodialysis</i>	<i>250–500 mg orally or enterally every 12–24 h</i>
	<i>CAPD</i>	<i>250 mg orally or enterally every 8 h</i>
	<i>CRRT</i>	<i>Not applicable (consider IV ampicillin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Amoxicillin and Clavulanate - Selected References

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- Augmentin<sup>®</sup> tablet, chewable tablet, and powder for suspension [package insert]. Research Triangle Park: GlaxoSmithKline; 2005.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Amoxicillin and Clavulanate/Augmentin®

{Antibacterial; aminopenicillin/β-lactamase inhibitor}

<b>Usual initial dose:</b>	500 mg orally
<b>Usual maintenance dose:</b>	250–500 mg orally or enterally every 8 h or 500–875 mg orally every 12 h
<b>Typical maximum dose:</b>	1,750 mg/day
<b>Proportion eliminated unchanged:</b>	60–80 %/25–40 %

### *Adjustment for Kidney Disease*

#### **FDA-approved product labeling:**

<i>CrCL &gt;30 mL/min</i>	<i>250–500 mg orally or enterally every 8–12 h</i>
<i>CrCL 10–30 mL/min</i>	<i>250–500 mg orally or enterally every 12 h</i>
<i>CrCL &lt;10 mL/min</i>	<i>250–500 mg orally or enterally every 24 h</i>
<i>Hemodialysis</i>	<i>250–500 mg orally or enterally every 24 h; administer an additional dose both during and at the end of dialysis.</i>
<i>CAPD</i>	<i>No data</i>
<i>CRRT</i>	<i>No data</i>

#### **Alternative adjustment:**

<i>eCrCL &gt;80 mL/min</i>	<i>250–500 mg orally or enterally every 8–12 h</i>
<i>eCrCL 51–80 mL/min</i>	<i>250–500 mg orally or enterally every 8–12 h</i>
<i>eCrCL 10–50 mL/min</i>	<i>250–500 mg orally or enterally every 12 h</i>
<i>eCrCL &lt;10 mL/min</i>	<i>250–500 mg orally or enterally every 24 h</i>
<i>Hemodialysis</i>	<i>250–500 mg orally or enterally every 24 h; give 250–500 mg enterally after dialysis</i>
<i>CAPD</i>	<i>250 mg orally or enterally every 12 h</i>
<i>CRRT</i>	<i>Not applicable (consider IV ampicillin/sulbactam)</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Ampicillin (Enteral) - Selected References**

- Ampicillin trihydrate capsule [package insert]. Fort Lee: DAVA Pharmaceuticals Inc; 2011.
- Ampicillin trihydrate suspension [package insert]. Fort Lee: DAVA Pharmaceuticals Inc; 2010.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Olyaei AJ, Bennett WM. Drug dosing in elderly patients with chronic kidney disease. *Clin Geriatr Med.* 2009;25:459–527.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ampicillin (Enteral)/Polycillin®

{Antibacterial; aminopenicillin}

<b>Usual initial dose:</b>	250–1,000 mg or 3.5 g once only enterally
<b>Usual maintenance dose:</b>	250–500 mg enterally every 6 h ( $\geq 1$ h prior to or $\geq 2$ h after meals)
<b>Typical maximum dose:</b>	3,000 mg/day
<b>Proportion eliminated unchanged:</b>	60 %

### *Adjustment for Kidney Disease*

#### **FDA-approved product labeling:**

<i>CrCL &gt;50 mL/min</i>	<i>250–500 mg orally or enterally every 6 h</i>
<i>CrCL 10–50 mL/min</i>	<i>250–500 mg orally enterally every 6–12 h</i>
<i>CrCL &lt;10 mL/min</i>	<i>250–500 mg orally or enterally every 12–16 h</i>
<i>Hemodialysis</i>	<i>250–500 mg orally or enterally every 12–24 h; give supplemental dose after dialysis</i>
<i>CAPD</i>	<i>250 mg orally or enterally every 12 h</i>

#### **Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>250–500 mg enterally every 6 h</i>
<i>GFR 10–50 mL/min</i>	<i>250–500 mg enterally every 8 h</i>
<i>GFR &lt;10 mL/min</i>	<i>250–500 mg enterally every 12 h</i>
<i>Hemodialysis</i>	<i>250–500 mg enterally every 12 h; administer after hemodialysis on dialysis days.</i>
<i>CRRT</i>	<i>Not applicable (consider IV ampicillin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ampicillin (IV) - Selected References

- Abramowicz M, Zuccotti G, Pflomm J-M, et al. Handbook of antimicrobial therapy. 19th ed. New Rochelle: The Medical Letter; 2011.
- Ampicillin sodium injection [package insert]. New York: Pfizer Laboratories Division of Pfizer Inc; 2010.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Kucers A, Bennett NMCK, Kemp RJ. The use of antibiotics: a comprehensive review with clinical emphasis. 4th ed. Philadelphia: JB Lippincott Co;1987:133–71.
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- Sjövall J, Westerlund D, Alván G. Renal excretion of intravenously infused amoxicillin and ampicillin. *Br J Clin Pharmacol*. 1985;19:191–201.



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ampicillin (IV)/Polycillin®

{Antibacterial; aminopenicillin}

<b>Usual initial dose:</b>	2 g IV
<b>Usual maintenance dose:</b>	1–2 g IV every 6 h
<b>Typical maximum dose:</b>	50 mg/kg/dose (~3 g/dose) or 250 mg/kg/day (~12 g/day)
<b>Proportion eliminated unchanged:</b>	60 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;50 mL/min</i>	<i>1–2 g IV every 4–6 h or 12 g/day continuous IV infusion</i>
	<i>CrCL 10–50 mL/min</i>	<i>1–2 g IV every 6–12 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1–2 g IV every 6 h</i>
	<i>GFR 10–50 mL/min</i>	<i>1–2 g IV every 8 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>500–1,500 mg IV every 12 h</i>
	<i>Hemodialysis</i>	<i>1 g IV every 12 h; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>250 mg IV every 12 h</i>
	<i>CVVH</i>	<i>1–2 g IV every 8–12 h</i>
	<i>CVVHD</i>	<i>1–2 g IV every 8 h</i>
	<i>CVVHDF</i>	<i>1–2 g IV every 6–8 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ampicillin and Sulbactam - Selected References

- Abramowicz M, Zuccotti G, Pflomm J-M, et al., editors. Handbook of antimicrobial therapy. 19th ed. New Rochelle: The Medical Letter; 2011.
- Blackwell BG, Leggett JE II, Johnson CA, Zimmerman SW, Craig WA II. Ampicillin and sulbactam pharmacokinetics and pharmacodynamics in continuous ambulatory peritoneal dialysis (CAPD). *Perit Dial Int.* 1990;10:221–6.
- Blum RA, Kohli RK, Harrison NJ, Schentag JJ. Pharmacokinetics of ampicillin (2.0 grams) and sulbactam (1.0 gram) coadministered to subjects with normal or abnormal renal function and with end-stage renal disease on hemodialysis. *Antimicrob Agents Chemother.* 1989;33:1470–6.
- Foulds G, Stankewich JP, Marshall DC, et al. Pharmacokinetics of sulbactam in humans. *Antimicrob Agents Chemother.* 1983;23:692–9.
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- Heintz BH, Matzke GR, Dager WF. Antimicrobial dosing concepts and recommendations for critically ill adult patients receiving continuous renal replacement therapy or intermittent hemodialysis. *Pharmacotherapy.* 2009;29:562–77.
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- Ripa S, Ferrante L, Prena M. Pharmacokinetics of sulbactam/ampicillin in humans after intravenous and intramuscular injection. *Chemotherapy.* 1990;36:185–92.
- Skoulas G, Bayer AS, Pogliano J, et al. Ampicillin enhances daptomycin- and cationic host defense peptide-mediated killing of ampicillin- and vancomycin-resistant *Enterococcus faecium*. *Antimicrob Agents Chemother.* 2011. Epub ahead of print. doi:[10.1128/AAC.05551-11](https://doi.org/10.1128/AAC.05551-11).
- Trotman RL, Williamson JC, Shoemaker M, Salzer WL. Antibiotic dosing in critically ill adult patients receiving continuous renal replacement therapy. *Clin Infect Dis.* 2005;41:1159–66.
- Unasyn® injection [package insert]. New York: Roerig Division of Pfizer Inc; 2010.
- Watson ID, Stewart MJ, Platt DJ. Clinical pharmacokinetics of enzyme inhibitors in antimicrobial chemotherapy. *Clin Pharmacokinet.* 1988;15:133–64.
- Wright N, Wise R. The elimination of sulbactam alone and combined with ampicillin in patients with renal dysfunction. *J Antimicrob Chemother.* 1983;11:583–7.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ampicillin and Sulbactam/Unasyn® {Antibacterial; aminopenicillin/β-lactamase inhibitor}

<b>Usual initial dose:</b>	1.5–3 g IV
<b>Usual maintenance dose:</b>	1.5–3 g IV every 6 h
<b>Typical maximum dose:</b>	3 g IV
<b>Proportion eliminated unchanged:</b>	35 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Ampicillin and sulbactam for injection dosage guide for patients with renal impairment*

<i>CrCL (mL/min)</i>	<i>Ampicillin/sulbactam half-life (h)</i>	<i>Recommended ampicillin/sulbactam for injection dosage</i>
<i>≥30</i>	<i>1</i>	<i>1.5–3 g IV q 6–q 8 h</i>
<i>15–29</i>	<i>5</i>	<i>1.5–3 g IV q 12 h</i>
<i>5–14</i>	<i>9</i>	<i>1.5–3 g IV q 24 h</i>

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1.5–3 g IV every 6 h</i>
	<i>GFR 10–50 mL/min</i>	<i>1.5–3 g IV every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>1.5–3 g IV every 24 h</i>
	<i>Hemodialysis</i>	<i>3 g IV every 24 h; administer after hemodialysis on dialysis days.</i>
	<i>Sustained low-efficiency dialysis</i>	<i>3 g IV every 12 h on dialysis days</i>
	<i>CAPD</i>	<i>3 g IV every 12 h</i>
	<i>CVVH</i>	<i>3 g IV every 12 h</i>
	<i>CVVHD or CVVHDF</i>	<i>3 g IV every 8 h</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Anakinra - Selected References**

Balakrishnan VS, Jaber BL, Natov SN, et al. Interleukin-2 receptor antagonist synthesis by peripheral blood mononuclear cells in hemodialysis patients. *Kidney Int.* 1998;54:2106–12.

Donati D, Degiannis D, Mazzola E, et al. Interleukin-1 receptors and receptor antagonist in haemodialysis. *Nephrol Dial Transplant.* 1997;12:111–8.

Ghani BA, Zainudin S, Ctkong N, et al. Serum IL-6 and IL-1-ra with sequential organ failure assessment scores in septic patients receiving high-volume haemofiltration and continuous venovenous haemofiltration. *Nephrology.* 2006;11:386–93.

Kineret® injection [package insert]. Thousand Oaks: Amgen Inc; 2010.

Schiff MH, DiVittorio G, Tesser J, et al. The safety of anakinra in high-risk patients with rheumatoid arthritis: six-month observations of patients with comorbid conditions. *Arthritis Rheum.* 2004;50:1752–60.

Schindler R, Lonnemann G, Schäffer K, et al. The effect of ultrafiltered dialysate on the cellular content of interleukin-1 receptor antagonist in patients on chronic hemodialysis. *Nephron.* 1994;68:229–33.

Yang B-B, Baughman S, Sullivan JT. Pharmacokinetics of anakinra in subjects with different levels of renal function. *Clin Pharmacol Ther.* 2003;74:85–94.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Anakinra/Kineret®

{Antirheumatic; human interleukin 1 receptor antagonist}

<b>Usual initial dose:</b>	100 mg subcutaneously
<b>Usual maintenance dose:</b>	100 mg subcutaneously once daily
<b>Typical maximum dose:</b>	100 mg/day
<b>Proportion eliminated unchanged:</b>	Unknown; plasma clearance decreased by 75 % in end-stage renal disease

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;30 mL/min</i>	<i>100 mg subcutaneously once daily</i>
	<i>CrCL ≤30 mL/min</i>	<i>100 mg subcutaneously every 48 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>100 mg subcutaneously once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>100 mg subcutaneously every 48 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>100 mg subcutaneously every 48 h</i>
	<i>Hemodialysis</i>	<i>100 mg subcutaneously every 48 h</i>
	<i>CAPD</i>	<i>100 mg subcutaneously every 48 h</i>
	<i>CRRT</i>	<i>Data not available</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Apomorphine - Selected References**

Apokyn® injection [package insert]. Brisbane: Tercica Inc, a subsidiary of the Ipsen Group; 2010.

Corboy DL, Wagner ML, Sage JI. Apomorphine for motor fluctuations and freezing in Parkinson's disease. *Ann Pharmacother.* 1995;29:282–8.

Eeleu D, Northway MG, Hanssens Y. Clinical pharmacokinetics and pharmacodynamics of drugs used in the treatment of Parkinson's disease. *Clin Pharmacokinet.* 2002;41:261–309.

Gancher St Bennett W, English J. Studies of renal function in animals chronically treated with apomorphine. *Res Commun Chem Pathol Pharmacol.* 1989;66:163–6.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Apomorphine/Apokyn**<sup>®</sup> {Anti-Parkinsonian; acetylcholinesterase inhibitor}

**Usual initial dose:** 2 mg subcutaneously (test dose)

**Usual maintenance dose:** 3–6 mg subcutaneously three times daily

**Typical maximum dose:** 20 mg/day

**Proportion eliminated unchanged:** Unknown

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild to moderate renal impairment</i>	<i>1 mg subcutaneously three times daily (test dose and initial maintenance dose)</i>
	<i>Severe renal impairment</i>	<i>Studies in subjects with severe renal impairment have not been conducted.</i>

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Arsenic Trioxide - Selected References

- Au W-Y, Cheung GT, Yuen TW, Kumana CR, Kwong Y-L. Successful treatment of relapsed acute promyelocytic leukemia in a patient receiving continuous ambulatory peritoneal dialysis with oral arsenic trioxide [letter]. *Arch Intern Med.* 2005;165:1067–8.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Arsenic Trioxide/Trisenox®

{Antineoplastic; fusion protein inhibitor; R for acute promyelocytic leukemia}

<b>Usual initial dose:</b>	0.15 mg/kg IV over 2 h
<b>Usual maintenance dose:</b>	Induction—0.15 mg/kg IV over 2 h daily until bone marrow remission; total induction dose should not exceed 60 doses. Consolidation—Beginning 3–6 weeks after completion of induction therapy, 0.15 mg/kg IV over 2 h daily for 25 doses over a period up to 5 weeks
<b>Typical maximum dose:</b>	0.15 mg/kg/day
<b>Proportion eliminated unchanged:</b>	20 % increasing to 60 % with repeated doses

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal impairment</i>	<i>Exposure of arsenic trioxide may be higher.</i>
	<i>CrCL &lt; 30 mL/min</i>	<i>Monitor closely for toxicity (e.g., QT interval prolongation, seizures, muscle weakness, confusion); a dose reduction may be warranted (toxicity with signs of overdose should be treated with chelation therapy).</i>
<b>Alternative adjustment:</b>	<i>CrCL &gt; 80 mL/min</i>	<i>Induction—0.15 mg/kg IV over 2 h daily until bone marrow remission; total induction dose should not exceed 60 doses. Consolidation—Beginning 3–6 weeks after completion of induction therapy, 0.15 mg/kg IV over 2 h daily for 25 doses over a period up to 5 weeks.</i>
	<i>CrCL 50–80 mL/min</i>	<i>Total arsenic exposure appears to be unchanged as compared to patients without renal impairment, but distribution volume of arsenic is contracted; although too few data are available to suggest exact dosages, consider dose reduction to 0.08 mg/kg IV daily.</i>
	<i>CrCL 30–49 mL/min</i>	<i>As compared to patients without renal impairment, distribution volume of arsenic is contracted, total exposure is increased, and the percentage of arsenic dose excreted in urine is decreased; although too few data are available to suggest exact dosages, consider dose reduction to 0.15 mg/kg IV twice weekly.</i>
	<i>CrCL &lt; 30 mL/min</i>	<i>As compared to patients without renal impairment, distribution volume of arsenic is contracted, total exposure is increased, and the percentage of arsenic dose excreted in urine is substantially decreased; although too few data are available to suggest exact dosages, consider dose reduction to 0.15 mg/kg IV twice weekly.</i>
	<i>Hemodialysis</i>	<i>Very small numbers of patients have been treated with 0.15 mg/kg IV two to three times weekly with monitoring of plasma arsenic levels; hemodialytic clearance of arsenic has been calculated as approximately 5 mL/min.</i>
	<i>CAPD</i>	<i>Presently, data not available for use of IV arsenic trioxide</i>
	<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Aspirin - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Aspirin/Bayer Aspirin®, Ecotrin®** {Anti-inflammatory; analgesic; platelet aggregation inhibitor}

**Usual initial dose:** 325–650 mg orally or rectally

**Usual maintenance dose:** 81–325 mg orally once daily (antiplatelet) or 300–650 mg orally or rectally every 4 h as necessary (analgesic/antipyretic)

**Typical maximum dose:** 4,000 mg/day

**Proportion eliminated unchanged:** 2–80 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥50 mL/min</i>	<i>81–325 mg orally once daily (antiplatelet) or 300–650 mg orally or rectally every 4 h as necessary (analgesic/antipyretic)</i>
	<i>Kidney problems</i>	<i>Ask a doctor before use.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>81–325 mg orally once daily (antiplatelet) or 650 mg orally or rectally every 4 h as necessary (analgesic/antipyretic)</i>
	<i>GFR 10–50 mL/min</i>	<i>81–162 mg orally once daily (antiplatelet) or 650 mg orally or rectally every 6 h as necessary (analgesic/antipyretic)</i>
	<i>GFR &lt;10 mL/min</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses (e.g., 81 mg/day) and monitor carefully.</i>
	<i>Hemodialysis</i>	<i>81–162 mg orally or rectally after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>Minimal data available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses (e.g., 81 mg/day) and monitor carefully.</i>
	<i>CRRT</i>	<i>81–162 mg orally once daily (antiplatelet) or 650 mg enterally or rectally every 6 h as necessary (analgesic/antipyretic)</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Atazanavir - Selected References**

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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Atazanavir/Reyataz®**

**{Antiretroviral; protease inhibitor}**

<b>Usual initial dose:</b>	300 mg orally with ritonavir 100 mg or 400 mg orally (without ritonavir) with food once daily
<b>Usual maintenance dose:</b>	300 mg orally with ritonavir 100 mg or 400 mg orally (without ritonavir) with food once daily
<b>Typical maximum dose:</b>	400 mg/day
<b>Proportion eliminated unchanged:</b>	7 %

***Adjustment for Kidney Disease***

<b>FDA-approved product labeling:</b>	<i>Renal impairment, including patients with severe renal impairment not managed with hemodialysis</i>	<i>400 mg orally every 24 h (no dose adjustment necessary)</i>
	<i>Treatment-naïve patients with ESRD managed with hemodialysis</i>	<i>300 mg orally once daily with ritonavir 100 mg orally once daily</i>
	<i>HIV-treatment-experienced patients with ESRD managed with hemodialysis</i>	<i>Do not administer; avoid.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>400 mg orally every 24 h</i>
	<i>GFR 10–50 mL/min</i>	<i>Data not available</i>
	<i>GFR &lt;10 mL/min</i>	<i>Data not available</i>
	<i>Hemodialysis</i>	<i>400 mg orally every 24 h (no dose adjustment necessary—only very limited data available)</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Atenolol - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Atenolol/Tenormin®** {Antihypertensive; antianginal;  $\beta$ -adrenergic receptor blocker}

**Usual initial dose:** 25–50 mg orally or 5 mg IV followed by 5 mg IV 10 min later  
**Usual maintenance dose:** 50–100 mg orally once daily  
**Typical maximum dose:** 2 mg/kg/day up to 100 mg daily  
**Proportion eliminated unchanged:** 95 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Atenolol dosage adjustment in renal impairment*

<i>CrCL (mL/min)</i>	<i>Atenolol elimination half-life (h)</i>	<i>Maximum dosage</i>
<i>15–35</i>	<i>16–27</i>	<i>50 mg orally daily</i>
<i>&lt;15</i>	<i>&gt;27</i>	<i>25 mg orally daily</i>

*Hemodialysis: 25–50 mg orally after each dialysis*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>50–100 mg orally daily</i>
<i>GFR 10–50 mL/min</i>	<i>25–50 mg orally every 24 h (~75 % of usual dose)</i>
<i>GFR &lt;10 mL/min</i>	<i>25 mg orally every 24 h (~50 % of usual dose)</i>
<i>Hemodialysis</i>	<i>25–50 mg orally every 24 h; dose after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>25 mg orally every 24 h (~50 % of usual dose)</i>
<i>CRRT</i>	<i>25–50 mg orally every 24 h; titrate.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Atovaquone and Proguanil - Selected References

Gillotin C, Mamet JP, Veronese L. Lack of a pharmacokinetic interaction between atovaquone and proguanil. *Eur J Clin Pharmacol.* 1999;55:311–5.

Hussein Z, Eaves CJ, Hutchinson DB, Canfield CJ. Population pharmacokinetics of proguanil in patients with acute *P. falciparum* malaria after combined therapy with atovaquone. *Br J Clin Pharmacol.* 1996;42:589–97.

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Thapar MM, Ashton M, Lindegårdh N, et al. Time-dependent pharmacokinetics and drug metabolism of atovaquone plus proguanil (Malarone) when taken as chemoprophylaxis. *Eur J Clin Pharmacol.* 2002;58:19–27.



## Dosage Adjustment of Medications Eliminated by the Kidneys

**Atovaquone and Proguanil/Malarone®** {Antimalarial; ubiquinone-mediated mitochondrial electron transport and dihydrofolate reductase inhibitor}

**Usual initial dose:** Malaria treatment—1,000 mg/400 mg (four tablets) orally once daily for three consecutive days

Malaria prevention—250 mg/100 mg (one tablet) orally once daily beginning 1–2 days prior to entering malaria-endemic area

**Usual maintenance dose:** Malaria prevention—250 mg/100 mg (one tablet) daily, continuing for 7 days after leaving malaria-endemic area

**Typical maximum dose:** 1,000 mg/400 mg (four tablets)

**Proportion eliminated unchanged:** 40–60 % (proguanil)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL ≥30 mL/min* Malaria treatment—1,000 mg/400 mg (four tablets) orally once daily for three consecutive days

*Malaria prevention—250 mg/100 mg (one tablet) orally once daily*

*CrCL <30 mL/min* Malaria treatment—Use with caution only if the benefits of the 3-day regimen outweigh the potential risks associated with increased drug exposure.

*Malaria prophylaxis—contraindicated*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Auranofin - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Auranofin/Ridaura®** {Antirheumatic; gold macrophage phagocytosis and lysosomal enzyme inhibitor}

**Usual initial dose:** 3 mg orally  
**Usual maintenance dose:** 3 mg orally twice daily or 6 mg orally once daily  
**Typical maximum dose:** 9 mg/day  
**Proportion eliminated unchanged:** 60 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *The potential benefits of using (auranofin) in patients with progressive renal disease should be weighed against (1) the potential risks of gold toxicity on organ systems previously compromised or with decreased reserve and (2) the difficulty in quickly detecting and correctly attributing the toxic effect.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>3 mg orally every 24 h (50 % decrease)</i>
<i>GFR 10–50 mL/min</i>	<i>Preferably avoid due to risk for acute kidney injury and proteinuria and/or hematological toxicity.</i>
<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk for acute kidney injury and proteinuria and/or hematological toxicity.</i>
<i>Hemodialysis</i>	<i>Preferably avoid due to risk for acute kidney injury and proteinuria and/or hematological toxicity.</i>
<i>CAPD</i>	<i>Preferably avoid due to risk for acute kidney injury and proteinuria and/or hematological toxicity.</i>
<i>CRRT</i>	<i>Preferably avoid due to risk for acute kidney injury and proteinuria and/or hematological toxicity.</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Azacitidine - Selected References**

- Buckstein R, Yee K, Wells RA. 5-Azacitidine in myelodysplastic syndromes: a clinical practice guideline. *Cancer Treat Rev.* 2011;37:160–7.
- Campelo MD, Delgado RG, Moliias ACG, Sanchez JF. Azacitidine for the treatment of myelodysplastic syndromes in the elderly. *Adv Ther.* 2011;28(Suppl 2):10–5.
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- Vidaza<sup>®</sup> injection [package insert]. Summit: Celgene Corp; 2008.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Azacitidine/Vidaza®

{Antineoplastic; DNA demethylation agent, R for myelodysplastic syndromes}

<b>Usual initial dose:</b>	75 mg/m <sup>2</sup> IV or subcutaneously
<b>Usual maintenance dose:</b>	75 mg/m <sup>2</sup> subcutaneously daily for seven consecutive days every 4 weeks for a minimum of four cycles
<b>Typical maximum dose:</b>	100 mg/m <sup>2</sup> /day (if no beneficial effect is seen after two lower-dose treatment cycles and if no toxicity other than nausea and vomiting has occurred)
<b>Proportion eliminated unchanged:</b>	85 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Impaired renal function</i>	<i>Imparts greater risk of toxic reactions; if unexplained elevations of SCr or BUN occur, the next cycle should be delayed until values return to normal or baseline and the dose should be reduced to 50 % on the next treatment course.</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Azathioprine - Selected References**

Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.

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Imuran® tablet [package insert]. San Diego: Prometheus Laboratories Inc; 2009.

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Olyaei AJ, DeMattos AM, Bennett WM. Use of drugs in patients with renal failure. In: Schrier RW, editor. *Diseases of the kidney and urinary tract*. 8th ed. Philadelphia: Lippincott Williams & Wilkins; 2007. p. 2765–807.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Azathioprine/Imuran®** {Immunosuppressive; antirheumatic; T cell effect suppressor}

**Usual initial dose:** 3–5 mg/kg orally or IV daily  
**Usual maintenance dose:** 1–3 mg/kg orally or IV once daily  
**Typical maximum dose:** 5 mg/kg/day  
**Proportion eliminated unchanged:** <2 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Relatively oliguric patients, especially those with tubular necrosis in the immediate postcadaveric transplant period, may have delayed clearance of azathioprine or its metabolites, may be particularly sensitive to this drug, and are usually given lower doses.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>1.5–2.5 mg/kg orally or IV every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>1.125–1.875 mg/kg orally or IV every 24 h (~25 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>0.75–1.25 mg/kg orally or IV every 24 h (~50 % decrease)</i>
<i>Hemodialysis</i>	<i>0.75–1.25 mg/kg orally or IV every 24 h (~50 % decrease); supplement 0.25 mg/kg after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>1.125–1.875 mg/kg orally or IV every 24 h (~25 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Aztreonam - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Azactam® injection [package insert]. South San Francisco: Elan Pharmaceuticals Inc; 2009.
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- Swabb EA, Sugerman AA, McKinstry DN. Multiple-dose pharmacokinetics of the monobactam, aztreonam (SQ 26,776) in healthy subjects. *Chemotherapy.* 1983;29:313–21.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Aztreonam/Azactam®

{Antibacterial; monobactam}

<b>Usual initial dose:</b>	1–2 g IV
<b>Usual maintenance dose:</b>	1–2 g IV every 6–12 h
<b>Typical maximum dose:</b>	8 g/day
<b>Proportion eliminated unchanged:</b>	75 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 10–30 mL/min</i>	<i>500–1,000 mg IV every 6–12 h</i>
	<i>CrCL &lt;10 mL/min</i>	<i>250–500 mg IV every 6–12 h</i>
	<i>Hemodialysis</i>	<i>250–500 mg IV every 6–12 h plus 125–250 mg after dialysis</i>
	<i>CAPD</i>	<i>250–500 mg IV every 6–12 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500–2,000 mg IV every 8–12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>500–1,000 mg IV every 8–12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>500 mg IV every 8 h</i>
	<i>Hemodialysis</i>	<i>1,000 mg IV every 12 h</i>
	<i>CAPD</i>	<i>500 mg IV every 8 h or add to dialysate qs 1,000 mg/L × 1 then 250 mg/L</i>
	<i>CVVH</i>	<i>1,000–2,000 mg IV every 12 h</i>
	<i>CVVHD or CVVHDF</i>	<i>2,000 mg IV every 12 h</i>

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Bacitracin - Selected References

BACiiM® injection [package insert]. Northport: X-Gen Pharmaceuticals Inc; 2003.

Battistella M, Bholra C, Lok CE. Long-term follow-up of the Hemodialysis Infection Prevention with Polysporin Ointment (HIPPO) study: a quality improvement report. *Am J Kidney Dis.* 2011;57:432–41.

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Prince MEP, Lemkert RJ. Analysis of intranasal distribution of ointment. *J Otolaryngol.* 1997;26:657–60.

Smith LW, Schultz FH Jr, Ott WL, Payne HG. A comparative study of the renal damage produced in mice by various lots of bacitracin. *J Clin Invest.* 1949;28:1018–21.

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Zintel HA, Ma RA, Ellis H. The absorption, distribution, excretion and toxicity of bacitracin in man. *Am J Med Sci.* 1949;218:439–45.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Bacitracin/BACiiM™** {Antibacterial; polypeptide complex derived from *Bacillus subtilis*}

**Usual initial dose** 50,000 units IM  
**Usual maintenance dose** 50,000 units IM every 6 h  
**Typical maximum dose** 200,000 units/day  
**Proportion eliminated unchanged** 87 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *To reduce the development of drug-resistant bacteria and maintain the effectiveness of bacitracin and other antibacterial drugs, bacitracin should be used only to treat or prevent infections that are proven or strongly suspected to be caused by bacteria.*

*Warning—nephrotoxicity: Bacitracin in parenteral (intramuscular) therapy may cause renal failure due to tubular and glomerular necrosis. Its use should be restricted to infants with staphylococcal pneumonia and empyema when due to organisms shown to be susceptible to bacitracin. It should be used only where adequate laboratory facilities are available and when constant supervision of the patient is possible.*

*Renal function should be carefully determined prior to and daily during therapy. The recommended daily dose should not be exceeded and fluid intake and urinary output maintained at proper levels to avoid kidney toxicity. If renal toxicity occurs, the drug should be discontinued. The concurrent use of other nephrotoxic drugs, particularly streptomycin, kanamycin, polymyxin B, polymyxin E (colistin), neomycin, and viomycin, should be avoided.*

**Alternative adjustment:** *eGFR < 60 mL/min Avoid peritoneal lavage and IM/IV administration due to risk of drug accumulation and nephrotoxicity.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Benazepril - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Macdonald N-J, Sioufi A, Howie CA, Wade JR, Elliott HL. The effects of age on the pharmacokinetics of single oral doses of benazepril and enalapril. *Br J Clin Pharmacol*. 1993;36:205–9.
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- McIntyre CW, Owen PJ. Prescribing drugs in kidney disease. In: Brenner BM, editor. *Brenner & Rector’s the kidney*. 8th ed. Philadelphia: Saunders/Elsevier; 2008. p. 1930–55.
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- Olyaei AJ, Bennett WM. Pharmacologic approach to renal insufficiency. In: Dale DC, Federman DD, Antman K, editors. *ACP medicine, WebMD June 2007 update*. Hamilton: BC Decker; 2007. NEPHROLOGY IX: Appendix A1–25.
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- Reams GP, Lau A, Bauer JH. Effect of benazepril monotherapy in subjects with hypertension associated with renal dysfunction. *J Clin Pharmacol*. 1989;29:609–14.
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- Waldmeier F, Kaiser G, Ackermann R, et al. The disposition of [<sup>14</sup>C]-labelled benazepril HCl in normal adult volunteers after single and repeated oral doses. *Xenobiotica*. 1991;21:251–61.
- Yamamoto S, Takemori E, Hasegawa Y, et al. General pharmacology of the novel angiotensin converting enzyme inhibitor benazepril hydrochloride. *Arzneimittelforschung*. 1991;41:913–23.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Benazepril/Lotensin®** {Antihypertensive; vasodilator; angiotensin-converting enzyme (ACE)/renin inhibitor}

**Usual initial dose** 10 mg orally daily  
**Usual maintenance dose** 20–40 mg/day orally as either a single dose or two equally divided doses  
**Typical maximum dose** 40 mg/day  
**Proportion eliminated unchanged** 18 % (as active benazeprilat)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt; 30 mL/min</i>	<i>Initial dose is 5 mg once daily, increasing as necessary to maximum 40 mg/day</i>
<b>Alternative adjustment:</b>	<i>GFR &gt; 50 mL/min</i>	<i>20–40 mg orally daily (100 % of usual dose)</i>
	<i>GFR 10–50 mL/min</i>	<i>15–30 mg orally daily (75 % of usual dose)</i>
	<i>GFR &lt; 10 mL/min</i>	<i>5–20 mg orally daily (25–50 % of usual dose)</i>
	<i>Hemodialysis</i>	<i>5–20 mg orally daily (25–50 % of usual dose)</i>
	<i>CAPD</i>	<i>5–20 mg orally daily (25–50 % of usual dose)</i>
	<i>CRRT</i>	<i>15–30 mg orally daily (75 % of usual dose)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Bendamustine - Selected References

Chovan JP, Li F, Yu E, Ring SC. Metabolic profile of [<sup>14</sup>C]bendamustine in rat urine and bile: preliminary structural identification of metabolites. *Drug Metab Dispos.* 2007;35:1744–53.

Garnock-Jones KP. Bendamustine: a review of its use in the management of indolent non-Hodgkin's lymphoma and mantle cell lymphoma. *Drugs.* 2010;70:1703–18.

Knauf WU, Lissichkov T, Aldaoud A, et al. Phase III randomized study of bendamustine compared with chlorambucil in previously untreated patients with chronic lymphocytic leukemia. *J Clin Oncol.* 2009;27:4378–84.

Ogura M, Uchida T, Taniwaki M, et al. Phase I and pharmacokinetic study of bendamustine hydrochloride in relapsed or refractory indolent B-cell non-Hodgkin lymphoma and mantle cell lymphoma. *Cancer Sci.* 2010;101:2054–8.

Treanda® injection [package insert]. Frazer: Cephalon Inc; 2010.

von Minckwitz G, Chernozevsky I, Sirakova L, et al. Bendamustine prolongs progression-free survival in metastatic breast cancer (MBC): a phase III prospective, randomized, multicenter trial of bendamustine hydrochloride, methotrexate and 5-fluorouracil (BMF) versus cyclophosphamide, methotrexate and 5-fluorouracil (CMF) as first-line treatment of MBC. *Anticancer Drugs.* 2005;16:871–7.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Bendamustine/Treanda**<sup>®</sup> {Antineoplastic; alkylating agent, mechlorethamine derivative}

**Usual initial dose** 100 mg/m<sup>2</sup> IV

**Usual maintenance dose** 100 mg/m<sup>2</sup> administered IV over 30 min on days 1 and 2 of a 28-day cycle, up to 6 cycles

**Typical maximum dose** 100 mg/m<sup>2</sup>

**Proportion eliminated unchanged** ~10 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL > 40 mL/min* 100 mg/m<sup>2</sup> administered IV over 30 min on days 1 and 2 of a 28-day cycle, up to 6 cycles

*CrCL ≤ 40 mL/min* Avoid; safety not established

**Alternative adjustment:** *Data not available*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Bismuth Subsalicylate - Selected References

- Akpolat I, Kahrman H, Arik N, Akpolat T, Kandemir B, Cengiz K. Acute renal failure due to overdose of colloidal bismuth [letter]. *Nephrol Dial Transplant*. 1996;11:1890–1.
- Burr RE, Gotto AMK, Beaver DL. Isolation and analysis of renal bismuth inclusions. *Toxicol Appl Pharmacol*. 1965;7:588–91.
- Cengiz N, Uslu Y, Gök F, Anarat A. Acute renal failure after overdose of colloidal bismuth subcitrate. *Pediatr Nephrol*. 2005;20:1355–8.
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- Hruz P, Mayr M, Löw R, Drewe J, Huber G. Fanconi's syndrome, acute renal failure, and tonsil ulcerations after colloidal bismuth subcitrate intoxication. *Am J Kidney Dis*. 2002;39:e18. doi:10.1053/ajkd.2002.31429.
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- Peptic Relief Liquid [package insert]. Duluth: Rugby Laboratories Inc; 2007.
- Playford RJ, Matthews CH, Campbell MJ, et al. Bismuth induced encephalopathy caused by tri potassium dicitrate bismuthate in a patient with chronic renal failure. *Gut*. 1990;31:359–60.
- Slikkerveer A, de Wolff FA. Pharmacokinetics and toxicity of bismuth compounds. *Med Toxicol Adverse Drug Exp*. 1989;4:303–23.
- Taylor EG, Klenerman P. Acute renal failure after colloidal bismuth subcitrate overdose [letter]. *Lancet*. 1990;335:670–1.
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- Weil J, Bell GD, Powell K. Disposition of bismuth and renal function [letter]. *Aliment Pharmacol Ther*. 1992;6:395–7.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Bismuth Subsalicylate/Pepto-Bismol®** {Antidiarrheal; antiflatulent}

<b>Usual initial dose</b>	30 mL (524 mg) orally every 30–60 min PRN upset stomach, indigestion, simple diarrhea, and nausea
<b>Usual maintenance dose</b>	N/A
<b>Typical maximum dose</b>	240 mL/day
<b>Proportion eliminated unchanged</b>	Unknown

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Data not available</i>	
<b>Alternative adjustment:</b>	<i>GFR &lt; 50 mL/min</i>	<i>Preferably avoid due to risk for bismuth and/or salicylic acid accumulation and heavy metal or salicylate toxicity.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risk for bismuth and/or salicylic acid accumulation and heavy metal or salicylate toxicity.</i>
	<i>CAPD</i>	<i>Preferably avoid due to risk for bismuth and/or salicylic acid accumulation and heavy metal or salicylate toxicity.</i>
	<i>CRRT</i>	<i>Preferably avoid due to risk for bismuth and/or salicylic acid accumulation and heavy metal or salicylate toxicity.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Bisoprolol - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Benetos A, Adamopoulos C, Argyriadis P, Bean K, Consoli S, Safar M. Clinical results with bisoprolol 2.5 mg/hydrochlorothiazide 6.25 mg combination in systolic hypertension in the elderly. *J Hypertens*. 2002;20(Suppl 1):S21–5.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Bisoprolol/Zebeta®** {Antihypertensive; antianginal;  $\beta$ -adrenergic receptor blocker}

**Usual initial dose** 5 mg orally once daily  
**Usual maintenance dose** 10–20 mg orally once daily  
**Typical maximum dose** 20 mg/day  
**Proportion eliminated unchanged** 50 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt; 40 mL/min</i>	<i>The initial daily dose should be 2.5 mg orally and caution should be used in dose titration</i>
<b>Alternative adjustment:</b>	<i>GFR &gt; 50 mL/min</i>	<i>5 mg orally every 24 h</i>
	<i>GFR 10–50 mL/min</i>	<i>2.5–5 mg orally every 24 h (~25 % decrease)</i>
	<i>GFR &lt; 10 mL/min</i>	<i>2.5 mg orally every 24 h (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>2.5 mg orally every 24 h (50 % decrease), dose after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>2.5 mg orally every 24 h (50 % decrease)</i>
	<i>CRRT</i>	<i>2.5 mg orally every 24 h (50 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Bivalirudin - Selected References

- Angiomax® injection [package insert]. Parsippany: The Medicines Co; 2010.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Bivalirudin/Angiomax®**

{Antithrombotic; direct thrombin inhibitor}

<b>Usual initial dose</b>	0.75 mg/kg IV
<b>Usual maintenance dose</b>	Continuous IV infusion of 1.75 mg/kg/h for the duration of the percutaneous coronary intervention procedure
<b>Typical maximum dose</b>	As required to attain aPTT 1.5–2.5 times baseline or control value
<b>Proportion eliminated unchanged</b>	20 %

### *Adjustment for Kidney Disease*

#### **FDA-approved product labeling:**

*For anticoagulation in patients undergoing percutaneous coronary intervention*

<i>CrCL ≥ 60 mL/min</i>	<i>0.75 mg/kg IV followed by infusion of 1.75 mg/kg/h</i>
<i>CrCL 30–59 mL/min</i>	<i>0.75 mg/kg IV followed by infusion of 1.75 mg/kg/h</i>
<i>CrCL &lt; 30 mL/min</i>	<i>0.75 mg/kg IV followed by infusion of 1.00 mg/kg/h</i>
<i>Hemodialysis</i>	<i>0.75 mg/kg IV followed by infusion of 0.25 mg/kg/h</i>

#### **Alternative adjustment:**

*For anticoagulation in patients with venous thromboembolism*

<i>eCrCL ≥ 60 mL/min</i>	<i>Continuous IV infusion of 0.15 mg/kg/h (no initial bolus)</i>
<i>eCrCL 44–60 mL/min</i>	<i>Continuous IV infusion of 0.075 mg/kg/h (no initial bolus)</i>
<i>eCrCL 30–43 mL/min</i>	<i>Continuous IV infusion of 0.05 mg/kg/h (no initial bolus)</i>
<i>eCrCL &lt; 30 mL/min</i>	<i>Continuous IV infusion of 0.025 mg/kg/h (no initial bolus)</i>
<i>CRRT</i>	<i>Continuous IV (prefilter) infusion of 0.02 mg/kg/h (no initial bolus)</i>

*Note: dosage usually should be based on total body weight in normal body weight and obese patients*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Bleomycin - Selected References

Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.

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McIntyre CW, Owen PJ. Prescribing drugs in kidney disease. In: Brenner BM, editor. *Brenner & Rector's the kidney*. 8th ed. Philadelphia: Saunders/Elsevier; 2008. p. 1930–55.

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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Bleomycin/Blenoxane®** {Antineoplastic; DNA, RNA, and protein synthesis inhibitor}

**Usual initial dose** 0.25–0.50 units/kg (10–20 units/m<sup>2</sup>) given IV, IM, or subcutaneously weekly or twice weekly; because of the possibility of an anaphylactoid reaction, lymphoma patients should be given 2 units or less for the first two doses.

**Usual maintenance dose** 0.25–0.50 units/kg (10–20 units/m<sup>2</sup>) given IV, IM, or subcutaneously weekly or twice weekly. After a 50 % response, a maintenance dose of 1 unit daily or 5 units weekly intravenously or intramuscularly should be given.

**Typical maximum dose** 400 units (total dose)

**Proportion eliminated unchanged** 65 %

*Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Bleomycin clearance may be reduced in patients with impaired renal function. Bleomycin should be used with extreme caution in patients with significant renal impairment.*

**Alternative adjustment:**

<i>GFR &gt; 50 mL/min</i>	<i>10–20 units/m<sup>2</sup> IV, IM, or subcutaneously weekly or twice weekly</i>
<i>GFR 10–50 mL/min</i>	<i>7.5–15 units/m<sup>2</sup> IV, IM, or subcutaneously weekly or twice weekly (25 % decrease)</i>
<i>GFR &lt; 10 mL/min</i>	<i>5–10 units/m<sup>2</sup> IV, IM, or subcutaneously weekly or twice weekly (50 % decrease)</i>
<i>Hemodialysis</i>	<i>Minimal data available, effective dose unclear</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>7.5–15 units/m<sup>2</sup> IV, IM, or subcutaneously weekly or twice weekly (25 % decrease)</i>



## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Buspirone - Selected References**

Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.

BuSpar® tablet [package insert]. Princeton: Bristol-Myers Squibb Co; 2010.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Buspirone/BuSpar**<sup>®</sup> {Anxiolytic; serotonin 5-HT<sub>1A</sub> and D<sub>2</sub> dopamine receptor modifier}

**Usual initial dose** 7.5 mg orally twice daily  
**Usual maintenance dose** 10–15 mg orally twice daily  
**Typical maximum dose** 60 mg/day  
**Proportion eliminated unchanged** Minimal

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Severe renal impairment* *Not recommended; after multiple-dose administration of buspirone to renally impaired (CrCL = 10–70 mL/min/1.73 m<sup>2</sup>) patients, steady state AUC of buspirone increased 4-fold compared with healthy (CrCL ≥ 80 mL/min/1.73 m<sup>2</sup>) subjects.*

**Alternative adjustment:**

<i>GFR &gt; 50 mL/min</i>	<i>10–15 mg orally twice daily</i>
<i>GFR 10–50 mL/min</i>	<i>5–10 mg orally twice daily (~25 % decrease)</i>
<i>GFR &lt; 10 mL/min</i>	<i>2.5–7.5 mg orally twice daily (~50 % decrease)</i>
<i>Hemodialysis</i>	<i>2.5–7.5 mg orally twice daily</i>
<i>CAPD</i>	<i>2.5–7.5 mg orally twice daily</i>
<i>CRRT</i>	<i>5–10 mg enterally twice daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Butorphanol - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Butorphanol/Stadol®**

{Analgesic; opioid  $\mu$ -receptor partial agonist}

<b>Usual initial dose</b>	1 mg IV or IM or 1 mg (1 spray in 1 nostril) intranasally
<b>Usual maintenance dose</b>	1–2 mg IV or IM every 4 h as necessary or 1–2 mg (1 spray in 1 or 2 nostrils) intranasally every 4 h PRN
<b>Typical maximum dose</b>	4 mg/dose
<b>Proportion eliminated unchanged</b>	4 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt; 30 mL/min</i>	<i>0.5–1 mg IV or IM every 6 h as necessary (50 % decrease) or 1 mg (1 spray in 1 nostril) followed, if needed, by 1 mg (1 spray in 1 nostril) in 90–120 min; repeat doses should be determined by response but given at intervals of no less than 6 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt; 50 mL/min</i>	<i>0.5–1 mg IV or IM every 6 h PRN</i>
	<i>GFR 10–50 mL/min</i>	<i>0.375–0.75 mg IV or IM every 6 h PRN (25 % decrease)</i>
	<i>GFR &lt; 10 mL/min</i>	<i>0.25–0.5 mg IV or IM every 6 h PRN (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>0.375–0.75 mg IV or IM every 6 h PRN (25 % decrease)</i>

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Capecitabine - Selected References

- Beigner B, Verweij J, Dirix L, et al. Effect of food on the pharmacokinetics of capecitabine and its metabolites following oral administration in cancer patients. *Clin Cancer Res.* 1998;4:941–8.
- Cassidy J, Twelves C, Cameron D, et al. Bioequivalence of two tablet formulations of capecitabine and exploration of age, gender, body surface area, and creatinine clearance as factors influencing system exposure in cancer patients. *Cancer Chemother Pharmacol.* 1999;44:453–60.
- Desmoulin F, Gilard V, Malet-Martino M, Martino R. Metabolism of capecitabine, an oral fluorouracil prodrug: 19F NMR studies in animal models and human urine. *Drug Metab Dispos.* 2002;30:1221–9.
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- Twelves C, Glynn-Jones R, Cassidy J, et al. Effect of hepatic dysfunction due to liver metastases on the pharmacokinetics of capecitabine and its metabolites. *Clin Cancer Res.* 1999;5:1696–702.
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- Villalona-Calero MA, Weiss GR, Burris HA, et al. Phase I and pharmacokinetic study of the oral fluoropyrimidine capecitabine in combination with paclitaxel in patients with advanced solid malignancies. *J Clin Oncol.* 1999;17:1915–25.
- Xeloda® tablet [package insert]. South San Francisco: Genentech USA Inc; 2011.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Capecitabine/Xeloda®** {Antineoplastic; antimetabolite, 5-fluorouracil prodrug}

**Usual initial dose:** 1,250 mg/m<sup>2</sup> orally twice daily  
**Usual maintenance dose:** 1,250 mg/m<sup>2</sup> orally twice daily for 2 weeks in 3-week cycles  
**Typical maximum dose:** 2,500 mg/m<sup>2</sup>/day  
**Proportion eliminated unchanged:** 86 % (as parent drug and active metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

<i>CrCL &gt;50 mL/min</i>	<i>1,250 mg/m<sup>2</sup> orally twice daily for 2 weeks in 3-week cycles</i>
<i>CrCL 30–50 mL/min</i>	<i>950 mg/m<sup>2</sup> orally twice daily</i>
<i>CrCL &lt;30 mL/min</i>	<i>Contraindicated</i>

**Alternative adjustment:** *Data not available*

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Capreomycin - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Capreomycin/Capastat®** {Antitubercular; polypeptide antibiotic}

<b>Usual initial dose:</b>	1,000 mg IV or IM
<b>Usual maintenance dose:</b>	1,000 mg IV or IM once daily (not to exceed 20 mg/kg/day) for 60–120 days followed by 1,000 mg IV or IM 2–3 times/week
<b>Typical maximum dose:</b>	20 mg/kg/day
<b>Proportion eliminated unchanged:</b>	50 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Estimated dosages to attain mean steady-state serum capreomycin concentration of 10 mcg/mL (based on CrCL)*

<i>CrCL (mL/min)</i>	<i>Capreomycin clearance</i>		<i>Dose (mg/kg) for the following dosing intervals</i>		
	<i>(L/g/h × 10<sup>-2</sup>)</i>	<i>Half-life (h)</i>	<i>24 h</i>	<i>48 h</i>	<i>72 h</i>
0	0.54	55.5	1.29	2.58	3.87
10	1.01	29.4	2.43	4.87	7.3
20	1.49	20	3.58	7.16	10.7
30	1.97	15.1	4.72	9.45	14.2
40	2.45	12.2	5.87	11.7	–
50	2.92	10.2	7.01	14	–
60	3.4	8.8	8.16	–	–
80	4.35	6.8	10.4	–	–
100	5.31	5.6	12.7	–	–
110	5.78	5.2	13.9	–	–

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1 g IV every 24 h</i>
	<i>GFR 10–50 mL/min</i>	<i>1 g IV every 24–48 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>1 g IV every 48 h</i>
	<i>Hemodialysis</i>	<i>1 g IV after hemodialysis on dialysis days only</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>5 mg/kg IV every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Captopril - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Captopril/Capoten®** {Antihypertensive, vasodilator, angiotensin-converting enzyme (ACE)/  
renin inhibitor}

**Usual initial dose:** 6.25–12.5 mg orally three times daily

**Usual maintenance dose:** 25–50 mg orally three times daily

**Typical maximum dose:** 450 mg/day

**Proportion eliminated unchanged:** 30 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *For patients with significant renal impairment, initial daily dosage of captopril should be reduced, and smaller increments utilized for titration.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>25–50 mg orally every 8–12 h</i>
<i>GFR 10–50 mL/min</i>	<i>18.75–37.5 mg orally every 12 h (~25 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>12.5–25 mg orally every 24 h (~50 % decrease)</i>
<i>Hemodialysis</i>	<i>12.5–25 mg orally every 24 h (~50 % decrease); dose after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>18.75–37.5 mg orally (~25 % decrease) every 12–18 h</i>
<i>CRRT</i>	<i>18.75–37.5 mg enterally every 12 h (~25 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Carboplatin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

<b>Carboplatin/Paraplatin®</b>	{Antineoplastic; platinum coordination complex; DNA cross-link disruptor}
<b>Usual initial dose:</b>	300–360 mg/m <sup>2</sup> IV
<b>Usual maintenance dose:</b>	300–360 mg/m <sup>2</sup> IV every 4 weeks, or Total dose (mg) = (target AUC [usually 4–6 mg/mL • min]) × (GFR [mL/min] + 25)
<b>Typical maximum dose:</b>	360 mg/m <sup>2</sup>
<b>Proportion eliminated unchanged:</b>	50–75 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Carboplatin dosage modifications in adults with renal function impairment*

<i>Creatinine clearance (mL/min)</i>	<i>Carboplatin dose</i>
<i>41–59</i>	<i>250 mg/m<sup>2</sup> IV</i>
<i>16–40</i>	<i>200 mg/m<sup>2</sup> IV</i>
<i>≤15</i>	<i>Not recommended</i>
<b>Alternative adjustment:</b> <i>GFR &gt;50 mL/min</i>	<i>300 mg/m<sup>2</sup> IV</i>
<i>GFR 10–50 mL/min</i>	<i>150 mg/m<sup>2</sup> IV (50 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>75 mg/m<sup>2</sup> IV (75 % decrease)</i>
<i>Hemodialysis</i>	<i>150 mg/m<sup>2</sup> IV (50 % decrease)</i>
<i>CAPD</i>	<i>75 mg/m<sup>2</sup> IV (75 % decrease)</i>
<i>CRRT</i>	<i>200 mg/m<sup>2</sup> IV</i>

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Carmustine - Selected References**

Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.

BiCNU® injection [package insert]. Princeton: Bristol-Myers Squibb Co; 2010.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Carmustine/BiCNU**<sup>®</sup> {Antineoplastic; nitrosourea alkylating agent}

**Usual initial dose:** 150 mg/m<sup>2</sup> IV  
**Usual maintenance dose:** 150–200 mg/m<sup>2</sup> IV every 6 weeks  
**Typical maximum dose:** 200 mg/m<sup>2</sup> (up to 1,200 mg/m<sup>2</sup> IV in autologous stem cell transplantation)  
**Proportion eliminated unchanged:** 65 % (as active metabolites and unchanged drug)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Risk of toxic reactions may be greater in patients with impaired renal function.*

<b>Alternative adjustment:</b>	<i>GFR 45–60 mL/min</i>	<i>110–150 mg/m<sup>2</sup> IV every 2 weeks (25 % reduction)</i>
	<i>GFR 10–45 mL/min</i>	<i>Preferably avoid due to increased risk for drug accumulation and resultant toxicity</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to increased risk for drug accumulation and resultant toxicity</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to increased risk for drug accumulation and resultant toxicity</i>
	<i>CAPD</i>	<i>Preferably avoid due to increased risk for drug accumulation and resultant toxicity</i>
	<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefadroxil - Selected References

- Amsden GW. Tables of antimicrobial agent pharmacology. In: Mandell GL, Bennett JE, Dolin R, editors. *Mandell, Douglas, and Bennett's principles and practice of infectious diseases*, vol 1. 6th ed. Philadelphia: Elsevier; 2005. p. 634–700.
- Aronoff GA, Bennett WM, Berns JS, et al. *Drug prescribing in renal failure: dosing guidelines for adults and children*. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Cefadroxil/Duricef®**

{Antibacterial; first-generation cephalosporin}

<b>Usual initial dose:</b>	1 g orally
<b>Usual maintenance dose:</b>	1–2 g/day orally in single or divided doses (twice daily) for 10 days
<b>Typical maximum dose:</b>	2 g/day in single or divided (twice daily) doses
<b>Proportion eliminated unchanged:</b>	85 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *In patients with renal impairment, initial dose is 1 g of cefadroxil orally, and the maintenance dose (based on the creatinine clearance rate [mL/min]) is 500 mg orally at the time intervals listed below*

<i>CrCL (mL/min)</i>	<i>Dosage interval (h)</i>
<i>0–10</i>	<i>36</i>
<i>10–25</i>	<i>24</i>
<i>25–50</i>	<i>12</i>
<i>&gt;50</i>	<i>12</i>

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1,000 mg orally every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>500–1,000 mg orally every 12–24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>1,000 mg orally every 48 h</i>
	<i>Hemodialysis</i>	<i>1,000 mg orally every 72 h, after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>500 mg orally every 24 h</i>
	<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefazolin - Selected References

- Ahern JW, Possidente CJ, Hood V, Alston WK. Cefazolin dosing protocol for patients receiving long-term hemodialysis. *Am J Health Syst Pharm.* 2003;60:178–81.
- Amsden GW. Tables of antimicrobial agent pharmacology. In: Mandell GL, Bennett JE, Dolin R, editors. *Mandell, Douglas, and Bennett's principles and practice of infectious diseases*, vol 1. 6th ed. Philadelphia: Elsevier; 2005. p. 634–700.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefazolin/Ancel<sup>®</sup>

{Antibacterial; first-generation cephalosporin}

<b>Usual initial dose:</b>	1–2 g IV
<b>Usual maintenance dose:</b>	1–2 g IV every 8 h
<b>Typical maximum dose:</b>	6 g/day IV
<b>Proportion eliminated unchanged:</b>	96 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥55 mL/min or SCr ≤1.5 mg/dL</i>	<i>500 mg–2 g IV every 8 h</i>
	<i>CrCL 35–54 mL/min or SCr 1.6–3.0 mg/dL</i>	<i>500 mg–2 g IV every 12 h</i>
	<i>CrCL 11–34 mL/min or SCr 3.1–4.5 mg/dL</i>	<i>250–1,000 mg IV every 12 h</i>
	<i>CrCL ≤10 mL/min or SCr ≥4.6 mg/dL</i>	<i>250–1,000 mg IV every 18–24 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500–2,000 mg IV every 8 h</i>
	<i>GFR 10–50 mL/min</i>	<i>250–1,000 mg IV every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>250–1,000 mg IV every 24 h</i>
	<i>Hemodialysis</i>	<i>20 mg/kg (1,000–2,000 mg) IV after each dialysis</i>
	<i>CAPD</i>	<i>500 mg IV every 12 h or add 1,000 mg/2 L dialysate 4 × daily</i>
	<i>CVVH</i>	<i>1–2 g IV every 12 h</i>
	<i>CVVHD or CVVHDF</i>	<i>2 g IV every 12 h</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Cefdinir - Selected References**

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefdinir/Omnicef®

{Antibacterial; third-generation cephalosporin}

<b>Usual initial dose:</b>	600 mg orally
<b>Usual maintenance dose:</b>	300 mg orally every 12 h or 600 mg orally every 24 h
<b>Typical maximum dose:</b>	600 mg/day
<b>Proportion eliminated unchanged:</b>	15 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;30 mL/min</i>	<i>300 mg orally once daily</i>
	<i>Hemodialysis</i>	<i>300 mg or 7 mg/kg dose every other day. At the conclusion of each hemodialysis session, 300 mg (or 7 mg/kg) should be given.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>300 mg orally every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>300 mg orally every 24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>300 mg orally every 48 h</i>
	<i>Hemodialysis</i>	<i>300 mg orally every 48 h, after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>300 mg orally every 48 h</i>
	<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefditoren - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cefditoren/Spectracef®** {Antibacterial; second-generation cephalosporin}

**Usual initial dose:** 400 mg orally  
**Usual maintenance dose:** 200–400 mg orally every 12 h for 10 days  
**Typical maximum dose:** 400 mg  
**Proportion eliminated unchanged:** >90 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 50–80 mL/min</i>	<i>200–400 mg orally every 12 h with meals</i>
	<i>CrCL 30–49 mL/min</i>	<i>200 mg orally every 12 h with meals</i>
	<i>CrCL &lt;30 mL/min</i>	<i>200 mg orally every 24 h with meals (Note: the appropriate dose in patients with end-stage renal disease has not been determined.)</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>200–400 mg orally every 12 h with meals</i>
	<i>GFR 10–50 mL/min</i>	<i>200 mg orally every 12 h with meals</i>
	<i>GFR &lt;10 mL/min</i>	<i>200 mg orally every 24 h with meals</i>
	<i>Hemodialysis</i>	<i>200 mg orally every 24 h with meals; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>300 mg orally every 48 h with meals</i>
	<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefepime - Selected References

- Allaochiche B, Breilh D, Jaumain H, Gillard B, Renard S, Saux M-C. Pharmacokinetics of cefepime during continuous venovenous hemodiafiltration. *Antimicrob Agents Chemother.* 1997;41:2424–7.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cefepime/Maxipime®** {Antibacterial; fourth-generation cephalosporin}

**Usual initial dose:** 2 g IV  
**Usual maintenance dose:** 500 mg–2 g IV every 8–12 h or 1 g IV every 8 h infused over 4 h  
**Typical maximum dose:** 2 g IV  
**Proportion eliminated unchanged:** 85 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Cefepime dosing for adults with renal function impairment*

CrCL (mL/min)	Recommended maintenance schedule, dependent upon severity of infection			
	500 mg q 12 h	1 g q 12 h	2 g q 12 h	2 g q 8 h
>60 (normal)	500 mg q 12 h	1 g q 12 h	2 g q 12 h	2 g q 8 h
30–60	500 mg q 24 h	1 g q 24 h	2 g q 24 h	2 g q 12 h
11–29	500 mg q 24 h	500 mg q 24 h	1 g q 24 h	2 g q 24 h
<11	250 mg q 24 h	250 mg q 24 h	500 mg q 24 h	1 g q 24 h
CAPD	500 mg q 48 h	1 g q 48 h	2 g q 48 h	2 g q 48 h
Hemodialysis	1 g on day 1, then 500 mg q 24 h thereafter			1 g q 24 h

*On hemodialysis days, cefepime should be administered following dialysis. Whenever possible, cefepime should be administered at the same time each day*

**Alternative adjustment:**

*GFR >50 mL/min* 1 g IV every 4 h or 1 g IV over 4 h every 8 h or 1–2 g IV every 8–12 h

*GFR 10–50 mL/min* 1–2 g IV every 12–24 h

*GFR <10 mL/min* 500–1,000 mg IV every 24 h

*Hemodialysis* 1 g IV every 24 h; dose after hemodialysis on dialysis days

*CAPD* 500–1,000 mg IV every 24 h

*CVVH* 1–2 g IV every 12 h

*CVVHD or CVVHDF* 1–2 g IV every 12 h (consider 2 g IV every 8 h for gram-negative pathogens with MIC ≥4 mg/L)

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefixime - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- McIntyre CW, Owen PJ. Prescribing drugs in kidney disease. In: Brenner BM, editor. *Brenner & Rector's the kidney*. 8th ed. Philadelphia: Saunders Elsevier; 2008. p. 1930–55.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cefixime/Suprax®** {Antibacterial; third-generation cephalosporin}

**Usual initial dose:** 400 mg orally  
**Usual maintenance dose:** 400 mg/day orally  
**Typical maximum dose:** 400 mg  
**Proportion eliminated unchanged:** 85 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Cefixime dosage in renal function impairment*

<i>CrCL (mL/min)</i>	<i>Dosage</i>
<i>&gt;60</i>	<i>Standard (400 mg/day orally)</i>
<i>21–60 or hemodialysis<sup>a</sup></i>	<i>75 % of standard (300 mg/day orally)</i>
<i>&lt;20 or continuous ambulatory peritoneal dialysis<sup>a</sup></i>	<i>50 % of standard (200 mg/day orally)</i>

<sup>a</sup>Neither hemodialysis nor peritoneal dialysis removes significant amounts of drug from the body

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>400 mg orally once daily</i>
<i>GFR 10–50 mL/min</i>	<i>400 mg orally once daily</i>
<i>GFR &lt;10 mL/min</i>	<i>200 mg orally once daily (50 % decrease)</i>
<i>Hemodialysis</i>	<i>300 mg orally once daily, after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>200 mg orally once daily</i>
<i>CRRT</i>	<i>Not recommended (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefotaxime - Selected References

- Andrassy K. Pharmacokinetics of cefotaxime in dialysis patients. *Diagn Microbiol Infect Dis.* 1995;22:85–7.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cefotaxime/Claforan®** {Antibacterial; third-generation cephalosporin}

**Usual initial dose:** 1–2 g IV  
**Usual maintenance dose:** 1–2 g IV every 8 h  
**Typical maximum dose:** 12 g/day IV  
**Proportion eliminated unchanged:** 60 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥20 mL/min</i>	<i>1–2 g IV every 6–8 h</i>
	<i>CrCL &lt;20 mL/min</i>	<i>0.5–1 g IV every 8 h (50 % decrease)</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1–2 g IV every 8–12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>1–2 g IV every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>1–2 g IV every 24 h</i>
	<i>Hemodialysis</i>	<i>1–2 g IV every 24 h; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>0.5–1 g every 24 h</i>
	<i>CVVH</i>	<i>1–2 g IV every 8–12 h</i>
	<i>CVVHD</i>	<i>1–2 g IV every 8 h</i>
	<i>CVVHDF</i>	<i>1–2 g IV every 6–8 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefotetan - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Olyaei AJ, Bennett WM. Drug dosing in elderly patients with chronic kidney disease. *Clin Geriatr Med.* 2009;25:459–527.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cefotetan/Cefotan®** {Antibacterial; second-generation cephalosporin}

**Usual initial dose:** 2 g IV  
**Usual maintenance dose:** 1–2 g IV every 12 h  
**Typical maximum dose:** 6 g/day  
**Proportion eliminated unchanged:** 75 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Cefotetan dosage in patients with renal function impairment*

<i>CrCL (mL/min)</i>	<i>Dose</i>	<i>Frequency</i>
<i>&gt;30</i>	<i>Usual recommended dosage</i>	<i>Every 12 h</i>
<i>10–30</i>	<i>Usual recommended dosage</i>	<i>Every 24 h</i>
<i>&lt;10</i>	<i>Usual recommended dosage</i>	<i>Every 48 h</i>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>1–2 g IV every 12 h</i>
<i>GFR 10–50 mL/min</i>	<i>1–2 g IV every 24 h</i>
<i>GFR &lt;10 mL/min</i>	<i>1–2 g IV every 48 h or 0.5 g IV every 24 h</i>
<i>Hemodialysis</i>	<i>1 g IV after hemodialysis on dialysis days only</i>
<i>CAPD</i>	<i>1 g IV daily</i>
<i>CRRT</i>	<i>1–2 g IV every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefoxitin - Selected References

- Andriole VT. Pharmacokinetics of cephalosporins in patients with normal or reduced renal function. *J Infect Dis.* 1978;137(Suppl):S88–99.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Cefoxitin/Mefoxin®**

{Antibacterial; second-generation cephalosporin}

<b>Usual initial dose:</b>	1–2 g IV
<b>Usual maintenance dose:</b>	1–2 g IV every 6–8 h
<b>Typical maximum dose:</b>	2 g IV every 4 h or 3 g IV every 6 h
<b>Proportion eliminated unchanged:</b>	80 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Maintenance cefoxitin dosage in adults with renal impairment*

<i>Renal function</i>	<i>CrCL (mL/min)</i>	<i>Dose (g)</i>	<i>Frequency</i>
<i>Mild impairment</i>	<i>30–50</i>	<i>1–2</i>	<i>Every 8–12 h</i>
<i>Moderate impairment</i>	<i>10–29</i>	<i>1–2</i>	<i>Every 12–24 h</i>
<i>Severe impairment</i>	<i>5–9</i>	<i>0.5–1</i>	<i>Every 12–24 h</i>
<i>Essentially anephric</i>	<i>&lt;5</i>	<i>0.5–1</i>	<i>Every 24–48 h</i>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>1–2 g IV every 6 h</i>
<i>GFR 10–50 mL/min</i>	<i>1–2 g IV every 8–12 h</i>
<i>GFR &lt;10 mL/min</i>	<i>1–2 g IV every 12 h</i>
<i>Hemodialysis</i>	<i>As tabulated above plus 1–2 g IV after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>1 g IV every 24 h</i>
<i>CVVH</i>	<i>1–2 g IV every 12–18 h</i>
<i>CVVHD</i>	<i>1–2 g IV every 12 h</i>
<i>CVVHDF</i>	<i>1–2 g IV every 12 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefpodoxime - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefpodoxime/Vantin®

{Antibacterial; third-generation cephalosporin}

<b>Usual initial dose:</b>	200 mg orally
<b>Usual maintenance dose:</b>	200 mg orally every 12 h
<b>Typical maximum dose:</b>	400 mg/day
<b>Proportion eliminated unchanged:</b>	50 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;30 mL/min</i>	<i>200 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>200 mg orally 3 times/week after hemodialysis</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>200 mg orally every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>200 mg orally every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>100 mg orally every 12 h</i>
	<i>Hemodialysis</i>	<i>100–200 mg orally every 12 h, dose after dialysis</i>
	<i>CAPD</i>	<i>100–200 mg orally every 12 h</i>
	<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefprozil - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cefprozil/Cefzil®** {Antibacterial; second-generation cephalosporin}

**Usual initial dose:** 500 mg orally  
**Usual maintenance dose:** 250–500 mg orally every 12–24 h  
**Typical maximum dose:** 1,000 mg/day  
**Proportion eliminated unchanged:** 65 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Cefprozil dosing in renal impairment*

<i>CrCL (mL/min)</i>	<i>Dosage</i>	<i>Dosing interval</i>
<i>30–120</i>	<i>250–500 mg orally</i>	<i>Every 12–24 h</i>
<i>0–29</i>	<i>125–250 mg orally</i>	<i>Every 12–24 h</i>

*Hemodialysis: 250–500 mg orally after completion of hemodialysis*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>250–500 mg orally every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>125–250 mg orally every 24 h</i>
<i>GFR &lt;10 mL/min</i>	<i>125–250 mg orally every 24 h</i>
<i>Hemodialysis</i>	<i>125–250 mg orally every 24 h; administer supplemental 250 mg orally after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>125–250 mg orally every 24 h</i>
<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ceftaroline - Selected References

- Biek D, Critchley IA, Riccobene TA, Thye DA. Ceftaroline fosamil: a novel broad-spectrum cephalosporin with expanded anti-gram-positive activity. *J Antimicrob Chemother.* 2010;65(Suppl 4):iv9–16.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ceftaroline/Teflaro™** {Antibacterial; third-generation cephalosporin}

**Usual initial dose:** 600 mg IV over 1 h  
**Usual maintenance dose:** 600 mg IV over 1 h every 12 h  
**Typical maximum dose:** 1,200 mg/day  
**Proportion eliminated unchanged:** 50 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Ceftaroline injection dosage in renal impairment*

<i>Estimated CrCL (mL/min)</i>	<i>Ceftaroline recommended dosage regimen</i>
<i>&gt;50 mL/min</i>	<i>600 mg IV every 12 h</i>
<i>&gt;30 to ≤50 mL/min</i>	<i>400 mg IV every 12 h</i>
<i>≥15 to ≤30 mL/min</i>	<i>300 mg IV every 12 h</i>
<i>ESRD including hemodialysis</i>	<i>200 mg IV every 12 h</i>

**Alternative adjustment:** *Renal impairment* Presently (May 2012), data not available  
*CRRT* Presently (May 2012), data not available

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ceftazidime - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ceftazidime/Fortaz<sup>®</sup>, Tazicef<sup>®</sup>** {Antibacterial; third-generation cephalosporin}

**Usual initial dose:** 2 g IV  
**Usual maintenance dose:** 1–2 g IV every 8 h or 6 g/24 h continuous IV infusion  
**Typical maximum dose:** 6 g/day  
**Proportion eliminated unchanged:** 85 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Ceftazidime dosage in renal impairment*

<i>CrCL (mL/min)</i>	<i>Dose (g)</i>	<i>Frequency of dosing</i>
31–50	1–1.5	Every 12 h
16–30	1–1.5	Every 24 h
6–15	0.5–0.75	Every 24 h
<5	0.5–0.75	Every 48 h

*Hemodialysis: 1 g IV followed by 1 g IV after each hemodialysis*

*CAPD: 1 g IV followed by 500 mg IV every 24 h*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>1–2 g IV every 8 h or 6g/24 h continuous IV infusion</i>
<i>GFR 10–50 mL/min</i>	<i>1–2 g IV every 12–24 h or 0.6–1.2 mg/kg/min continuous IV infusion</i>
<i>GFR &lt;10 mL/min</i>	<i>0.5–1 g IV every 24 h or 0.3 mg/kg/min continuous IV infusion</i>
<i>Hemodialysis</i>	<i>0.5–1 g IV every 24 h; administer after hemodialysis on dialysis days or give supplemental 1 g IV after each dialysis.</i>
<i>CAPD</i>	<i>0.5 g IV every 24 h or 0.25 g/2 L dialysate</i>
<i>Automated PD</i>	<i>15 mg/kg IV every 24 h or 20 mg/kg intraperitoneally during long off-cycler dwell</i>
<i>CVVH</i>	<i>1–2 g IV every 12 h</i>
<i>CVVHD</i>	<i>2 g IV every 12 h</i>
<i>CVVHDF</i>	<i>2 g IV every 12 h (consider 2 g IV every 8 h for gram-negative pathogens with MIC ≥4 mg/L) or 3 g/24 h continuous IV infusion</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ceftibuten - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ceftibuten/Cedax®** {Antibacterial; third-generation cephalosporin}

**Usual initial dose:** 400 mg orally  
**Usual maintenance dose:** 400 mg orally once daily for 10 days  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 65 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Ceftibuten dosing in renal impairment*

<i>CrCL (mL/min)</i>	<i>Recommended dosing schedule</i>
<i>&gt;50</i>	<i>9 mg/kg or 400 mg every 24 h</i>
<i>30–49</i>	<i>4.5 mg/kg or 200 mg every 24 h</i>
<i>5–29</i>	<i>2.25 mg/kg or 100 mg every 24 h</i>
<i>Hemodialysis: 400 mg or 9 mg/kg (maximum 400 mg) orally after each hemodialysis</i>	
<b>Alternative adjustment:</b> <i>GFR &gt;50 mL/min</i>	<i>400 mg orally every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>200 mg orally every 24 h (50 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>100 mg orally every 24 h (75 % decrease)</i>
<i>Hemodialysis</i>	<i>400 mg orally three times weekly or after each dialysis</i>
<i>CAPD</i>	<i>100 mg orally every 24 h</i>
<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ceftizoxime - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ceftizoxime/Cefizox®** {Antibacterial; third-generation cephalosporin}

**Usual initial dose:** 1,000–2,000 mg IV  
**Usual maintenance dose:** 1,000–2,000 mg IV every 8–12 h  
**Typical maximum dose:** 12,000 mg/day  
**Proportion eliminated unchanged:** 57–93 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Ceftizoxime dosing in renal impairment (severe/life-threatening infection)*

CrCL (mL/min)	Dosage (mg)	Dosing interval
50–79	750–1,500	Every 8 h
5–49	500–1,000	Every 12 h

*Hemodialysis (CrCL <4 mL/min): 500–1,000 mg every 48 h or 500 mg every 24 h. In patients undergoing hemodialysis, no additional supplemental dosing is required following hemodialysis; however, dosing should be timed so that the patient receives the dose at the end of dialysis*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>1–2 g IV every 8–12 h</i>
<i>GFR 10–50 mL/min</i>	<i>1 g IV every 8–12 h</i>
<i>GFR &lt;10 mL/min</i>	<i>500–1,000 mg IV every 24 h</i>
<i>Hemodialysis</i>	<i>500 mg IV every 24 h; administer after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>1 g IV every 24 h or 3 g IV every 48 h</i>
<i>CRRT</i>	<i>500–1,000 mg IV every 12 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefuroxime Axetil - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cefuroxime Axetil/Ceftin®** {Antibacterial; second-generation cephalosporin}

**Usual initial dose:** 500 mg orally  
**Usual maintenance dose:** 250–500 mg orally twice daily with meals  
**Typical maximum dose:** 1,000 mg/day  
**Proportion eliminated unchanged:** 65 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *The safety and efficacy of cefuroxime axetil in patients with renal failure have not been established. Since cefuroxime is renally eliminated, its half-life will be prolonged in patients with renal failure.*

**Alternative adjustment:**

<i>eCrCL &gt;30 mL/min</i>	<i>250–500 mg orally twice daily with meals</i>
<i>eCrCL 10–29 mL/min</i>	<i>250–500 mg orally every 24 h</i>
<i>eCrCL &lt;10 mL/min</i>	<i>250–500 mg orally every 48 h</i>
<i>Hemodialysis</i>	<i>250–500 mg orally every 24 h; administer after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>250–500 mg orally every 48 h</i>
<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cefuroxime Sodium - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cefuroxime Sodium/Zinacef®** {Antibacterial; second-generation cephalosporin}

**Usual initial dose:** 750–1,500 mg IV  
**Usual maintenance dose:** 750 mg to 1,500 mg IV every 8 h  
**Typical maximum dose:** 9 g/day IV  
**Proportion eliminated unchanged:** 90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Cefuroxime dosing in renal impairment*

<i>CrCL (mL/min)</i>	<i>Recommended dosing schedule</i>
<i>&gt;20</i>	<i>750–1,500 mg every 8 h</i>
<i>10–20</i>	<i>750 mg every 24 h</i>
<i>&lt;10</i>	<i>750 mg every 24 h</i>
<i>Hemodialysis: 750 mg every 24 h; give after hemodialysis on dialysis days</i>	
<i>GFR &gt;50 mL/min</i>	<i>750–1,500 mg IV every 8 h</i>
<i>GFR 10–50 mL/min</i>	<i>750–1,500 mg IV every 8–12 h</i>
<i>GFR &lt;10 mL/min</i>	<i>750 mg IV every 24 h</i>
<i>Hemodialysis</i>	<i>750 mg IV every 24 h; administer after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>750 mg IV every 24 h</i>
<i>CRRT</i>	<i>1,500 mg IV once followed by 750 mg IV every 12 h</i>

**Alternative adjustment:**

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Celecoxib - Selected References

- Ahmad SR, Kortepeter C, Brinker A, Chen M, Beitz J. Renal failure associated with the use of celecoxib and rofecoxib. *Drug Saf.* 2002;25:537–44.
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- Celebrex® capsule [package insert]. New York: GD Searle LLC division of Pfizer Inc; 2011.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Celecoxib/Celebrex®** {Anti-inflammatory; nonsteroidal anti-inflammatory drug; selective cyclooxygenase (COX)-2 inhibitor}

**Usual initial dose:** 200 mg orally  
**Usual maintenance dose:** 100–200 mg orally once or twice daily  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 3 % as unchanged drug, ~30 % as minimally active primary metabolite

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal insufficiency</i>	<i>Use not recommended</i>
<b>Alternative adjustment:</b>	<i>GFR &lt;30 mL/min</i>	<i>Minimal data available. Preferably avoid due to risk for renal and/or gastrointestinal toxicity; if indeed necessary, begin with low doses and monitor carefully.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cephalexin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cephalexin/Keflex®** {Antibacterial; first-generation cephalosporin}

**Usual initial dose:** 500 mg orally  
**Usual maintenance dose:** 1–4 g/day orally in divided doses  
**Typical maximum dose:** 4 g/day  
**Proportion eliminated unchanged:** 96 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Administer with caution in the presence of markedly impaired renal function. Under such conditions, careful clinical observation and laboratory studies should be made because safe dosage may be lower than that usually recommended.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>250–500 mg orally every 6 h</i>
<i>GFR 10–50 mL/min</i>	<i>260–500 mg orally every 6–8 h</i>
<i>GFR &lt;10 mL/min</i>	<i>250–500 mg orally every 12–24 h</i>
<i>Hemodialysis</i>	<i>250–500 mg orally every 12–24 h; administer supplemental dose after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>250–500 mg orally every 12–24 h</i>
<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cetirizine - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Zyrtec® [package insert]. New York: Pfizer Labs division of Pfizer Inc; 2006.

**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Cetirizine/Zyrtec®** {Antihistamine; second-generation histamine H<sub>1</sub> blocker}

**Usual initial dose:** 10 mg orally  
**Usual maintenance dose:** 5–10 mg orally once daily, depending on symptom severity  
**Typical maximum dose:** 20 mg daily  
**Proportion eliminated unchanged:** 70 %

*Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Cetirizine dosing in renal impairment*

<i>CrCL (mL/min)</i>	<i>Recommended dosing schedule</i>
<i>≥32</i>	<i>10 mg every 24 h</i>
<i>11–31</i>	<i>5 mg every 24 h</i>
<i>≤10</i>	<i>Not recommended</i>
<i>GFR &gt;50 mL/min</i>	<i>5–10 mg orally once daily</i>
<i>GFR 10–50 mL/min</i>	<i>5 mg orally once daily</i>
<i>GFR &lt;10 mL/min</i>	<i>5 mg orally once daily</i>
<i>Hemodialysis</i>	<i>5 mg orally three times weekly to 5 mg orally daily; no supplemental dose after dialysis</i>
<i>CAPD</i>	<i>5 mg orally once daily</i>
<i>CRRT</i>	<i>Data not available</i>

**Alternative adjustment:**

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cetrorelix - Selected References

Cetrotide® injection [package insert]. Rockland: EMD Serono Inc; 2008.

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Erb K, Klipping C, Duijkers I, Pechstein B, Schueler A, Hermann R. Pharmacodynamic effects and plasma pharmacokinetics of single doses of cetrorelix acetate in healthy premenopausal women. *Fertil Steril.* 2001;75:316–23.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Cetrorelix/Cetrotide®**

**{Gonadotropin-releasing hormone antagonist}**

<b>Usual initial dose:</b>	3 mg subcutaneously once or 0.25 mg subcutaneously daily
<b>Usual maintenance dose:</b>	3 mg subcutaneously once during early- to mid-follicular phase or 0.25 mg subcutaneously once daily until the day of hCG administration
<b>Typical maximum dose:</b>	~3.5 mg/cycle
<b>Proportion eliminated unchanged:</b>	7–14 %

### ***Adjustment for Kidney Disease***

**FDA-approved product labeling:** *Severe renal impairment*      *Contraindicated*

**Alternative adjustment:**      *Data not available*

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Chloral Hydrate - Selected References**

Breimer DD. Clinical pharmacokinetics of hypnotics. *Clin Pharmacokinet.* 1977;2:93–109.

Buur T, Larsson R, Norlander B. Pharmacokinetics of chloral hydrate poisoning treated with hemodialysis and hemoperfusion. *Acta Med Scand.* 1988;223:269–74.

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Gorecki DKJ, Hindmarsh KW, Hall CA, Mayers DJ. Determination of chloral hydrate metabolism in adult and neonate biological fluids after single-dose administration. *J Chromatogr.* 1990;528:333–41.

McIntyre CW, Owen PJ. Prescribing drugs in kidney disease. In: Brenner BM, editor. *Brenner & Rector's the kidney.* 8th ed. Philadelphia: Saunders Elsevier; 2008. p. 1930–55.

Müller G, Spassovski M, Henschler D. Metabolism of trichloroethylene in man. II. Pharmacokinetics of metabolites. *Arch Toxicol.* 1974;32:283–95.

Ni Y-C, Wong T-Y, Kadlubar FF, Fu PP. Hepatic metabolism of chloral hydrate to free radical(s) and induction of lipid peroxidation. *Biochem Biophys Res Commun.* 1994;204:937–43.

Somnote<sup>®</sup> capsule [package insert]. Boca Raton: Breckenridge Pharmaceutical Inc; 2007.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Chloral Hydrate/Somnote®

{Sedative hypnotic}

<b>Usual initial dose:</b>	500–1,000 mg orally at bedtime or 30 min prior to procedure
<b>Usual maintenance dose:</b>	500–1,000 mg orally at bedtime
<b>Typical maximum dose:</b>	2 g/day
<b>Proportion eliminated unchanged:</b>	Minimal; active metabolite (trichloroethanol) primarily eliminated in urine

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Marked renal impairment*      *Contraindicated*

**Alternative adjustment:**      *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Chlorambucil - Selected References

- Alberts DS, Chang SY, Chen H-SG, Larcom BJ, Jones SE. Pharmacokinetics and metabolism of chlorambucil in man: a preliminary report. *Cancer Treat Rev.* 1979;6(Suppl):9–17.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Ehrsson H, Wallin I, Simonsson S, Hartvig P, Öberg G. Effect of food on pharmacokinetics of chlorambucil and its main metabolite, phenylacetic acid mustard. *Eur J Clin Pharmacol.* 1984;27:111–4.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Chlorambucil/Leukeran®** {Antineoplastic; nitrogen mustard alkylating agent}

**Usual initial dose:** 0.1–0.2 mg/kg orally once daily  
**Usual maintenance dose:** 0.1 mg/kg orally once daily (~2–4 mg)  
**Typical maximum dose:** 0.4 mg/kg/day  
**Proportion eliminated unchanged:** <1 % (~95 % of each dose appears in urine as cytotoxic metabolite)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Not available*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>0.1 mg/kg orally every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>0.075 mg/kg orally every 24 h (25 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>0.05 mg/kg orally every 24 h (50 % decrease)</i>
<i>Hemodialysis</i>	<i>0.05 mg/kg orally every 24 h (50 % decrease)</i>
<i>CAPD</i>	<i>0.05 mg/kg orally every 24 h (50 % decrease)</i>
<i>CRRT</i>	<i>Data not available</i>

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Chlorothiazide - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Chlorothiazide sodium injection [package insert]. Schaumburg: APP Pharmaceuticals LLC; 2009.
- Chlorothiazide tablet [package insert]. Eatontown: West-ward Pharmaceuticals Corp; 2005.
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- Diuril® suspension [package insert]. Whitehouse Station: Merck & Co; 2006.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Chlorothiazide/Diuril®**                      {Diuretic; thiazide}

**Usual initial dose:**                      125–500 mg enterally or IV  
**Usual maintenance dose:**              500–1,000 mg enterally or IV once or twice daily  
**Typical maximum dose:**                2,000 mg/day  
**Proportion eliminated unchanged:**    25 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**    *Use with caution in severe renal disease.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500–1,000 mg enterally or IV every 12–24 h</i>
	<i>GFR 30–50 mL/min</i>	<i>500–1,000 mg enterally or IV every 12–24 h</i>
	<i>GFR &lt;30 mL/min</i>	<i>Possibly ineffective; may be effective at low GFR in combination with loop diuretic</i>
	<i>GFR &lt;10 mL/min</i>	<i>Usually ineffective. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CAPD</i>	<i>Usually ineffective. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>CRRT</i>	<i>Not applicable</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Chlorpropamide - Selected References**

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Chlorpropamide tablet [package insert]. Pomona: Barr Laboratories Inc; 2007.
- Hanlon JT, Aspinall SL, Semla TP, et al. Consensus guidelines for oral dosing of primarily renally cleared medications in older adults. *J Am Geriatr Soc.* 2009;57:335–40.
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- McIntyre CW, Owen PJ. Prescribing drugs in kidney disease. In: Brenner BM, editor. *Brenner & Rector's the kidney.* 8th ed. Philadelphia: Saunders Elsevier; 2008. p. 1930–55.
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- Olyaei AJ, Bennett WM. Pharmacologic approach to renal insufficiency. In: Dale DC, Federman DD, Antman K, editors. *ACP medicine, WebMD June 2007 update.* Hamilton: BC Decker; 2007; NEPHROLOGY IX: Appendix A1–25.
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- Seltzer HS. Drug-induced hypoglycemia: a review of 1418 cases. *Endocrinol Metab Clin North Am.* 1989;18:163–83.



## Dosage Adjustment of Medications Eliminated by the Kidneys

**Chlorpropamide/Diabinese®**      {Antidiabetic; sulfonyleurea}

**Usual initial dose:**                      100–250 mg  
**Usual maintenance dose:**              50–250 mg orally once daily  
**Typical maximum dose:**                500 mg orally once daily  
**Proportion eliminated unchanged:**    85 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal insufficiency</i>	<i>May increase the risk of serious hypoglycemic reactions</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>50–250 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>Avoid due to risk for severe, prolonged hypoglycemia.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid due to risk for severe, prolonged hypoglycemia.</i>
	<i>Hemodialysis</i>	<i>Avoid due to risk for severe, prolonged hypoglycemia.</i>
	<i>CAPD</i>	<i>Avoid due to risk for severe, prolonged hypoglycemia.</i>
	<i>CRRT</i>	<i>Not applicable; avoid due to risk for severe, prolonged hypoglycemia.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Chlorthalidone - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Collste P, Garle M, Rawlins MD, Sjöqvist F. Interindividual differences in chlorthalidone concentration in plasma and red cells of man after single and multiple doses. *Eur J Clin Pharmacol.* 1976;9:319–25.
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- Sica DA. Chlorthalidone – a renaissance in use? *Expert Opin Pharmacother.* 2009;10:2037–9.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Chlorthalidone/Thalitone®, Hygroton®**

**{Diuretic; thiazide-like}**

<b>Usual initial dose:</b>	25 mg orally
<b>Usual maintenance dose:</b>	25 mg orally once daily
<b>Typical maximum dose:</b>	100 mg orally once daily
<b>Proportion eliminated unchanged:</b>	95 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Severe renal disease      Use with caution.*

*Anuria                              Contraindicated*

**Alternative adjustment:**

*GFR >50 mL/min      25 mg orally once daily*

*GFR 10–50 mL/min      25 mg orally once daily*

*GFR <10 mL/min      Usually ineffective; preferably avoid.*

*Hemodialysis              Usually ineffective; preferably avoid.*

*CAPD                              Usually ineffective; preferably avoid.*

*CRRT                              Not applicable; preferably avoid.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cidofovir - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Brody SR, Humphreys MH, Gambertoglio JG, et al. Pharmacokinetics of cidofovir in renal insufficiency and in continuous ambulatory peritoneal dialysis or high-flux dialysis. *Clin Pharmacol Ther.* 1999;65:21–8.
- Cihlar T, Ho ES, Lin DC, Mulato AS. Human renal organic anion transporter 1 (hOAT1) and its role in the nephrotoxicity of antiviral nucleotide analogs. *Nucleosides Nucleotides Nucleic Acids.* 2001;20:641–8.
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- Ganguly N, Clough LA, DuBois LK, et al. Low-dose cidofovir in the treatment of symptomatic BK virus infection in patients undergoing allogeneic hematopoietic stem cell transplantation: a retrospective analysis of an algorithmic approach. *Transpl Infect Dis.* 2010;12:406–11.
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- Kay TD, Hogan PG, McLeod SE, Johnson DW. Severe irreversible proximal renal tubular acidosis and azotaemia secondary to cidofovir [letter]. *Nephron.* 2000;86:348–9.
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- Vistide® injection [package insert]. Foster City: Gilead Sciences Inc; 2000.
- Wachsmann M, Petty BG, Cundy KC, et al. Pharmacokinetics, safety and bioavailability of HPMPC (cidofovir) in human immunodeficiency virus-infected patients. *Antiviral Res.* 1996;29:153–61.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cidofovir/Vistide®** {Antiviral; R for cytomegalovirus infection}

**Usual initial dose:** 5 mg/kg IV

**Usual maintenance dose:** 5 mg/kg IV over 1 h once weekly for 2 weeks; maintenance 5 mg/kg IV every other week (with probenecid 2 g administered orally 3 h prior to the cidofovir infusion and again at 8 h after completion of the cidofovir infusion)

**Typical maximum dose:** 5 mg/kg IV

**Proportion eliminated unchanged:** 90 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *With acute increase in SCr of 0.3–0.5 mg/dL over baseline, decrease dose to 3 mg/kg IV weekly ×2; discontinue for an increase in SCr of ≥0.5 mg/dL above baseline or development of ≥3+ proteinuria (with probenecid).*

*Contraindicated in patients with SCr ≥1.5 mg/dL, calculated CrCL <55 mL/min, and/or urine protein >100 mg/dL (equivalent to ≥2+ proteinuria); contraindicated in patients receiving agents with nephrotoxic potential or within 7 days after use of such agents*

<b>Alternative adjustment:</b>	<i>GFR &gt;55 mL/min</i>	<i>5 mg/kg IV weekly ×2 then 5 mg/kg IV every other week or 0.5–1 mg/kg IV weekly or 0.25 mg/kg IV weekly until symptom resolution (with probenecid 2 g orally 1 h prior to the cidofovir infusion)</i>
	<i>GFR 10–55 mL/min</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 0.25–0.5 mg/kg IV every 2 weeks (with probenecid; minimal data available).</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 0.25–0.5 mg/kg IV every 2 weeks (with probenecid; minimal data available).</i>
	<i>Hemodialysis</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 0.25–0.5 mg/kg IV every 2 weeks (without probenecid; minimal data available).</i>
	<i>CAPD</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 0.25–0.5 mg/kg IV every 2 weeks (without probenecid; minimal data available).</i>
	<i>CRRT</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 2 mg/kg IV weekly (with probenecid).</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cimetidine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cimetidine/Tagamet®** {Antacid; histamine H<sub>2</sub> receptor antagonist}

**Usual initial dose:** 300 mg IV

**Usual maintenance dose:** 300 mg IV every 6–8 h or 400–800 mg orally twice daily or 800 mg orally at bedtime

**Typical maximum dose:** 2,400 mg/day

**Proportion eliminated unchanged:** 50–80 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Impaired renal function (CrCL <30 mL/min)* 300 mg IV or orally every 12 h

**Alternative adjustment:** *GFR >50 mL/min* 300 mg IV every 8 h or 400 mg orally twice daily

*GFR 10–50 mL/min* 150 mg IV every 8 h or 200 mg orally twice daily

*GFR <10 mL/min* 150 mg IV every 12 h or 200 mg orally once daily (avoid in older adults.)

*Hemodialysis* 150 mg IV every 12 h or 200 mg orally once daily; administer after hemodialysis on dialysis days

*CAPD* 150 mg IV every 12 h or 200 mg orally once daily

*CRRT* 150 mg IV every 8 h or 200 mg enterally twice daily

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ciprofloxacin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Ciprofloxacin/Cipro®** {Antibacterial; fluoroquinolone}

**Usual initial dose:** 500–750 mg orally or 400 mg IV

**Usual maintenance dose:** 250–750 mg orally every 12 h or 200–400 mg IV every 12 h or 400 mg IV every 8 h

*Ciprofloxacin equivalent area under the curve (AUC) dosing regimens*

<i>Ciprofloxacin oral dosage</i>	<i>Equivalent ciprofloxacin IV dosage</i>
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<i>250 mg tablet every 12 h</i>	<i>200 mg IV every 12 h</i>
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<i>500 mg tablet every 12 h</i>	<i>400 mg IV every 12 h</i>
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<i>750 mg tablet every 12 h</i>	<i>400 mg IV every 8 h</i>
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**Typical maximum dose:** 750 mg/dose orally or 400 mg/dose IV

**Proportion eliminated unchanged:** 50 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Ciprofloxacin dosage adjustment in adults with renal function impairment*

<i>CrCL (mL/min)</i>	<i>Dose</i>
<i>&gt;50</i>	<i>250–750 mg orally every 12 h<sup>a</sup></i>
<i>30–50</i>	<i>250–500 mg orally every 12 h<sup>a</sup></i>
<i>5–29</i>	<i>250–500 mg orally every 18 h<sup>a</sup></i>
<i>Hemodialysis or peritoneal dialysis</i>	<i>250–500 mg orally every 24 h (after hemodialysis on dialysis days)<sup>a</sup></i>

<sup>a</sup>See table above for equivalent ciprofloxacin IV dosages

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>500–750 mg orally or 400 mg IV every 12 h</i>
<i>GFR 10–50 mL/min</i>	<i>250–500 mg orally or 200 mg IV every 12 h</i>
<i>GFR &lt;10 mL/min</i>	<i>250 mg orally or 200 mg IV every 12 h</i>
<i>Hemodialysis</i>	<i>250 mg orally or 200 mg IV every 12 h</i>
<i>CAPD</i>	<i>250 mg orally or 200 mg IV every 12 h or addition to dialysate in a concentration of 25 mg/L</i>
<i>CVVH</i>	<i>200–400 mg IV every 12 h</i>
<i>CVVHD or CVVHDF</i>	<i>200–400 mg IV every 8 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cisplatin - Selected References

- Anand AJ, Bashey B. Newer insights into cisplatin nephrotoxicity. *Ann Pharmacother.* 1993;27:1519–25.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cisplatin/Platinol®** {Antineoplastic; platinum coordination complex}

**Usual initial dose:** 75–100 mg/m<sup>2</sup> IV  
**Usual maintenance dose:** 75–100 mg/m<sup>2</sup> IV every 3–4 weeks  
**Typical maximum dose:** 120 mg/m<sup>2</sup> IV  
**Proportion eliminated unchanged:** 30–40 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Preexisting renal impairment</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>75–100 mg/m<sup>2</sup> IV every 3–4 weeks (100 % of usual dose)</i>
	<i>GFR 10–50 mL/min</i>	<i>60–75 mg/m<sup>2</sup> every 3–4 weeks (25 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>37.5–50 mg/m<sup>2</sup> every 3–4 weeks (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>37.5–50 mg/m<sup>2</sup> every 3–4 weeks (50 % decrease); administer supplemental dose after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>37.5–50 mg/m<sup>2</sup> every 3–4 weeks (50 % decrease)</i>
	<i>CRRT</i>	<i>60–75 mg/m<sup>2</sup> every 3–4 weeks (25 % decrease)</i>

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cladribine - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Cladribine/Leustatin®** {Antineoplastic; pyrimidine analog antimetabolite}

**Usual initial dose:** 0.09 mg/kg/day IV  
**Usual maintenance dose:** 0.09 mg/kg/day continuous IV infusion for seven consecutive days  
**Typical maximum dose:** 0.09 mg/kg/day IV  
**Proportion eliminated unchanged:** 15 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Proceed carefully in patients with known or suspected renal insufficiency.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>0.09 mg/kg/day continuous IV infusion</i>
	<i>GFR 10–50 mL/min</i>	<i>0.0675 mg/kg/day continuous IV infusion</i>
	<i>GFR &lt;10 mL/min</i>	<i>0.045 mg/kg/day continuous IV infusion</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CAPD</i>	<i>0.045 mg/kg/day continuous IV infusion</i>
	<i>CRRT</i>	<i>Limited data; preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Clarithromycin - Selected References

Abramowicz M, Zuccotti G, Pflomm J-M, et al., editors. Handbook of antimicrobial therapy. 19th ed. New Rochelle: The Medical Letter; 2011.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Clarithromycin/Biaxin®** {Antibacterial, macrolide}

**Usual initial dose:** 500 mg orally  
**Usual maintenance dose:** 250–500 mg orally twice daily  
**Typical maximum dose:** 1,500 mg/day  
**Proportion eliminated unchanged:** 15 % (plus 7 % of absorbed dose as metabolite)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *In the presence of severe renal impairment with or without coexisting hepatic impairment, decreased dosage or prolonged dosing intervals may be appropriate.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>250–500 mg orally every 12 h</i>
<i>GFR 10–50 mL/min</i>	<i>125–500 mg orally every 12 h</i>
<i>GFR &lt;10 mL/min</i>	<i>125–250 mg orally every 12 h</i>
<i>Hemodialysis</i>	<i>Data not available</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>125–500 mg enterally every 12 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Clomipramine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Clomipramine/Anafranil®** {Antidepressant; tricyclic}

**Usual initial dose:** 25 mg orally  
**Usual maintenance dose:** 100 mg orally once daily  
**Typical maximum dose:** 250 mg orally once daily  
**Proportion eliminated unchanged:** 60 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Use with caution in patients with significantly impaired renal function.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>100 mg orally once daily</i>
<i>GFR 10–50 mL/min</i>	<i>100 mg orally once daily</i>
<i>GFR &lt;10 mL/min</i>	<i>100 mg orally once daily</i>
<i>Hemodialysis</i>	<i>100 mg orally once daily, supplemental dose after hemodialysis not required</i>
<i>CAPD</i>	<i>100 mg orally once daily</i>
<i>CRRT</i>	<i>Date not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Clozapine/Clozaril®, FazaClo®** {Atypical antipsychotic; dibenzepine derivative}

**Usual initial dose:** 12.5 mg orally  
**Usual maintenance dose:** 300–450 mg/day orally in two to three divided doses  
**Typical maximum dose:** 900 mg/day  
**Proportion eliminated unchanged:** 1 % as parent compound, ~13 % as metabolites with limited activity

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Caution is advisable in using clozapine in patients with renal disease.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>300–450 mg/day orally (100 % of usual dose)</i>
<i>GFR 10–50 mL/min</i>	<i>300–450 mg/day orally (100 % of usual dose)</i>
<i>GFR &lt;10 mL/min</i>	<i>300–450 mg/day orally (100 % of usual dose)</i>
<i>Hemodialysis</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor drug levels.</i>
<i>CAPD</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor drug levels.</i>
<i>CRRT</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor drug levels.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Codeine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Codeine

{Analgesic; opioid  $\mu$ -receptor agonist}

<b>Usual initial dose:</b>	15–60 mg orally, subcutaneously, IM, or IV
<b>Usual maintenance dose:</b>	15–60 mg (usually 30 mg) orally, subcutaneously, IM, or IV every 4 h as necessary
<b>Typical maximum dose:</b>	360 mg/24 h
<b>Proportion eliminated unchanged:</b>	Minimal; predominantly excreted in urine as norcodeine and free and conjugated morphine

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Use with caution in elderly or debilitated patients and those with severe impairment of renal function.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>15–60 mg orally, subcutaneously, IM, or IV q4h PRN</i>
	<i>GFR 10–50 mL/min</i>	<i>10–45 mg orally, subcutaneously, IM, or IV q4h PRN</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>CAPD</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>CRRT</i>	<i>10–45 mg orally, subcutaneously, IM, or IV q4h PRN</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Colchicine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Colchicine/Colcrys® {Anti-gout agent; antimitotic}

<b>Usual initial dose:</b>	For acute gout flare: 1.2 mg orally followed by 0.6 mg orally 6 h later
<b>Usual maintenance dose:</b>	0.6 mg orally once or twice daily
<b>Typical maximum dose:</b>	1.2 mg/day orally
<b>Proportion eliminated unchanged:</b>	5–15 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Colchicine dosage adjustment in adults with renal function impairment*

<i>CrCL (mL/min)</i>	<i>Dose</i>
50–80	0.6 mg orally once or twice daily
30–49	0.6 mg orally once or twice daily
<30	0.3 mg orally once daily
Hemodialysis	0.6 mg orally once, followed by 0.3 mg orally once daily

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	0.6 mg orally once or twice daily
<i>GFR 10–50 mL/min</i>	0.3–0.6 mg orally once or twice daily
<i>GFR &lt;10 mL/min</i>	Due to potential colchicine-related cellular toxicity, preferably avoid unless no suitable alternative exists; if indeed necessary, 0.3 mg orally once daily. Monitor carefully.
<i>Hemodialysis</i>	0.3 mg once daily; monitor carefully.
<i>CAPD</i>	Due to potential colchicine-related cellular toxicity, preferably avoid unless no suitable alternative exists; if indeed necessary, 0.3 mg orally once daily. Monitor carefully.
<i>CRRT</i>	0.3–0.6 mg enterally once or twice daily

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Colistimethate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Colistimethate (Colistin, Polymyxin E)/Coly-Mycin® M {Antibacterial; polymyxin derivative}**

<b>Usual initial dose:</b>	1.25–2.5 mg/kg IV or IM
<b>Usual maintenance dose:</b>	2.5–5 mg/kg/day IV or IM in two to four divided doses, depending on severity of infection
<b>Typical maximum dose:</b>	5 mg/kg/day IV or IM
<b>Proportion eliminated unchanged:</b>	70 %

#### *Adjustment for Kidney Disease*

##### **FDA-approved product labeling:**

*Colistimethate dosage schedules for adults with impaired renal function*

Renal function			Dosage			
Degree of impairment	Serum		Dose (mg)	Frequency (times per day)	Total daily dose (mg)	Approx daily dose (mg/kg)
	creatinine (mg/dL)	Urea clearance (% of normal)				
Normal	0.7–1.2	80–100	100–150	2–4	300	5
Mild	1.3–1.5	40–70	75–115	2	150–230	2.5–3.8
Moderate	1.6–2.5	25–40	66–150	1–2	133–150	2.5
Severe	2.6–4	10–25	100–150	q 36 h	100	1.5

*Note: The suggested unit dose is 2.5–5 mg/kg; the time interval between doses should be increased in the presence of impaired renal function*

##### **Alternative adjustment:**

<i>eCrCL &gt;80 mL/min</i>	<i>2.5–5 mg/kg/day IV in two to three divided doses</i>
<i>eCrCL 50–80 mL/min</i>	<i>2.5–3.8 mg/kg/day IV in two divided doses</i>
<i>eCrCL 10–49 mL/min</i>	<i>2.5 mg/kg/day IV or IM in one or two divided doses</i>
<i>CrCL &lt;10 mL/min</i>	<i>1.5 mg/kg IV or IM every 36 h</i>
<i>Hemodialysis</i>	<i>1.5 mg/kg IV every 24–48 h</i>
<i>CVVH</i>	<i>2.5 mg/kg IV every 48 h</i>
<i>CVVHD or CVVHDF</i>	<i>2.5 mg/kg IV every 48 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Conivaptan - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Conivaptan/Vaprisol<sup>®</sup>

{Vasopressin receptor antagonist; R for hypovolemic/euvolemic hyponatremia}

<b>Usual initial dose:</b>	20 mg IV over 30 min
<b>Usual maintenance dose:</b>	20 mg/24 h continuous IV infusion for 2–4 days; depending on response, may increase to 40 mg/24 h IV on treatment day 2 and thereafter
<b>Typical maximum dose:</b>	40 mg/day
<b>Proportion eliminated unchanged:</b>	1 % (plus 10 % as minimally active metabolites)

### *Adjustment for Kidney Disease*

#### **FDA-approved product labeling:**

<i>CrCL &gt;60 mL/min</i>	<i>20 mg/24 h continuous IV infusion for 2–4 days; monitor fluid status and serum sodium frequently and discontinue if patient develops hypovolemia, hypotension, or an undesirably rapid rate of rise of serum sodium.</i>
<i>CrCL 30–60 mg/min</i>	<i>10 mg IV followed by 10 mg/24 h continuous IV infusion for 2–4 days; if serum sodium is not increasing at a desired rate, may increase to 20 mg/24 h continuous IV infusion.</i>
<i>CrCL &lt;30 ml/min, anuria</i>	<i>Contraindicated (no improvement can be expected.)</i>

#### **Alternative adjustment:**

*Data not available*

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Cycloserine - Selected References**

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Cycloserine/Seromycin®

{Antitubercular; cell wall biosynthesis inhibitor}

<b>Usual initial dose:</b>	250 mg orally twice daily
<b>Usual maintenance dose:</b>	250–500 mg orally twice daily
<b>Typical maximum dose:</b>	1,000 mg/day orally
<b>Proportion eliminated unchanged:</b>	65 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal insufficiency</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>250–500 mg orally every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>250–500 mg orally every 24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>250–500 mg orally every 36–48 h</i>
	<i>Hemodialysis</i>	<i>250–500 mg orally three times weekly after hemodialysis</i>
	<i>CAPD</i>	<i>Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.</i>
	<i>CRRT</i>	<i>250–500 mg orally every 24 h</i>

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Dabigatran - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Dabigatran/Pradaxa®**

{Antithrombotic; direct thrombin inhibitor}

<b>Usual initial dose:</b>	150 mg orally
<b>Usual maintenance dose:</b>	150 mg orally twice daily
<b>Typical maximum dose:</b>	300 mg/day orally
<b>Proportion eliminated unchanged:</b>	51–80 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;30 mL/min</i>	<i>150 mg orally twice daily</i>
	<i>CrCL 15–30 mL/min</i>	<i>75 mg orally twice daily</i>
	<i>CrCL &lt;15 mL/min</i>	<i>Dosing recommendations cannot be provided.</i>
	<i>Hemodialysis</i>	<i>Dosing recommendations cannot be provided.</i>

*Note: Renal function should be assessed by calculating the CrCL prior to initiation of treatment. While on treatment, renal function should be assessed in clinical situations which may be associated with a decline in renal function. In patients with a CrCL <50 mL/min or >75 years of age, renal function should be assessed at least once a year.*

<b>Alternative adjustment:</b>	<i>eCrCL &gt;30 mL/min</i>	<i>150 mg orally twice daily</i>
	<i>eCrCL ≤30 mL/min</i>	<i>Due to the exclusionary lack of clinical trial data and information on patients affected by kidney disease as well as the lack of a clinically effective anticoagulant reversal agent for dabigatran-associated hemorrhage, consider beginning alternative anticoagulation therapy upon hospitalization at a minimum 24 h after patient's last dose of dabigatran:</i>
		<i>Cardiac failure, hypertension, age, diabetes mellitus, and stroke [doubled] (CHADS) score = 1–2 (low risk) → Suggest prophylactic dose subcutaneous low-molecular-weight heparin (LMWH) or no bridging over bridging with therapeutic dose LMWH or unfractionated heparin (UFH).</i>
		<i>CHADS = 2–3 (moderate risk) → Suggest therapeutic dose subcutaneous or IV UFH or prophylactic dose subcutaneous LMWH over no bridging.</i>
		<i>CHADS = 4–5 (high risk) → Recommend therapeutic dose subcutaneous or IV UFH over no bridging.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to hemorrhagic risk</i>
	<i>CRRT</i>	<i>Data not available</i>



## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Dalfampridine - Selected References**

Ampyra™ tablet film coated extended release [package insert]. Hawthorne: Acorda Therapeutics Inc; 2010.

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Dunn J, Blight A. Dalfampridine: a brief review of its mechanism of action and efficacy as a treatment to improve walking in patients with multiple sclerosis. *Curr Med Res Opin.* 2011;27:1415–23.

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Jeffrey DR, Pharr EP. Dalfampridine sustained-release for symptomatic improvement of walking speed in patients with multiple sclerosis. *Core Evid.* 2010;5:107–12.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Dalfampridine/Ampyra™** {Potassium channel blocker; R for improved walking distance in patients with multiple sclerosis (MS)}

**Usual initial dose:** 10 mg orally twice daily

**Usual maintenance dose:** 10 mg orally twice daily

**Typical maximum dose:** 20 mg/day

**Proportion eliminated unchanged:** 90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL >50 mL/min 10 mg orally twice daily (Note: In patients with mild renal impairment [CrCL 51–80 mL/min], this dose was associated serum drug levels equivalent to higher doses in patients with normal renal function that resulted in a fourfold increase in the incidence of drug-induced seizures.)*

*CrCL ≤50 mL/min Contraindicated*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Dalteparin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Dalteparin/Fragmin®**

**{Antithrombotic; low-molecular weight heparin}**

**Usual initial dose:**

2,500–5,000 units subcutaneously (prophylaxis)

200 units/kg subcutaneously (treatment)

**Usual maintenance dose:**

2,500–5,000 units subcutaneously every 24 h (prophylaxis)

200 units/kg subcutaneously every 24 h if  $\leq 95$  kg or 100 units/kg subcutaneously every 12 h if  $>95$  kg (treatment)

**Typical maximum dose:**

~30,000 units/day

**Proportion eliminated unchanged:**

Data not available

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*CrCL*  $<30$  mL/min

*In patients with symptomatic venous thromboembolism with severely impaired renal function (*CrCL*  $<30$  mL/min), monitoring for anti-Xa levels is recommended to determine the appropriate dose. Target anti-Xa range is 0.5–1.5 IU/mL. When monitoring anti-Xa in these patients, sampling should be performed 4–6 h after dosing and only after the patient has received three to four doses.*

**Alternative adjustment:**

*eGFR*  $<30$  mL/min

*Not recommended, preferably avoid—although substantial data indicate that usual doses of dalteparin provide adequate prophylactic, therapeutic, and intradialytic antithrombotic actions, currently available clinical information suggests that dalteparin effects are highly variable in patients with kidney disease and, accordingly, its use generally should be discouraged in favor of unfractionated heparin, parenteral direct thrombin inhibitors, or warfarin.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Daptomycin - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Daptomycin/Cubicin®**

**{Antibacterial, lipopeptide bacterial membrane depolarizer and protein, DNA, and RNA biosynthesis inhibitor}**

**Usual initial dose:** 6 mg/kg IV (actual body weight)

**Usual maintenance dose:** 6 mg/kg IV every 24 h

**Typical maximum dose:** 10 mg/kg/day

**Proportion eliminated unchanged:** 80 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Recommended daptomycin dosage regimen for adult patients*

<i>CrCL (mL/min)</i>	<i>Complicated skin infections</i>	<i>Staphylococcus aureus bloodstream infections</i>
$\geq 30$	4 mg/kg once every 24 h	6 mg/kg once every 24 h
$< 30$ (including hemodialysis or CAPD)	4 mg/kg once every 48 h	6 mg/kg once every 48 h

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>6–10 mg/kg actual body weight IV every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>4–6 mg/kg IV every 24–48 h</i>
<i>GFR &lt;10 mL/min</i>	<i>4–6 mg/kg IV every 48 h</i>
<i>Hemodialysis</i>	<i>4–6 mg/kg IV every 48 h or 6 mg/kg IV at end of dialysis three times weekly</i>
<i>Sustained low-efficiency dialysis</i>	<i>6 mg/kg IV daily on dialysis days</i>
<i>CAPD</i>	<i>4–6 mg/kg IV every 48 h or addition of 20 mg/L in peritoneal dialysate (limited data)</i>
<i>CVVH</i>	<i>4–6 mg/kg IV every 48 h</i>
<i>CVVHD or CVVHDF</i>	<i>8 mg/kg IV every 48 h</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Daunorubicin - Selected References**

Bachur NR, Huffman DH. Daunorubicin metabolism: estimation of daunorubicin reductase. *Br J Pharmacol.* 1971; 43:828–33.

Cerubidine® injection [package insert]. Bedford: Bedford Laboratories; 2007.

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Huffman DH, Benjamin RS, Bachur NR. Daunorubicin metabolism in acute nonlymphocytic leukemia. *Clin Pharmacol Ther.* 1972;13:895–905.

Takanashi S, Bachur NR. Daunorubicin metabolites in human urine. *J Pharmacol Exp Ther.* 1975;195:41–9.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Daunorubicin/Cerubidine®**

**{Antineoplastic, anthracycline DNA topoisomerase II, and polymerase blocker}**

<b>Usual initial dose:</b>	25–45 mg/m <sup>2</sup> IV
<b>Usual maintenance dose:</b>	25–45 mg/m <sup>2</sup> /day IV for two to three consecutive days of each cycle
<b>Typical maximum dose:</b>	60 mg/m <sup>2</sup> IV
<b>Proportion eliminated unchanged:</b>	20 % (as unchanged drug and active metabolites)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>SCr &gt;3.0 mg/dL</i>	<i>Administer 50 % of the usual daily dose.</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Deferasirox - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Deferasirox/Exjade®**

**{Fe<sup>3+</sup> chelating agent; R for chronic iron overload caused by blood transfusions (transfusional hemosiderosis)}**

<b>Usual initial dose:</b>	20 mg/kg orally
<b>Usual maintenance dose:</b>	20 mg/kg orally once daily 30 min before food
<b>Typical maximum dose:</b>	40 mg/kg/day
<b>Proportion eliminated unchanged:</b>	8 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Reduce the daily dose by 10 mg/kg if a rise in SCr to >33 % above the average of the pretreatment measurements is seen at two consecutive visits and cannot be attributed to other causes.*

*CrCL <40 mL/min or >2 times the age-appropriate upper limit of normal*

*Contraindicated*

**Alternative adjustment:**

*Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Deferoxamine - Selected References

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- Clajus C, Becker JU, Stichtenoth DO, Wortmann J, Schwarz A, Kielsterin JT. Acute kidney injury due to deferoxamine in a renal transplant patient. *Nephrol Dial Transplant*. 2008;23:1061–4.
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- Desferal® injection [package insert]. East Hanover: Novartis Pharmaceuticals Corp; 2010.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Deferoxamine (Desferrioxamine)/Desferal®**

**{Fe-chelating agent; R for acute iron intoxication and chronic iron overload from multiple transfusions (transfusional hemosiderosis); R for aluminum overload}**

#### **Usual initial dose:**

A dose of 1,000 mg IM should be administered initially. This may be followed by 500 mg IM every 4 h for two doses. Depending upon the clinical response, subsequent doses of 500 mg may be administered every 4–12 h. IV administration should be used only for patients in a state of cardiovascular collapse and then only by slow infusion. The rate of infusion should not exceed 15 mg/kg/h for the first 1,000 mg administered. Subsequent IV dosing, if needed, must be at a slower rate, not to exceed 125 mg/h.

#### **Usual maintenance dose:**

A daily dose of 1,000–2,000 mg (20–40 mg/kg/day) should be administered subcutaneously over 8–24 h, utilizing a small portable pump capable of providing continuous mini-infusion. The duration of infusion must be individualized. In some patients, as much iron will be excreted after a short infusion of 8–12 h as with the same dose given over 24 h.

#### **Typical maximum dose:**

The total amount administered should not exceed 6,000 mg in 24 h.

#### **Proportion eliminated unchanged:**

Deferoxamine and the iron chelate are excreted primarily by the kidney.

### ***Adjustment for Kidney Disease***

#### **FDA-approved product labeling:**

*Severe renal disease or anuria*      *Contraindicated*

#### **Alternative adjustment:**

*GFR >50 mL/min*      *1,000 mg IM once, then 500 mg IM every 4–12 h*

*GFR 10–50 mL/min*      *500 mg IM once, then 250 mg IM every 4–12 h (50 % decrease)*

*GFR <10 mL/min*      *Preferably avoid due to risk for accumulation of deferoxamine and the iron chelate*

*Hemodialysis*      *Preferably avoid due to risk for accumulation of deferoxamine and the iron chelate*

*CAPD*      *Preferably avoid due to risk for accumulation of deferoxamine and the iron chelate*

*CRRT*      *500 mg IM once, then 250 mg IM every 4–12 h (50 % decrease)*

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Demeclocycline - Selected References**

Agwuh KN, MacGowan A. Pharmacokinetics and pharmacodynamics of the tetracyclines including glycylicyclines. *J Antimicrob Chemother.* 2006;58:256–65.

Demeclocycline hydrochloride tablet [package insert]. Pomona: Barr Laboratories Inc; 2008.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Demeclocycline/Declomycin®** {Antibacterial; tetracycline derivative; ⚠ for hyponatremia associated with syndrome of inappropriate antidiuretic hormone (SIADH)}

**Usual initial dose:** 150 mg orally

**Usual maintenance dose:** 150 mg orally four times daily or 300 mg orally twice daily

**Typical maximum dose:** 1,200 mg/day

**Proportion eliminated unchanged:** 40 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *If renal impairment exists, even usual oral or parenteral doses may lead to excessive systemic accumulation of the drug and possible liver toxicity. Under such conditions, lower than usual total doses are indicated, and if therapy is prolonged, serum level determinations of the drug may be advisable.*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Desirudin - Selected References

- Boyce SW, Bandyk DF, Bartholomew JR, Frame JN, Rice L. A randomized, open-label pilot study comparing desirudin and argatroban in patients with suspected heparin-induced thrombocytopenia with or without thrombosis: PREVENT-HIT study. *Am J Ther.* 2011;18:14–22.
- Desirudin (Iprivask) for DVT prevention. *Med Lett Drugs Ther.* 2010;52:85–6.
- Eriksson BI, Ekman S, Lindbratt S, et al. Prevention of thromboembolism with use of recombinant hirudin. Results of a double-blind, multicenter trial comparing the efficacy of desirudin (Revasc) with that of unfractionated heparin in patients having a total hip replacement. *J Bone Joint Surg Am.* 1997;79:326–33.
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- Iprivask® injection [package insert]. Hunt Valley: Canyon Pharmaceuticals; 2010.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Desirudin/Iprivask®**

**{Antithrombotic; direct thrombin inhibitor}**

<b>Usual initial dose:</b>	15 mg subcutaneously
<b>Usual maintenance dose:</b>	15 mg subcutaneously every 12 h
<b>Typical maximum dose:</b>	30 mg/day
<b>Proportion eliminated unchanged:</b>	40–50 %

### ***Adjustment for Kidney Disease***

<b>FDA-approved product labeling:</b>	<i>CrCL ≥61 mL/min</i>	<i>15 mg subcutaneously every 12 h</i>
	<i>CrCL ≥30–60 mL/min</i>	<i>5 mg subcutaneously every 12 h<sup>a</sup></i>
	<i>CrCL &lt;31 mL/min</i>	<i>1.7 mg subcutaneously every 12 h<sup>a</sup></i>

*<sup>a</sup>Monitor aPTT and SCr at least daily; if aPTT exceeds two times control, interrupt therapy until the value returns to <2 times control. Then resume therapy at a further reduced dose guided by the initial degree of aPTT abnormality*

<b>Alternative adjustment:</b>	<i>GFR &lt;10 mL/min</i>	<i>Minimal data available. Preferably avoid due to hemorrhagic risk</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Data not available</i>



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Desmopressin - Selected References

- Agersø H, Larsen LS, Riis A, Lövgren U, Karlsson MO, Senderovitz T. Pharmacokinetics and renal excretion of desmopressin after intravenous administration to healthy subjects and renally impaired patients. *Br J Clin Pharmacol.* 2004;58:352–8.
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- DDAVP® nasal spray [package insert]. Bridgewater: Sanofi-Aventis US LLC; 2007.
- Desmopressin acetate injection USP [package insert]. Lake Forest: Hospira Inc; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Desmopressin/DDAVP<sup>®</sup>, Stimate<sup>®</sup>**

**{Antidiuretic; hemostatic; arginine vasopressin analog; coagulation factor VIII stimulator; R for central diabetes insipidus; R for nocturnal enuresis; R for hemorrhage}**

<b>Usual initial dose:</b>	For bleeding, 0.3 mcg/kg IV over 30 min or 300 mcg total dose administered as a single 150 mcg nasal insufflation per nostril; for patients <50 kg body weight, 150 mcg total dose intranasally
<b>Usual maintenance dose:</b>	For diabetes insipidus, 0.1–1.2 mg/day orally in two to three divided doses or 10–40 mcg/day intranasally in one to three doses or 2–4 mcg/day IV or subcutaneously in two divided doses
<b>Typical maximum dose:</b>	For bleeding, 300 mcg intranasally or 0.4 mcg/kg IV; for diabetes insipidus, 1.2 mg/day orally or 40 mcg/day intranasally or 4 mcg/day IV or subcutaneously
<b>Proportion eliminated unchanged:</b>	48 % (subcutaneously), 92 % (intranasal)

### ***Adjustment for Kidney Disease***

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;50 mL/min</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>CrCL &lt;50 mL/min</i>	<i>Although clinical experience and some treatment guidelines suggest that usual parenteral or slightly reduced intranasal single doses of desmopressin are effective for prevention or treatment of uremic bleeding, pharmacological studies and isolated case reports indicate that these patients may be at heightened risk for not only hyponatremia but also stroke, myocardial infarction, and other serious thrombotic complications.</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Desvenlafaxine - Selected References**

Dolder C, Nelson M, Stump A. Pharmacological and clinical profile of newer antidepressants: implications for the treatment of elderly patients. *Drugs Aging*. 2010;27:625–40.

Klamerus KJ, Maloney K, Rudolph RL, Sisenwine SF, Jusko WJ, Chiang ST. Introduction of a composite parameter to the pharmacokinetics of venlafaxine and its active O-desmethyl metabolite. *J Clin Pharmacol*. 1992;32:716–24.

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Preskorn S, Patroneva A, Nichols A, Silman H, Pedersen R, Paul J, Ahmed S. A comparison of the pharmacokinetics of venlafaxine extended release and desvenlafaxine succinate in healthy subjects [abstract]. *Eur Neuropsychopharmacol*. 2007;17:S339.

Pristiq® tablet extended release [package insert]. Philadelphia: Wyeth Pharmaceuticals Inc; 2011.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Desvenlafaxine/Pristiq®** {Antidepressant; serotonin and norepinephrine reuptake inhibitor (SRNI)}

**Usual initial dose:** 50 mg once daily  
**Usual maintenance dose:** 50–400 mg orally once daily  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 49 % plus 4 % as active didesmethylated metabolite

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;50 mL/min</i>	<i>50–400 mg orally once daily</i>
	<i>CrCL 30–50 mL/min</i>	<i>50 mg orally once daily</i>
	<i>CrCL &lt;30 mL/min</i>	<i>50 mg orally every 48 h</i>
	<i>Hemodialysis</i>	<i>50 mg orally every 48 h (no supplemental dose after dialysis)</i>

*Note: Doses should not be escalated in patients with moderate or severe renal impairment or end-stage renal disease.*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Dexrazoxane - Selected References

- Brier ME, Gaylor SK, McGovern JP, Glue P, Fang A, Aronoff GR. Pharmacokinetics of dexrazoxane in subjects with impaired kidney function. *J Clin Pharmacol.* 2011;51:731–8.
- Chow WA, Synold TW, Tetef ML, et al. Feasibility and pharmacokinetic study of infusional dexrazoxane and dose-intensive doxorubicin administered concurrently over 96 h for the treatment of advanced malignancies. *Cancer Chemother Pharmacol.* 2004;54:241–8.
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- Dexrazoxane injection [package insert]. Bedford: Bedford Laboratories; 2005.
- Earhart RH, Tutsch KD, Koeller JM, et al. Pharmacokinetics of (+)-1,2-di(3,5-dioxopiperazin-i-yl) propane intravenous infusions in adult cancer patients. *Cancer Res.* 1982;42:5255–61.
- Herman EH, El-Hage A, Ferrans VJ. Protective effect of ICRF-187 on doxorubicin-induced cardiac and renal toxicity in spontaneously hypertensive (SHR) and normotensive (WKY) rats. *Toxicol Appl Pharmacol.* 1988;92:42–53.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Dexrazoxane/Totect®, Zinecard®** {Cytoprotective agent; R for reducing the incidence of cardiomyopathy associated with anthracyclines; R for extravasation resulting from anthracycline chemotherapy}

**Usual initial dose:** Recommended dosage ratio of dexrazoxane:doxorubicin is 10:1 (e.g., 500 mg/m<sup>2</sup> dexrazoxane IV to 50 mg/m<sup>2</sup> doxorubicin).

**Usual maintenance dose:** Ten times the proportional doxorubicin dose (ratio 10:1) IV every 3 weeks

**Typical maximum dose:** 1,000 mg/m<sup>2</sup> every 3 weeks

**Proportion eliminated unchanged:** 11–49 % depending on excretory renal function

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Moderate to severe renal dysfunction (CrCL <40 mL/min)*      *The recommended dosage ratio of dexrazoxane:doxorubicin is 5:1 (e.g., 250 mg/m<sup>2</sup> dexrazoxane to 50 mg/m<sup>2</sup> doxorubicin).*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Diatrizoate - Selected References

- Ackrill P, McIntosh CS, Nimmon C, Baker LRI, Cattell WR. A comparison of the clearance of urographic contrast medium (sodium diatrizoate) by peritoneal and haemodialysis. *Clin Sci Mol Med*. 1976;50:69–74.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Diatrizoate/Hypaque-76™**                      **{Iodinated radiocontrast media}**

**Usual initial dose:**                              Excretory urography—20 mL IV

**Usual maintenance dose:**                      N/A

**Typical maximum dose:**                      Excretory urography—40 mL IV

**Proportion eliminated unchanged:**      94–100 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Severely impaired renal function*

*Urography should be performed with caution.*

*All other indications—dose adjustment not required*

*Azotemia and dehydration*

*Urography and large-dose vascular procedures are contraindicated.*

*Anuria*

*Urography is contraindicated.*

**Alternative adjustment:**

*All patients*

*Caution: contrast induced nephropathy*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Diclofenac - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Diclofenac/Voltaren<sup>®</sup>, Cataflam<sup>®</sup>** {Anti-inflammatory; nonsteroidal anti-inflammatory drug}

<b>Usual initial dose:</b>	50 mg orally
<b>Usual maintenance dose:</b>	50 mg orally two to three times daily
<b>Typical maximum dose:</b>	200 mg/day
<b>Proportion eliminated unchanged:</b>	65 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Treatment with diclofenac potassium tablets is not recommended in patients with advanced renal disease; if therapy with diclofenac is undertaken, close monitoring of the patient's renal function is advisable.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>50 mg twice daily (50–100 % of usual dose)</i>
	<i>GFR 10–50 mL/min</i>	<i>25 mg twice daily (50 % of usual dose)</i>
	<i>GFR &lt;10 mL/min</i>	<i>25 mg once daily (25 % of usual dose)</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to potential for gastrointestinal and renal toxicity</i>
	<i>CAPD</i>	<i>Preferably avoid due to potential for gastrointestinal and renal toxicity</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid due to potential for gastrointestinal and renal toxicity</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Didanosine - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Didanosine (EC)/ddI, Videx® EC** {Antiretroviral; nucleoside reverse transcriptase inhibitor}

<b>Usual initial dose:</b>	400 mg orally (250 mg if weight <60 kg)
<b>Usual maintenance dose:</b>	400 mg orally every 24 h (250 mg q12h if weight <60 kg)
<b>Typical maximum dose:</b>	400 mg orally
<b>Proportion eliminated unchanged:</b>	60 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Recommended didanosine EC oral dosage in patients with renal impairment by body weight*

<i>CrCL (mL/min)</i>	<i>Dosage (mg)</i>	
	<i>≥60 kg</i>	<i>&lt;60 kg</i>
<i>≥60</i>	<i>400 once daily</i>	<i>250 once daily</i>
<i>30–59</i>	<i>200 once daily</i>	<i>125 once daily</i>
<i>10–29</i>	<i>125 once daily</i>	<i>125 once daily</i>
<i>&lt;10</i>	<i>125 once daily</i>	<i>Not suitable for use in patients &lt;60 kg with CrCL &lt;10 mL/min</i>

*An alternate formulation of didanosine should be used*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>200 mg orally every 12 h (125 mg q12h if &lt;60 kg)</i>
	<i>GFR 10–50 mL/min</i>	<i>200 mg orally every 24 h (125 mg q12h if &lt;60 kg)</i>
	<i>GFR &lt;10 mL/min</i>	<i>125 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>125 mg orally every 24 h</i>
	<i>CAPD</i>	<i>125 mg orally every 24 h</i>
	<i>CRRT</i>	<i>200 mg enterally every 24 h (125 mg q12h if &lt;60 kg)</i>

*Note: If taken together with tenofovir, a dose reduction of didanosine EC to 250 mg (adults ≥60 kg with CrCL ≥60 mL/min) or 200 mg (adults <60 kg with CrCL ≥60 mL/min) once daily with a light meal (400 kcal or less, 20 % fat or less) or in the fasted state is recommended.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Digoxin - Selected References

- Ahmed A, Rich MW, Fleg JL, et al. Effects of digoxin on morbidity and mortality in diastolic heart failure: the Ancillary Digitalis Investigation Group trial. *Circulation*. 2006;114:397–403.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Lanoxin<sup>®</sup> injection [package insert]. Research Triangle Park: GlaxoSmithKline; 2009.
- Lanoxin<sup>®</sup> tablets [package insert]. Research Triangle Park: GlaxoSmithKline; 2009.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Digoxin/Lanoxin<sup>®</sup>, Digitek<sup>®</sup>**

**{Inotropic agent; cardiac glycoside}**

<b>Usual initial dose:</b>	8–12 µg/kg IV or orally, e.g., 500 µg followed by 125 µg every 6 h ×2 doses
<b>Usual maintenance dose:</b>	125 µg IV or orally once daily
<b>Typical maximum dose:</b>	375 µg IV or orally once daily
<b>Proportion eliminated unchanged:</b>	25 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Usual daily maintenance dose requirements (mcg) of digoxin for estimated peak body stores of 10 mcg/kg*

CrCL (mL/min)	Lean body weight						Number of days before steady state achieved
	50 kg; 110 lb	60 kg; 132 lb	70 kg; 154 lb	80 kg; 176 lb	90 kg; 198 lb	100 kg; 220 lb	
0	62.5	125	125	125	187.5	187.5	22
10	125	125	125	187.5	187.5	187.5	19
20	125	125	187.5	187.5	187.5	250	16
30	125	187.5	187.5	187.5	250	250	14
40	125	187.5	187.5	250	250	250	13
50	187.5	187.5	250	250	250	250	12
60	187.5	187.5	250	250	250	375	11
70	187.5	250	250	250	250	375	10
80	187.5	250	250	250	375	375	9
90	187.5	250	250	250	375	500	8
100	250	250	250	375	375	500	7

### **Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>125–250 µg IV or orally once daily (100 % of usual dose every 24 h)</i>
<i>GFR 10–50 mL/min</i>	<i>62.5 µg orally every 24–36 h (25–75 % of usual dose every 24–36 h)</i>
<i>GFR &lt;10 mL/min</i>	<i>62.5 µg every 48 h (10–25 % of usual dose every 48 h)</i>
<i>CAPD</i>	<i>62.5 µg every 48 h (10–25 % of usual dose every 48 h)</i>
<i>Hemodialysis</i>	<i>62.5 µg every 48 h (10–25 % of usual dose every 48 h)</i>
<i>CRRT</i>	<i>62.5 µg every 48 h (10–25 % of usual dose every 48 h)</i>

### **Therapeutic drug monitoring**

**Therapeutic plasma levels:** *0.8–2 ng/mL; draw sample 8–24 h after dose.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Dihydroergotamine - Selected References

- Aylward M, Davies DE, Maddock J, Robinson PR, Jones M. On the treatment of migraine: pharmacokinetic-pharmacodynamic relationships for programmed release formulation of dihydroergotamine administered orally in the human. *Cephalgia*. 1983;3(Suppl 1):146–50.
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- Little PJ, Jennings GI, Skews H, Bobik A. Bioavailability of dihydroergotamine in man. *Br J Clin Pharmacol*. 1982;13:785–90.
- Migranal<sup>®</sup> nasal spray [package insert]. Aliso Viejo: Valeant Pharmaceuticals North America; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Dihydroergotamine/DHE 45®, Migranal®** {Antimigraine; ergotamine derivative}

**Usual initial dose:** 1 mg (1 mL) intravenously, intramuscularly, or subcutaneously; 1 spray (0.5 mg) in each nostril

**Usual maintenance dose:** 1 mg (1 mL) intravenously, intramuscularly, or subcutaneously repeated, as needed, at 1-h intervals to a total dose of 3 mg (3 mL) for intramuscular or subcutaneous delivery or 2 mg (2 mL) for intravenous delivery in a 24-h period; 1 spray (0.5 mg) in each nostril repeated if necessary in 15 min for a total of 4 sprays (2 mg)

**Typical maximum dose:** The total weekly dosage should not exceed 6 mg (6 mL).

**Proportion eliminated unchanged:** 7 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Severely impaired renal function*      *Contraindicated*

**Alternative adjustment:** *Data not available*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Disopyramide - Selected References

- Aitio M-L. Plasma concentrations and protein binding of disopyramide and mono-N-dealkyldisopyramide during chronic oral disopyramide therapy. *Br J Clin Pharmacol*. 1981;11:369–76.
- Aitio M-L, Allonen H, Kanto J, Mäntylä R. The pharmacokinetics of disopyramide and mono-N-dealkyldisopyramide in humans. *Int J Clin Pharmacol Ther Toxicol*. 1982;20:219–26.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Bonde J, Jensen NM, Pedersen LE, et al. Disposition kinetics and urinary disopyramide in human healthy volunteers described by an open three compartment model. *Pharmacol Toxicol*. 1989;64:412–6.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Disopyramide/Norpace®** {Antiarrhythmic, class IA}

**Usual initial dose:** 100 mg orally  
**Usual maintenance dose:** 100 mg orally every 6 h or 200 mg (CR) orally every 12 h (if ≤50 kg)  
 150 mg orally every 6 h or 300 mg (CR) orally every 12 h (if >50 kg)  
**Typical maximum dose:** 400 mg orally every 6 h  
**Proportion eliminated unchanged:** 47 % plus 22 % as active oxidative metabolite

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Disopyramide dosage interval for patients with renal insufficiency*

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*Following an initial dose of 150 mg orally, administer 100 mg orally at the following intervals*

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<i>CrCL (mL/min)</i>	<i>30–40</i>	<i>15–30</i>	<i>&lt;15</i>
<i>Approx maintenance–dosing interval</i>	<i>q 8 h</i>	<i>q 12 h</i>	<i>q 24 h</i>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>100–150 mg every 8 h</i>
<i>GFR 10–50 mL/min</i>	<i>100 mg orally every 12–24 h; monitor and titrate to clinical effect.</i>
<i>GFR &lt;10 mL/min</i>	<i>100 mg orally every 24–48 h; monitor and titrate to clinical effect.</i>
<i>Hemodialysis</i>	<i>100 mg orally every 24–48 h; monitor and titrate to clinical effect.</i>
<i>CAPD</i>	<i>100 mg orally every 24–48 h; monitor and titrate to clinical effect.</i>
<i>CRRT</i>	<i>100 mg enterally every 12–24 h; monitor and titrate to clinical effect.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Dofetilide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Dofetilide/Tikosyn**<sup>®</sup> {Antiarrhythmic, class III; potassium channel ( $I_{KR}$ ) blocker}

**Usual initial dose:** 500 mcg orally  
**Usual maintenance dose:** 500 mcg orally twice daily  
**Typical maximum dose:** 1,000 mcg/day  
**Proportion eliminated unchanged:** 80 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Dofetilide starting dose determination*

<i>Calculated CrCL (mL/min)</i>	<i>Dofetilide dose</i>
>60	500 mcg twice daily
40–60	250 mcg twice daily
20–39	125 mcg twice daily
<20	Contraindicated

**Alternative adjustment:** *Data not available*

*Note: Treatment in all patients should be initiated with electrocardiographic monitoring; prolongation of 2-h post-dose corrected QT interval >15 % of baseline or >500 ms indicates need for downward dosage adjustment.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Doripenem - Selected References

- Abramowicz M, Zuccotti G, Pflomm J-M, et al., editors. Handbook of antimicrobial therapy. 19th ed. New Rochelle: The Medical Letter; 2011.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Doripenem/Doribax®** {Antibacterial; carbapenem}

**Usual initial dose:** 500 mg IV  
**Usual maintenance dose:** 500 mg IV every 8 h  
**Typical maximum dose:** 500 mg IV every 8 h  
**Proportion eliminated unchanged:** 70 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Doripenem dosage in patients with renal function impairment*

<i>Estimated CrCL (mL/min)</i>	<i>Recommended dosage</i>
<i>&gt;50</i>	<i>No dosage adjustment necessary</i>
<i>≥30 to ≤50</i>	<i>250 mg IV every 8 h</i>
<i>&gt;10 to &lt;30</i>	<i>250 mg IV every 12 h</i>
<i>eCrCL &gt;50 mL/min</i>	<i>500 mg IV over 1–4 h every 8 h</i>
<i>eCrCL 30–50 mL/min</i>	<i>250 mg IV over 1–4 h every 8 h</i>
<i>eCrCL 10–29 mL/min</i>	<i>250 mg IV over 1–4 h every 12 h</i>
<i>eCrCL &lt;10 mL/min</i>	<i>250 mg IV every 12 h</i>
<i>Hemodialysis</i>	<i>250 mg IV every 12 h or 500 mg IV every 24 h</i>
<i>CVVHD</i>	<i>250 mg IV every 12 h</i>
<i>High flow CVVHDF</i>	<i>500 mg IV every 12 h</i>

**Alternative adjustment:**

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Duloxetine - Selected References

- Carter NJ, McCormack PL. Duloxetine: a review of its use in generalized anxiety disorder. *CNS Drugs*. 2009;23:523–41.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Duloxetine/Cymbalta®** {Antidepressant; anxiolytic; R for neuropathic pain; CNS serotonergic and noradrenergic action potentiator}

**Usual initial dose:** 30 mg orally  
**Usual maintenance dose:** 60 mg orally once daily  
**Typical maximum dose:** 120 mg orally once daily  
**Proportion eliminated unchanged:** Minimal (72 % of an absorbed dose is eliminated in urine as the glucuronide and/or sulfate conjugates of the oxidative duloxetine metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Increased plasma concentration of duloxetine and especially its metabolites occurs in patients with end-stage renal disease (requiring dialysis); duloxetine ordinarily should not be used in patients with end-stage renal disease or severe renal impairment (CrCL <30 mL/min).*

**Alternative adjustment:**

<i>eCrCL ≥30 mL/min</i>	<i>30–120 mg orally once daily (no dose adjustment necessary)</i>
<i>eCrCL &lt;30 mL/min</i>	<i>Data not available; preferably avoid unless no suitable alternative is available; if indeed necessary, dose conservatively, carefully monitor responses, and cautiously adjust doses.</i>



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Dyphylline - Selected References

- Acara M, Carr EA Jr, Terry EN. Probenecid inhibition of the renal excretion of dyphylline in chicken, rat, and man. *J Pharm Sci.* 1987;39:526–30.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Dyphylline/Lufyllin®

{Bronchodilator; theophylline derivative; phosphodiesterase and prostaglandin inhibitor}

<b>Usual initial dose:</b>	200 mg orally
<b>Usual maintenance dose:</b>	200–400 mg orally three or four times daily
<b>Typical maximum dose:</b>	15 mg/kg/day
<b>Proportion eliminated unchanged:</b>	83 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Appropriate dosage adjustments should be made in patients with impaired renal function. The renal clearance would be reduced in patients with impaired renal function. In anuric patients, the half-life (approx. 2 h) may be increased three to four times normal.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>150–300 mg orally three or four times daily (25 % decrease)</i>
	<i>GFR 10–50 mL/min</i>	<i>100–200 mg orally three or four times daily (50 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>50–100 mg orally three or four times daily (75 % decrease)</i>
	<i>Hemodialysis</i>	<i>50–100 mg orally three or four times daily; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>100–200 mg orally three or four times daily</i>

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## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Edetate Calcium Disodium - Selected References**

Calcium disodium Versenate® injection [package insert]. Northridge: 3M Pharmaceuticals; 2004.

Cory-Slechta DA, Weiss B, Cox C. Mobilization and redistribution of lead over the course of calcium disodium ethylenediamine tetraacetate chelation therapy. *J Pharmacol Exp Ther.* 1987;243:804–13.

Osterloh J, Becker CE. Pharmacokinetics of  $\text{CaNa}_2\text{EDTA}$  and chelation of lead in renal failure. *Clin Pharmacol Ther.* 1986;40:686–93.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Edetate Calcium Disodium/ Calcium Disodium Versenate®

{Chelating agent; R for lead poisoning}

<b>Usual initial dose:</b>	1,000 mg/m <sup>2</sup> IV or IM
<b>Usual maintenance dose:</b>	If blood lead level is <70 mcg/dL but >20 mcg/dL (World Health Organization recommended upper allowable level), administer 1,000 mg/m <sup>2</sup> /day IV or IM.
<b>Typical maximum dose:</b>	1,000 mg/m <sup>2</sup> IV or IM
<b>Proportion eliminated unchanged:</b>	~100 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Normal renal function</i>	<i>500 mg/m<sup>2</sup> every 24 h for 5 days for patients with SCr levels of 2–3 mg/dL, every 48 h for three doses for patients with SCr levels of 3–4 mg/dL, and once weekly for patients with SCr levels above 4 mg/dL. These regimens may be repeated at 1-month intervals.</i>
	<i>Active renal disease/ anuria</i>	<i>Contraindicated</i>

**Alternative adjustment:** *Data not available*

*Note: Edetate calcium disodium may be confused with edetate disodium. Fatal hypocalcemia may result if edetate disodium is used for chelation therapy instead of edetate calcium disodium. Always confirm diagnosis to distinguish between the two drugs prior to dispensing and/or administering either medication.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Efavirenz and Emtricitabine and Tenofovir - Selected References

A once-daily combination tablet (Atripla) for HIV. *Med Lett Drugs Ther.* 2006;48:78–9.

Atripla® tablet [package insert]. Foster City: Bristol-Myers Squibb & Gilead Sciences LLC; 2011.

Deeks ED, Perry CM. Efavirenz/emtricitabine/tenofovir disoproxil fumarate single-tablet regimen (Atripla®): a review of its use in the management of HIV infection. *Drugs.* 2010;70:2315–38.

Feng JY, Ly JK, Myrick F, et al. The triple combination of tenofovir, emtricitabine and efavirenz shows synergistic anti-HIV-1 activity in vitro: a mechanism of action study. *Retrovirology.* 2009;6:44. doi:[10.1186/1742-4690-6-44](https://doi.org/10.1186/1742-4690-6-44).

Goicoechea M, Best B. Efavirenz/emtricitabine/tenofovir disoproxil fumarate fixed-dose combination: first-line therapy for all? *Expert Opin Pharmacother.* 2007;8:371–82.

Gupta SK, Eustace JA, Winston JA, et al. Guidelines for the management of chronic kidney disease in HIV-infected patients: recommendations of the HIV Medicine Section of the Infectious Diseases Society of America. *Clin Infect Dis.* 2005;40:1559–85.

Jhaveri MA, Browning SR, Bush H, Thornton A, Greenberg RN. Comparison of 3-drug versus 4-drug and PI versus non-PI combinations as initial HAART: experience from 1998 to 2007. *J Int Assoc Physicians AIDS Care (Chic).* 2009;8:299–307.

Mathias AA, Hinkle J, Menning M, Hui J, Kaul S, Kearney BP. Bioequivalence of efavirenz/emtricitabine/tenofovir disoproxil fumarate single-tablet regimen. *J Acquir Immune Defic Syndr.* 2007;46:167–73.

Thompson MA, Aberg JA, Cahn P, et al. Antiretroviral treatment of adult HIV infection: 2010 recommendations of the International AIDS Society—USA Panel. *JAMA.* 2010;304:321–33.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Efavirenz and Emtricitabine and Tenofovir/Atripla®** {Antiretroviral; combination non-nucleoside and nucleoside reverse transcriptase inhibitor}

**Usual initial dose:** One tablet

**Usual maintenance dose:** One tablet once daily taken orally on an empty stomach; dosing at bedtime may improve the tolerability of nervous system symptoms.

**Typical maximum dose:** One tablet daily

**Proportion eliminated unchanged:** 85 % (emtricitabine)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Because efavirenz/emtricitabine/tenofovir is a fixed-dose combination, it should not be prescribed for patients requiring dosage adjustment, such as those with moderate or severe renal impairment (CrCL <50 mL/min).*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Emtricitabine - Selected References

- Anderson PL, Kakuda TN, Lichtenstein KA. The cellular pharmacology of nucleoside- and nucleotide-analogue reverse-transcriptase inhibitors and its relationship to clinical toxicities. *Clin Infect Dis*. 2004;38:743–53.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Bang LM, Scott LJ. Emtricitabine: an antiretroviral agent for HIV infection. *Drugs*. 2003;63:2413–24.
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- Emtriva® capsule and solution [package insert]. Foster City: Gilead Sciences Inc; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Emtricitabine/FTC, Emtriva®** {Antiretroviral; nucleoside reverse transcriptase inhibitor}

**Usual initial dose:** 200 mg orally  
**Usual maintenance dose:** 200 mg orally once daily  
**Typical maximum dose:** 200 mg orally once daily  
**Proportion eliminated unchanged:** 85 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Emtricitabine dosage adjustment in adult patients with renal impairment*

Formulation	CrCL (mL/min)			
	≥50	30–49	15–29	<15 or on hemodialysis
Capsule	200 mg every 24 h	200 mg every 48 h	200 mg every 72 h	200 mg every 96 h
Solution	240 mg every 24 h (24 mL)	120 mg every 24 h (12 mL)	80 mg every 24 h (8 mL)	60 mg every 24 h (6 mL)

*Hemodialysis patients: if dosing on day of dialysis, administer after dialysis*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>200 mg every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>200 mg orally every 48–96 h</i>
<i>GFR &lt;10 mL/min</i>	<i>200 mg orally every 96 h</i>
<i>Hemodialysis</i>	<i>200 mg orally every 96 h; administer after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>200 mg enterally every 48 h or 120 mg (solution) every 24 h</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Emtricitabine and Tenofovir - Selected References**

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Emtricitabine and Tenofovir/Truvada®** {Antiretroviral; nucleoside/nucleotide analogue reverse transcriptase inhibitor}

**Usual initial dose:** One tablet

**Usual maintenance dose:** One tablet (containing 200 mg of emtricitabine and 300 mg of tenofovir disoproxil fumarate) once daily taken orally with or without food

**Typical maximum dose:** One tablet once daily

**Proportion eliminated unchanged:** 85 % (emtricitabine)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Dosage interval adjustment of Truvada for patients with altered creatinine clearance*

<i>CrCL (mL/min)<sup>a</sup></i>	<i>≥50</i>	<i>30–49</i>	<i>&lt;30 (including patients requiring hemodialysis)</i>
<i>Dosing interval</i>	<i>Every 24 h</i>	<i>Every 48 h</i>	<i>Avoid</i>

<sup>a</sup>*Calculated using ideal (lean) body weight*

**Alternative adjustment:**

*GFR >50 mL/min*                      *One tablet orally every 24 h*

*GFR 10–50 mL/min*                      *One tablet orally every 48 h*

*GFR <10 mL/min*                      *Minimal data available*

*Hemodialysis*                      *Minimal data available*

*CAPD*                      *Data not available*

*CRRT*                      *One tablet enterally every 48 h*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Enalapril - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Enalapril/Vasotec®** {Antihypertensive; vasodilator; angiotensin-converting enzyme (ACE)/renin inhibitor}

**Usual initial dose:** 2.5 mg  
**Usual maintenance dose:** 5–20 mg orally twice daily  
**Typical maximum dose:** 40 mg/day  
**Proportion eliminated unchanged:** 90 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Dosage adjustments for enalapril in hypertensive patients with renal function impairment*

<i>Renal status</i>	<i>CrCL (mL/min)</i>	<i>Initial dose (mg/day)</i>
<i>Normal renal function</i>	<i>&gt;80</i>	<i>5 mg</i>
<i>Mild impairment</i>	<i>30 to ≤80</i>	<i>5 mg</i>
<i>Moderate to severe impairment</i>	<i>≤30</i>	<i>2.5 mg</i>
<i>Hemodialysis</i>	<i>–</i>	<i>2.5 mg on dialysis day</i>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>5–20 mg orally twice daily</i>
<i>GFR 10–50 mL/min</i>	<i>2.5–10 orally twice daily</i>
<i>GFR &lt;10 mL/min</i>	<i>1.25–5 mg orally twice daily</i>
<i>Hemodialysis</i>	<i>1.25–5 mg orally twice daily; dose after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>1.25–5 mg orally twice daily</i>
<i>CRRT</i>	<i>2.5–10 enterally twice daily; titrate</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Enalaprilat - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Enalaprilat/Vasotec® IV** {Antihypertensive, vasodilator, angiotensin-converting enzyme (ACE)/renin inhibitor}

**Usual initial dose:** 0.625 mg IV  
**Usual maintenance dose:** 1.25 mg IV every 6 h over a 5-min period  
**Typical maximum dose:** 2.5 mg IV  
**Proportion eliminated unchanged:** 90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Dosage adjustments for enalaprilat in hypertensive patients with renal function impairment*

<i>CrCL (mL/min)</i>	<i>Enalaprilat initial dose</i>
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<i>≥30 (or SCr &lt;3.0 mg/dL)</i>	<i>1.25 mg IV every 6 h</i>
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<i>&lt;30 (or SCr ≥3.0 mg/dL)</i>	<i>0.625 mg IV; if response is inadequate, dose may be repeated in 1 h</i>
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*Additional doses of 1.25 mg IV q6h may be given*

<i>Hemodialysis</i>	<i>0.625 mg IV</i>
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<b>Alternative adjustment:</b> <i>GFR &gt;50 mL/min</i>	<i>1.25 mg IV every 6 h over a 5-min period</i>
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<i>GFR 10–50 mL/min</i>	<i>0.625–1.25 mg IV every 6 h</i>
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<i>GFR &lt;10 mL/min</i>	<i>0.312–0.625 mg IV every 6 h</i>
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<i>Hemodialysis</i>	<i>0.312–0.625 mg IV every 6 h; dose after hemodialysis on dialysis days</i>
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<i>CAPD</i>	<i>0.312–0.625 mg IV every 6 h</i>
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<i>CRRT</i>	<i>0.625–1.25 mg IV every 6 h; titrate</i>
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Enoxaparin - Selected References

- Aggarwal A, Whitaker DA, Rimmer JM, et al. Attenuation of platelet reactivity by enoxaparin compared with unfractionated heparin in patients undergoing haemodialysis. *Nephrol Dial Transplant*. 2004;19:1559–63.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Enoxaparin/Lovenox®** {Antithrombotic; low-molecular-weight heparin}

<b>Usual initial dose:</b>	30–40 mg subcutaneously (prophylaxis); 1 mg/kg subcutaneously (treatment)
<b>Usual maintenance dose:</b>	30 mg subcutaneously every 12 h or 40 mg subcutaneously every 24 h (prophylaxis); 1 mg/kg subcutaneously every 12 h or 1.5 mg/kg subcutaneously every 24 h (treatment)
<b>Typical maximum dose:</b>	120 mg subcutaneously
<b>Proportion eliminated unchanged:</b>	40 %

#### *Adjustment for Kidney Disease*

##### **FDA-approved product labeling:**

*Enoxaparin dosage regimens for patients with severe renal function impairment (CrCL <30 mL/min)*

<i>Indication</i>	<i>Dosage regimen</i>
<i>Acute STEMI<sup>a</sup> in patients &lt;75 years of age</i>	<i>30-mg single IV bolus plus 1-mg/kg subcutaneous dose followed by 1 mg/kg subcutaneously once daily</i>
<i>Acute STEMI in patients ≥75 years of age</i>	<i>1 mg/kg subcutaneously once daily (no initial bolus)</i>
<i>Prophylaxis of DVT<sup>a</sup>, abdominal surgery, hip or knee replacement surgery, medical patients during acute illness</i>	<i>30 mg subcutaneously once daily</i>
<i>Treatment of acute DVT with or without PE<sup>a</sup>, when administered in conjunction with warfarin</i>	<i>1 mg/kg subcutaneously once daily</i>
<i>Unstable angina/non-Q-wave MI, when coadministered with aspirin</i>	<i>1 mg/kg subcutaneously once daily</i>

*Although no dose adjustment is recommended in patients with moderate (CrCL 30–49 mL/min) and mild (CrCL 50–80 mL/min) renal function impairment, all such patients should be observed carefully for signs and symptoms of bleeding*

<sup>a</sup>STEMI ST-elevation myocardial infarction, DVT deep vein thrombosis, PE pulmonary embolism

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>30 mg subcutaneously every 12 h or 40 mg subcutaneously every 24 h (prophylaxis) or 1 mg/kg subcutaneously every 12 h or 1.5 mg/kg subcutaneously every 24 h (treatment)</i>
	<i>GFR 10–50 mL/min</i>	<i>15–20 mg subcutaneously every 12 h (prophylaxis) or 0.5–0.75 mg/kg subcutaneously every 12 h (treatment) (25–50 % decrease); monitor anti-Xa levels.</i>
	<i>GFR &lt;10 mL/min</i>	<i>15 mg subcutaneously every 12 h (prophylaxis) or 0.5 mg/kg subcutaneously every 12 h (treatment) (50 % decrease); monitor anti-Xa levels.</i>
	<i>Hemodialysis</i>	<i>0.5 mg/kg subcutaneously every 12 h; monitor anti-Xa levels.</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CVVHD</i>	<i>0.5–0.7 mg/kg IV every 12 h; monitor anti-Xa levels</i>

*Note: Patients presenting with STEMI with all levels of kidney function have been successfully managed with IV enoxaparin 0.5 mg/kg ×1 prior to **percutaneous coronary intervention**.*

*Due to **excessive bleeding risk** documented in clinical trials in patients with **eGFR <30 mL/min**, enoxaparin use generally should be discouraged in these individuals in favor of unfractionated heparin or parenteral direct thrombin inhibitors.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Entecavir - Selected References

- Baraclude® tablet and oral solution[package insert]. Princeton: Bristol-Myers Squibb Co; 2010.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Entecavir/Baraclude®** {Antiviral; R for chronic hepatitis B}

<b>Usual initial dose:</b>	0.5 mg orally
<b>Usual maintenance dose:</b>	0.5–1 mg orally once daily
<b>Typical maximum dose:</b>	1 mg
<b>Proportion eliminated unchanged:</b>	65 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Entecavir oral dosage for adult patients with renal function impairment*

<i>CrCL (mL/min)</i>	<i>Usual dose (nucleoside naïve)</i>	<i>Lamivudine-refractory or decompensated liver disease</i>
$\geq 50$	0.5 mg once daily	1 mg once daily
30 to <50	0.25 mg once daily <sup>b</sup> or 0.5 mg every 48 h	0.5 mg once daily or 1 mg every 48 h
10 to <30	0.15 mg once daily <sup>b</sup> or 0.5 mg every 72 h	0.3 mg once daily <sup>b</sup> or 1 mg every 72 h
<10; hemodialysis <sup>a</sup> or CAPD	0.05 mg once daily <sup>b</sup> or 0.5 mg every 7 days	0.1 mg once daily <sup>b</sup> or 1 mg every 7 days

<sup>a</sup>Administer after hemodialysis on dialysis days

<sup>b</sup>Oral solution is recommended for doses <0.5 mg

#### **Alternative adjustment:**

*Entecavir oral dosage adapted to renal function*

<i>GFR (mL/min)</i>	<i>Naïve patients</i>	<i>Lamivudine-resistant patients</i>
>50	0.5 mg/day	1 mg/day
30–49	0.25 mg/day <sup>b</sup> or 0.5 mg every 48 h	0.5 mg/day
10–29	0.15 mg/day <sup>b</sup> or 0.5 mg every 72 h	0.3 mg/day <sup>b</sup> or 0.5 mg every 48 h
Hemodialysis <sup>a</sup>	0.05 mg/day <sup>b</sup> or 0.5 mg every 5–7 days	0.1 mg/day <sup>b</sup> or 0.5 mg every 72 h

<sup>a</sup>Administer after hemodialysis on dialysis days

<sup>b</sup>Oral solution is recommended for doses <0.5 mg

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Eplerenone - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Eplerenone/Inspra™** {Selective aldosterone receptor antagonist; renin inhibitor}

**Usual initial dose:** 25 mg orally  
**Usual maintenance dose:** 25–50 mg orally once daily  
**Typical maximum dose:** 100 mg/day  
**Proportion eliminated unchanged:** 7 % (~65 % as metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL <30 mL/min or  
SCr >2.0 mg/dL in males or  
SCr >1.8 mg/dL in females* *Contraindicated*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Eptifibatide - Selected References

- Alexander KP, Chen AY, Newby LK, et al. Sex differences in major bleeding with glycoprotein IIb/IIIa inhibitors: results from the CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation of the ACC/AHA Guidelines) initiative. *Circulation*. 2006;114:1380–7.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Eptifibatide/Integrilin®** {Platelet aggregation inhibitor; glycoprotein IIb/IIIa antagonist}

**Usual initial dose:** 180 mcg IV over 1–2 min repeated ×1 10 min after the initial dose

**Usual maintenance dose:** 2 mcg/kg/min continuous IV infusion

**Typical maximum dose:** 15 mg/h

**Proportion eliminated unchanged:** 50 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Acute coronary syndrome*

*CrCL ≥50 mL/min* 180 mcg/kg IV followed by continuous infusion of 2 mcg/kg/min until hospital discharge or initiation of coronary bypass surgery, up to 72 h. If the patient undergoes percutaneous coronary intervention while receiving eptifibatide, the infusion should be continued up to hospital discharge (max 96 h) or for up to 18–24 h after the procedure, whichever comes first.

*CrCL <50 mL/min* 180 mcg/kg IV as soon as possible following diagnosis, immediately followed by continuous infusion of 1 mcg/kg/min

*Hemodialysis* Contraindicated

#### ***Percutaneous coronary intervention***

*CrCL ≥50 mL/min* 180 mcg/kg IV immediately before initiation of PCI followed by continuous infusion of 2 mcg/kg/min and a second 180 mcg/kg IV bolus 10 min after the first. Infusion should be continued until hospital discharge or for up to 18–24 h, whichever comes first.

*CrCL <50 mL/min* 180 mcg/kg IV administered immediately before initiation of PCI followed by continuous infusion of 1 mcg/kg/min and a second 180 mcg/kg IV bolus 10 min after the first

*Hemodialysis* Contraindicated

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Eribulin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Eribulin/Halaven™**

**{Antineoplastic; tubulin-based antimetabolic; R for refractory metastatic breast cancer}**

<b>Usual initial dose:</b>	1.4 mg/m <sup>2</sup> IV over 2–5 min
<b>Usual maintenance dose:</b>	1.4 mg/m <sup>2</sup> IV over 2–5 min on days 1 and 8 of a 21-day cycle for a minimum of four cycles
<b>Typical maximum dose:</b>	1.4 mg/m <sup>2</sup> /dose
<b>Proportion eliminated unchanged:</b>	7 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Cr CL &gt;50 mL/min</i>	<i>1.4 mg/m<sup>2</sup> IV over 2–5 min on days 1 and 8 of a 21-day cycle</i>
	<i>CrCL 30–50 mL/min</i>	<i>1.1 mg/m<sup>2</sup> IV over 2–5 min on days 1 and 8 of a 21-day cycle</i>
	<i>CrCL &lt;30 mL/min</i>	<i>Not recommended (no data)</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ertapenem - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Ertapenem/Invanz®** {Antibacterial; carbapenem}

<b>Usual initial dose:</b>	1 g IM or IV
<b>Usual maintenance dose:</b>	1 g IM or IV once daily
<b>Typical maximum dose:</b>	1 g/day
<b>Proportion eliminated unchanged:</b>	40 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;30 mL/min</i>	<i>1 g IV daily</i>
	<i>CrCL ≤30 mL/min</i>	<i>500 mg IV daily</i>
	<i>Hemodialysis</i>	<i>500 mg IV daily; no supplemental dose is necessary if the daily doses are given within 6 h before dialysis; if given &gt;6 h prior to dialysis, give supplemental dose of 150 mg IV.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1 g IM or IV every 24 h or 1 g IV followed by continuous IV infusion of 1 g/24 h</i>
	<i>GFR 10–50 mL/min</i>	<i>1 g IM or IV every 24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>500 mg IV every 24 h</i>
	<i>Extended daily dialysis</i>	<i>1 g IV every 24 h</i>
	<i>Hemodialysis</i>	<i>500 mg IV every 24 h; administer supplemental 150 mg IV after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>500 mg IM or IV every 24 h</i>
	<i>CRRT</i>	<i>1 g IV every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ethacrynic Acid - Selected References

- Auger RG, Dayton DA, Harrison CE Jr, Tucker RM, Anderson CF. Use of ethacrynic acid in mannitol-resistant oliguric renal failure. *JAMA*. 1968;206:891-3.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ethacrynic Acid;

### Ethacrynate Sodium / Edecrin®

{Diuretic, loop/high ceiling}

<b>Usual initial dose:</b>	25–50 mg orally or 50 mg (0.5–1 mg/kg) IV
<b>Usual maintenance dose:</b>	50 mg once daily after meals to 50–100 mg twice daily after meals orally 0.5–1 mg/kg IV; dose may be repeated once/24 h if necessary.
<b>Typical maximum dose:</b>	400 mg/day orally or 200 mg/day IV
<b>Proportion eliminated unchanged:</b>	20 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Anuria or severe progressive renal disease</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>50–200 mg/day</i>
	<i>GFR 10–50 mL/min</i>	<i>50–200 mg/day</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk for gastrointestinal toxicity and ototoxicity</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ethambutol - Selected References

- Alffenaar J-W, van der Werf T. Dosing ethambutol in obese patients [letter]. *Antimicrob Agents Chemother*. 2010;54:4044–5.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ethambutol/Myambutol®** {Antitubercular; metabolite synthesis inhibitor}

**Usual initial dose:** 15 mg/kg orally  
**Usual maintenance dose:** 15 mg/kg orally once daily  
**Typical maximum dose:** 25 mg/kg/day  
**Proportion eliminated unchanged:** 50 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Patients with decreased renal function need the dosage reduced as determined by serum levels of ethambutol, since the main path of excretion of this drug is by the kidneys.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>15–25 mg/kg orally every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>15 mg/kg orally every 24–36 h or 10 mg/kg orally every 24 h</i>
<i>GFR &lt;10 mL/min</i>	<i>15 mg/kg orally every 48 h or 7 mg/kg orally every 24 h</i>
<i>Hemodialysis</i>	<i>15–25 mg/kg orally every 48 h; after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>15 mg/kg orally every 48 h</i>
<i>CRRT</i>	<i>15–25 mg/kg enterally every 24–36 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Ethionamide/Trecator®**

**{Antitubercular; peptide synthesis inhibitor}**

<b>Usual initial dose:</b>	250 mg orally
<b>Usual maintenance dose:</b>	500–1,000 mg/day (15–20 mg/kg/day) orally in three to four divided doses
<b>Typical maximum dose:</b>	1,000 mg/day
<b>Proportion eliminated unchanged:</b>	1 %

### ***Adjustment for Kidney Disease***

**FDA-approved product labeling:** *Data not available*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500–1,000 mg/day (15–20 mg/kg/day) orally with or without food in two to four divided doses</i>
	<i>GFR 10–50 mL/min</i>	<i>500–1,000 mg/day (15–20 mg/kg/day) orally with or without food in two to four divided doses</i>
	<i>GFR &lt;10 mL/min</i>	<i>250–500 mg/day (5–10 mg/kg/day) orally with or without food in two to three divided doses</i>
	<i>Hemodialysis</i>	<i>250–500 mg orally twice daily with or without food, after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>250–500 mg/day (5–10 mg/kg/day) orally with or without food in two to three divided doses</i>
	<i>CRRT</i>	<i>500–1,000 mg/day (15–20 mg/kg/day) orally with or without food in two to four divided doses</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Etodolac - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Etodolac/Lodine®** {Anti-inflammatory; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 200–400 mg orally  
**Usual maintenance dose:** 200–400 mg orally every 6–8 h as needed for pain; 300–500 mg twice daily  
**Typical maximum dose:** 1,200 mg/day  
**Proportion eliminated unchanged:** 1 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Mild to moderate renal insufficiency (CrCL 37–88 mL/min)* No dose adjustment necessary

*Advanced renal disease* Use not recommended

**Alternative adjustment:** *GFR >50 mL/min* 200–400 mg orally every 6–8 h as needed for pain or 300–500 mg orally twice daily

*GFR 10–50 mL/min* 200–400 mg orally every 6–8 h as needed for pain or 300–500 mg orally twice daily

*GFR <10 mL/min* 200 mg orally every 6–8 h as needed for pain or 200–300 mg orally twice daily

*Hemodialysis* 200 mg orally every 6–8 h as needed for pain or 200–300 mg orally twice daily

*CAPD* Data not available

*CRRT* Not applicable; preferably avoid due to risk for gastrointestinal and/or renal toxicity

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Etoposide (VP-16) - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Etoposide (VP-16)/Toposar™** {Antineoplastic; podophyllotoxin derivative; antimetabolic}

**Usual initial dose:** 35–100 mg/m<sup>2</sup> IV

**Usual maintenance dose:** 50–100 mg/m<sup>2</sup>/day IV on days 1–5 to 100 mg/m<sup>2</sup>/day IV on days 1, 3, and 5 (testicular cancer); 35 mg/m<sup>2</sup>/day for 4 days to 50 mg/m<sup>2</sup>/day for 5 days (small cell lung cancer). Courses are repeated at 3- to 4-week intervals after adequate recovery from any toxicity.

**Typical maximum dose:** 100 mg/m<sup>2</sup>

**Proportion eliminated unchanged:** 45 %

### Adjustment for Kidney Disease

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;50 mL/min</i>	<i>35–100 mg/m<sup>2</sup> IV according to cancer type or protocol schedule</i>
	<i>CrCL 15–50 mL/min</i>	<i>26.25–75 mg/m<sup>2</sup> IV according to cancer type or protocol (75 % of usual dose)</i>
	<i>CrCL &lt;15 mL/min</i>	<i>No data; further dose reduction should be considered.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>35–100 mg/m<sup>2</sup> IV according to cancer type or protocol schedule</i>
	<i>GFR 30–50 mL/min</i>	<i>26.25–75 mg/m<sup>2</sup> IV according to cancer type or protocol (75 % of usual dose)</i>
	<i>GFR 10–29 mL/min</i>	<i>26.25–75 mg/m<sup>2</sup> IV according to cancer type or protocol (75 % of usual dose)</i>
	<i>GFR &lt;10 mL/min</i>	<i>17.5–50 mg/m<sup>2</sup> IV according to cancer type or protocol (50 % of usual dose)</i>
	<i>Hemodialysis</i>	<i>17.5–50 mg/m<sup>2</sup> IV according to cancer type or protocol (50 % of usual dose)</i>
	<i>CAPD</i>	<i>17.5–50 mg/m<sup>2</sup> IV according to cancer type or protocol (50 % of usual dose)</i>
	<i>CRRT</i>	<i>26.25–75 mg/m<sup>2</sup> IV according to cancer type or protocol (75 % of usual dose)</i>

*Note: Hematological, organ function, and other considerations may suggest further dose adjustments; monitoring drug levels is considered potentially useful, especially in patients with severe renal impairment.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Exenatide - Selected References

Byetta® injection [package insert]. San Diego: Amylin Pharmaceuticals Inc; 2010.

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Weise WJ, Sivanandy MS, Block CA, Comi RJ. Exenatide-associated ischemic renal failure [letter]. *Diabetes Care*. 2009;32:e22–3.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Exenatide/Byetta®, Bydureon®

**Extended-Release Suspension** {Antidiabetic; incretin mimetic; glucagon-like peptide (GLP)-1 agonist}

**Usual initial dose:** 5 mcg subcutaneously or 2 mg extended-release subcutaneously

**Usual maintenance Dose:** 5 mcg subcutaneously twice daily or 2 mg extended-release subcutaneously once every 7 days

**Typical maximum dose:** 10 mcg subcutaneously twice daily or 2 mg extended-release subcutaneously once every 7 days

**Proportion eliminated unchanged:** The kidney appears to be the primary route of elimination and degradation.

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 30–50 mL/min</i>	<i>Caution should be applied when initiating treatment or when escalating doses of prompt exenatide from 5 to 10 mcg in patients with moderate renal impairment.</i>
	<i>CrCL &lt;30 mL/min</i>	<i>Avoid; prompt or extended-release injection should not be used in patients with severe renal impairment or end-stage renal disease receiving dialysis due to gastrointestinal side effects and intolerance.</i>
	<i>Renal transplantation</i>	<i>Use with caution; exenatide may induce nausea and vomiting with transient hypovolemia, and treatment may worsen renal function.</i>
<b>Alternative adjustment:</b>	<i>eCrCL &lt;30 mL/min</i>	<i>Preferably avoid. As compared with subjects with normal renal function, patients with end-stage renal disease requiring hemodialysis displayed exenatide clearance that was reduced by 84 % and concurrent areas under the plasma concentration-time curve (AUC) that were increased more than 6-fold. Following exenatide administration, most experienced severe nausea and vomiting and some developed headache, tachycardia, and transient increases in systolic and diastolic blood pressure not associated with hypoglycemia. Extended-release exenatide has not been studied in patients with CrCL &lt;30 mL/min, although in patients with moderate renal impairment, exenatide exposure was increased by 62 %.</i>

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## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Famciclovir - Selected References**

Famvir® tablet [package insert]. East Hanover: Novartis Pharmaceuticals Corp; 2011.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Famciclovir/Famvir®** {Antiviral; penciclovir prodrug; nucleoside analog; viral DNA polymerase inhibitor}

**Usual initial dose:** 1,500 mg orally  
**Usual maintenance dose:** 500 mg orally every 8–12 h  
**Typical maximum dose:** 1,000 mg orally twice daily  
**Proportion eliminated unchanged:** 60 % (as penciclovir)

### Adjustment for Kidney Disease

#### FDA-approved product labeling:

*Famciclovir dosage recommendations for adult patients with renal impairment*

Indication and normal dosage regimen	CrCL (mL/min)	Adjusted dosage (mg)	Dosing interval
<i>Single-day dosing regimens</i>			
<i>Recurrent genital herpes 1,000 mg every 12 h for 1 day</i>	≥60	1,000	Every 12 h for 1 day
	40–59	500	Every 12 h for 1 day
	20–39	500	Single dose
	<20	250	Single dose
	Hemodialysis	250	Single dose following dialysis
<i>Recurrent herpes labialis 1,500 mg single dose</i>	≥60	1,500	Single dose
	40–59	750	Single dose
	20–39	500	Single dose
	<20	250	Single dose
	Hemodialysis	250	Single dose following dialysis
<i>Multiple-day dosing regimens</i>			
<i>Herpes zoster 500 mg every 8 h</i>	≥60	500	Every 8 h
	40–59	500	Every 12 h
	20–39	500	Every 24 h
	<20	250	Every 24 h
	Hemodialysis	250	Following each dialysis
<i>Suppression of recurrent genital herpes 250 mg every 12 h</i>	≥40	250	Every 12 h
	20–39	125	Every 12 h
	<20	125	Every 24 h
	Hemodialysis	125	Following each dialysis
<i>Recurrent orolabial or genital herpes in HIV-infected patients 500 mg every 12 h</i>	≥40	500	Every 12 h
	20–39	500	Every 24 h
	<20	250	Every 24 h
	Hemodialysis	250	Following each dialysis
<b>Alternative adjustment:</b>	CRRT	Not applicable (consider IV ganciclovir)	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Famotidine (Oral) - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
- Chremos AN. Clinical pharmacology of famotidine: a summary. *J Clin Gastroenterol.* 1987;9(Suppl 2):7–12.
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- Olyaei AJ, Bennett WM. Drug dosing in elderly patients with chronic kidney disease. *Clin Geriatr Med.* 2009;25:459–527.
- Olyaei AJ, DeMattos AM, Bennett WM. Use of drugs in patients with renal failure. In: Schrier RW, editor. *Diseases of the kidney and urinary tract.* 8th ed. Philadelphia: Lippincott Williams & Wilkins; 2007. p. 2765–807.
- Pepcid® tablet film coated [package insert]. Whitehouse Station; Merck & Co Inc; 2010.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Famotidine (Oral)/Pepcid®** {Antacid; histamine H<sub>2</sub> receptor antagonist}

**Usual initial dose:** 40 mg orally  
**Usual maintenance dose:** 40 mg orally once daily at bedtime or 20 mg twice daily  
**Typical maximum dose:** Up to 160 mg orally every 6 h  
**Proportion eliminated unchanged:** 40 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;50 mL/min</i>	<i>20 mg orally daily at bedtime or 40 mg orally every 36–48 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>20 mg orally at bedtime or 10 mg orally twice daily</i>
	<i>GFR 10–50 mL/min</i>	<i>10–20 mg orally at bedtime</i>
	<i>GFR &lt;10 mL/min</i>	<i>5–10 mg orally at bedtime</i>
	<i>Hemodialysis</i>	<i>10 mg orally at bedtime (after dialysis) or 20 mg orally three times weekly immediately after dialysis</i>
	<i>CAPD</i>	<i>5–10 mg orally at bedtime</i>
	<i>CRRT</i>	<i>10–20 mg enterally once daily in the evening</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Famotidine (IV) - Selected References

- Abraham PA, Opsahl JA, Halstenson CE, Chremos AN, Matzke GR, Keane WF. The effect of famotidine on renal function in patients with renal insufficiency. *Br J Clin Pharmacol.* 1987;24:385–9.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Famotidine (IV)/Pepcid® IV** {Antacid; histamine H<sub>2</sub> receptor antagonist}

**Usual initial dose:** 20 mg IV  
**Usual maintenance dose:** 20 mg IV every 12 h  
**Typical maximum dose:** 40 mg/day  
**Proportion eliminated unchanged:** 70 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;50 mL/min</i>	<i>10 mg IV every 12 h or 20 mg every 36–48 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>20 mg IV every 12 h or 20 mg IV followed by continuous IV infusion of 1.66 mg/h (40 mg/24 h)</i>
	<i>GFR 10–50 mL/min</i>	<i>10 mg IV every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>10 mg IV every 24 h</i>
	<i>Hemodialysis</i>	<i>10 mg IV every 24 h (after dialysis)</i>
	<i>CAPD</i>	<i>10 mg IV every 24 h</i>
	<i>CRRT</i>	<i>10 mg IV every 12 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Felbamate - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Felbamate/Felbatol®**

**{Antiepileptic; N-methyl-D-aspartate (NMDA) antagonist}**

<b>Usual initial dose:</b>	1,200 mg/day orally in three or four divided doses
<b>Usual maintenance dose:</b>	1,200–3,600 mg/day orally in three or four divided doses
<b>Typical maximum dose:</b>	3,600 mg/day
<b>Proportion eliminated unchanged:</b>	25 %

### ***Adjustment for Kidney Disease***

<b>FDA-approved product labeling:</b>	<i>Renal dysfunction</i>	<i>Starting and maintenance doses should be reduced by one-half.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1,200–3,600 mg/day orally in three or four divided doses</i>
	<i>GFR 10–50 mL/min</i>	<i>800–2,400 mg/day orally in three or four divided doses (25–50 % dose reduction)</i>
	<i>GFR &lt;10 mL/min</i>	<i>600–1,800 mg/day orally in three or four divided doses (50 % dose reduction)</i>
	<i>Hemodialysis</i>	<i>600–1,800 mg/day orally in three or four divided doses (50 % dose reduction, dose after dialysis)</i>
	<i>CAPD</i>	<i>600–1,800 mg/day orally in three or four divided doses (50 % dose reduction)</i>
	<i>CRRT</i>	<i>600–1,800 mg/day enterally in three or four divided doses (50 % dose reduction)</i>



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Fenofibrate - Selected References

- Alves de Sousa A, Kronit HS, de Assis Rocha Neves F, Amato AA. Fenofibrate-induced rhabdomyolysis in a patient with chronic kidney disease: an unusual presenting feature of hypothyroidism. *Arq Bras Endocrinol Metabol.* 2009;53:383–6.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Fenofibrate/TriCor®** {Antihypercholesterolemic; fibric acid derivative; peroxisome proliferator-activated receptor- $\alpha$  activator}

**Usual initial dose:** 48–145 mg orally  
**Usual maintenance dose:** 145 mg orally once daily  
**Typical maximum dose:** 145 mg/day  
**Proportion eliminated unchanged:** 60 % (as metabolites fenofibric acid and fenofibrate glucuronide)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild to moderate renal impairment (CrCL 30–80 mL/min)</i>	<i>48 mg orally once daily; increase only after evaluation of the effects on renal function and lipid levels at this dose.</i>
	<i>Severe renal dysfunction (CrCL <math>\leq</math>30 mL/min)</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Fenoprofen - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Volland C, Sun H, Dammeyer J, Benet LZ. Stereoselective degradation of the fenoprofen acyl glucuronide enantiomers and irreversible binding to plasma proteins. *Drug Metab Dispos*. 1991;19:1080–6.
- Wendland ML, Wagoner RD, Holley KE. Renal failure associated with fenoprofen. *Mayo Clin Proc*. 1980;55:103–7.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Fenoprofen/Nalfon®** {Anti-inflammatory; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 300 mg  
**Usual maintenance dose:** 300–600 mg three to four times daily  
**Typical maximum dose:** 3,200 mg/day  
**Proportion eliminated unchanged:** 30 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Significantly impaired renal function</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>300–600 mg three to four times daily</i>
	<i>GFR 10–50 mL/min</i>	<i>300–600 mg three to four times daily</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk for gastrointestinal and renal toxicity.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risk for gastrointestinal and renal toxicity.</i>
	<i>CAPD</i>	<i>Preferably avoid due to risk for gastrointestinal and renal toxicity.</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Fexofenadine - Selected References

Allegra® [package insert]. Bridgewater: Sanofi-Aventis US LLC; 2008.

Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.

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Russell T, Stoltz M, Weir S. Pharmacokinetics, pharmacodynamics, and tolerance of single- and multiple-dose fexofenadine hydrochloride in healthy male volunteers. *Clin Pharmacol Ther*. 1998;64:612–21.

Shimizu M, Fuse K, Okudaira K, et al. Contribution of OATP (organic anion-transporting polypeptide) family transporters to the hepatic uptake of fexofenadine in humans. *Drug Metab Dispos*. 2005;33:1477–81.

Tahara H, Kusuhara H, Fuse E, Sugiyama Y. P-glycoprotein plays a major role in the efflux of fexofenadine in the small intestine and blood-brain barrier, but only a limited role in its biliary excretion. *Drug Metab Dispos*. 2005;33:963–8.

Zhao R, Kalvass JC, Yanni SB, Bridges AS, Pollack GM. Fexofenadine brain exposure and the influence of blood-brain barrier P-glycoprotein after fexofenadine and terfenadine administration. *Drug Metab Dispos*. 2009;37:529–35.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Fexofenadine/Allegra®** {Antihistamine; second-generation histamine H<sub>1</sub> blocker}

**Usual initial dose:** 60 mg orally  
**Usual maintenance dose:** 60 mg orally twice daily or 180 mg once daily  
**Typical maximum dose:** 180 mg/day  
**Proportion eliminated unchanged:** 11 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Decreased renal function</i>	<i>Starting dose is 60 mg once daily.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>60 mg orally every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>60 mg orally every 12–24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>60 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>60 mg orally every 24 h (after dialysis)</i>
	<i>CAPD</i>	<i>60 mg orally every 24 h</i>
	<i>CRRT</i>	<i>60 mg enterally every 12 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Flecainide - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Flecainide/Tambocor™** {Antiarrhythmic, class IC}

**Usual initial dose:** 50 mg orally  
**Usual maintenance dose:** 50–150 mg orally every 12 h  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 40 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Severe renal impairment (CrCL ≤35 mL/min)* Initial dosage should be 100 mg orally once daily or 50 mg orally twice daily.  
*Less severe renal disease* Initial dosage should be 100 mg orally every 12 h.

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>50–100 mg orally every 12 h</i>
<i>GFR 10–50 mL/min</i>	<i>50–75 mg orally every 12 h<sup>a</sup></i>
<i>GFR &lt;10 mL/min</i>	<i>25–50 mg orally every 12 h<sup>a</sup></i>
<i>Hemodialysis</i>	<i>25–50 mg orally every 12 h<sup>a</sup></i>
<i>CAPD</i>	<i>25–50 mg orally every 12 h<sup>a</sup></i>
<i>CVVH</i>	<i>25–50 mg orally every 12 h<sup>a</sup></i>

*<sup>a</sup>Depending on metabolizer genotype, wide variation in flecainide levels has been documented, particularly in patients with impaired kidney function. Careful electrocardiographic monitoring of PR and QRS intervals and frequent determination of steady-state serum drug levels are recommended.*



## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Fluconazole (IV)/Diflucan® IV** {Antifungal; triazole ergosterol biosynthesis inhibitor}

**Usual initial dose:** 400 mg IV  
**Usual maintenance dose:** 400 mg IV every 24 h  
**Typical maximum dose:** 1,200 mg/day  
**Proportion eliminated unchanged:** 80 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Fluconazole dosage in adult patients with impaired renal function*

<i>CrCL (mL/min)</i>	<i>Percent of recommended dose</i>
<i>&gt;50</i>	<i>100 %</i>
<i>≤50 (no dialysis)</i>	<i>50 %</i>
<i>Regular dialysis</i>	<i>100 % after each dialysis</i>
<b>Alternative adjustment:</b> <i>GFR &gt;50 mL/min</i>	<i>400–800 mg IV every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>200–400 mg IV every 24 h</i>
<i>GFR &lt;10 mL/min</i>	<i>200 mg every IV 24 h</i>
<i>Hemodialysis</i>	<i>400 mg IV after dialysis</i>
<i>CAPD</i>	<i>200 mg IV every 24 h</i>
<i>CVVH</i>	<i>200–800 mg IV every 24 h</i>
<i>CVVHD</i>	<i>400–800 mg IV every 24 h</i>
<i>CVVHDF</i>	<i>400–800 mg IV every 24 h (consider 800 mg q24h if dialysate flow rate &gt;2 L/h or treating Candida glabrata or other relatively azole-resistant species.)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Fluconazole (Enteral)/Diflucan®** {Antifungal; triazole ergosterol biosynthesis inhibitor}

**Usual initial dose:** 200 mg  
**Usual maintenance dose:** 50–200 mg enterally every 24 h  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 80 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Fluconazole dosage in patients with impaired renal function*

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*Single-dose treatment of vaginal candidiasis*    *No adjustment needed*

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*Other fungal infections*

<i>CrCL (mL/min)</i>	<i>Percent of recommended dose</i>
<i>&gt;50</i>	<i>100 %</i>
<i>≤50 (no dialysis)</i>	<i>50 %</i>
<i>Regular dialysis</i>	<i>100 % after each dialysis</i>

<b>Alternative adjustment:</b>	<i>eCrCL &gt;50 mL/min</i>	<i>50–400 mg enterally every 24 h</i>
	<i>eCrCL 10–50 mL/min</i>	<i>25–200 mg enterally every 24 h (50 % decrease)</i>
	<i>eCrCL &lt;10 mL/min</i>	<i>25–100 mg enterally every 24 h (75 % decrease)</i>
	<i>Hemodialysis</i>	<i>50–400 mg enterally after each dialysis</i>
	<i>CAPD</i>	<i>100 mg enterally every 24 h or 200 mg intraperitoneally during a 12-h dwell every 48 h</i>
	<i>CRRT</i>	<i>Not applicable (consider parenteral antifungal)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Flucytosine - Selected References

- Ancobon® capsule [package insert]. Costa Mesa: Valeant Pharmaceuticals International; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Flucytosine/Ancobon®** {Antifungal; purine and pyrimidine uptake inhibitor}

**Usual initial dose:** 37.5 mg/kg orally (ideal body weight or lean body mass)

**Usual maintenance dose:** 50–150 mg/kg/day orally in divided doses every 6 h

**Typical maximum dose:** 150 mg/kg/day

**Proportion eliminated unchanged:** 90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *If the BUN or the SCr is elevated or if there are other signs of renal impairment, the initial dose should be at the lower level.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>37.5 mg/kg orally every 6 h</i>
<i>GFR 10–50 mL/min</i>	<i>25–37.5 mg/kg orally every 12–24 h</i>
<i>GFR &lt;10 mL/min</i>	<i>15–25 mg/kg orally every 24 h</i>
<i>Hemodialysis</i>	<i>15–25 mg/kg orally every 24 h or 25–37.5 mg/kg orally every 48 h (after hemodialysis on dialysis days) or 25–37.5 mg/kg orally three times weekly after dialysis</i>
<i>CAPD</i>	<i>500–1,000 mg orally every 24 h or 50 mg/L of peritoneal dialysis fluid (limited data)</i>
<i>CVVH</i>	<i>25–37.5 mg/kg orally every 24–48 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Fludarabine - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Fludarabine/Fludara®** {Antineoplastic; DNA polymerase- $\alpha$  and ribonucleotide reductase inhibitor}

**Usual initial dose:** 25 mg/m<sup>2</sup> IV  
**Usual maintenance dose:** 25 mg/m<sup>2</sup> IV over 30 min daily for five consecutive days; each 5-day course of treatment should commence every 28 days.  
**Typical maximum dose:** 50 mg/m<sup>2</sup> IV daily  
**Proportion eliminated unchanged:** 60 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Fludarabine starting dose for renal impairment*

<i>CrCL (mL/min)</i>	<i>Starting dose</i>
$\geq 80$	25 mg/m <sup>2</sup> (full dose)
50–79	20 mg/m <sup>2</sup>
30–49	15 mg/m <sup>2</sup>
<30	Do not administer/avoid

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>30–50 mg/m<sup>2</sup> IV daily <math>\times 3</math> to 5 prior to hematopoietic stem cell transplantation</i>
<i>GFR 10–50 mL/min</i>	<i>25 mg/m<sup>2</sup> IV daily <math>\times 5</math> prior to hematopoietic stem cell transplantation</i>
<i>GFR &lt;10 mL/min</i>	<i>12.5 mg/m<sup>2</sup> IV daily <math>\times 5</math></i>
<i>Hemodialysis</i>	<i>6–12.5 mg/m<sup>2</sup> IV daily <math>\times 5</math> (after dialysis)</i>
<i>Extended daily dialysis</i>	<i>40 mg/m<sup>2</sup> IV daily <math>\times 3</math> (limited data)</i>
<i>CAPD</i>	<i>12.5 mg/m<sup>2</sup> IV daily <math>\times 5</math></i>
<i>CRRT</i>	<i>18.75 mg/m<sup>2</sup> IV daily <math>\times 5</math></i>



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Fomepizole - Selected References

- Antizol® injection [package insert]. Dover: Paladin Labs (USA) Inc; 2009.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Fomepizole/Antizol®

{Antidote; R for methanol or ethylene glycol poisoning}

**Usual initial dose:**

15 mg/kg IV over 30 min; begin treatment immediately upon suspicion of ethylene glycol or methanol ingestion based on patient history and/or anion gap metabolic acidosis, increased osmolar gap, visual disturbances, or oxalate crystals in the urine or a documented serum ethylene glycol or methanol concentration >20 mg/dL.

**Usual maintenance dose:**

10 mg/kg IV over 30 min every 12 h for four doses and then 15 mg/kg every 12 h thereafter until ethylene glycol or methanol concentrations are undetectable or have been reduced below 20 mg/dL and the patient is asymptomatic with normal pH

**Typical maximum dose:**

30 mg/kg/day

**Proportion eliminated unchanged:**

3 % (metabolites 85 %)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Fomepizole dosing in patients requiring hemodialysis*

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***Dose at the beginning of hemodialysis***

*If <6 h since last fomepizole dose                      If ≥6 h since last fomepizole dose*

*Do not administer dose                      Administer next scheduled dose*

***Dosing during hemodialysis***

*Dose every 4 h*

***Dosing at the time hemodialysis is completed***

*Time between last dose and the end of hemodialysis*

*<1 h    Do not administer dose at the end of hemodialysis*

*1–3 h    Administer one half of next scheduled dose*

*>3 h    Administer next scheduled dose*

***Maintenance dosing off hemodialysis***

*Give next scheduled dose 12 h from last dose administered*

**Alternative adjustment:**

*Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Fondaparinux - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Fondaparinux/Arixtra®**

{Antithrombotic; selective antithrombin III-mediated coagulation factor Xa inhibitor}

<b>Usual initial dose:</b>	2.5 mg subcutaneously (prophylaxis), 5–10 mg subcutaneously (treatment)
<b>Usual maintenance dose:</b>	2.5 mg subcutaneously every 24 h after hemostasis has been established but not earlier than 6 h after surgery (prophylaxis) 5 mg (body weight <50 kg), 7.5 mg (body weight 50–100 kg), or 10 mg (body weight >100 kg) subcutaneously every 24 h (treatment)
<b>Typical maximum dose:</b>	10 mg/day
<b>Proportion eliminated unchanged:</b>	77 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 30–50 mL/min</i>	<i>Use with caution</i>
	<i>CrCL &lt;30 mL/min</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>2.5–10 mg subcutaneously once daily</i>
	<i>GFR 30–50 mL/min</i>	<i>1.5 mg subcutaneously once daily (prophylaxis)</i>
	<i>GFR &lt;30 mL/min</i>	<i>Preferably avoid due to increased hemorrhagic risk.</i>
	<i>Hemodialysis</i>	<i>Data not available; preferably avoid due to increased hemorrhagic risk.</i>
	<i>CAPD</i>	<i>Data not available; preferably avoid due to increased hemorrhagic risk.</i>
	<i>CRRT</i>	<i>Data not available; preferably avoid due to increased hemorrhagic risk.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Foscarnet - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Foscarnet/Foscavir®** {Antiviral; cytomegalovirus/herpes simplex viral DNA polymerase inhibitor}

**Usual initial dose:** 60 mg/kg IV  
**Usual maintenance dose:** 40–60 mg/kg IV over a minimum of 1 h every 8–12 h or 90–120 mg/kg IV over 1.5–2 h daily  
**Typical maximum dose:** 180 mg/kg/day  
**Proportion eliminated unchanged:** 88 %

### Adjustment for Kidney Disease

#### FDA-approved product labeling:

##### Foscarnet dosing guide: Induction

CrCL (mL/min/kg)	Herpes simplex: equivalent to		Cytomegalovirus: equivalent to	
	80 mg/kg/day total (40 mg/kg q12h)	120 mg/kg/day total (40 mg/kg q8h)	180 mg/kg/day total 60 mg/kg q8h	90 mg/kg q12h
>1.4	40 mg/kg q12h	40 mg/kg q8h	60 mg/kg q8h	90 mg/kg q12h
>1.0–1.4	30 mg/kg q12h	30 mg/kg q8h	45 mg/kg q8h	70 mg/kg q12h
>0.8–1.0	20 mg/kg q12h	35 mg/kg q12h	50 mg/kg q12h	50 mg/kg q12h
>0.6–0.8	35 mg/kg q24h	25 mg/kg q12h	40 mg/kg q12h	80 mg/kg q24h
>0.5–0.6	25 mg/kg q24h	40 mg/kg q24h	60 mg/kg q24h	60 mg/kg q24h
≥0.4–0.5	20 mg/kg q24h	35 mg/kg q24h	50 mg/kg q24h	50 mg/kg q24h
<0.4	Not recommended	Not recommended	Not recommended	Not recommended

Note that tabulated CrCL units are mL/min/kg; this value may be derived from eCrCL by dividing the value in mL/min by body weight in kg

##### Foscarnet dosing guide: Maintenance

CrCL (mL/min/kg)	Cytomegalovirus: equivalent to	
	90 mg/kg/day (once daily)	120 mg/kg/day (once daily)
>1.4	90 mg/kg q24h	120 mg/kg q24h
>1.0–1.4	70 mg/kg q24h	90 mg/kg q24h
>0.8–1.0	50 mg/kg q24h	65 mg/kg q24h
>0.6–0.8	80 mg/kg q48h	105 mg/kg q48h
>0.5–0.6	60 mg/kg q48h	80 mg/kg q48h
≥0.4–0.5	50 mg/kg q48h	65 mg/kg q48h
<0.4	Not recommended	Not recommended

Note that tabulated CrCL units are mL/min/kg; this value may be derived from eCrCL by dividing the value in mL/min by body weight in kg

**Alternative adjustment:**

GFR >50 mL/min	40–60 mg/kg IV every 8–12 h
GFR 10–50 mL/min	45–60 mg/kg IV every 24 h
GFR <10 mL/min	Use not recommended due to lack of experience
Hemodialysis	60–90 mg/kg IV once followed by 45–60 mg/kg IV three times weekly after dialysis
CAPD	45 mg/kg IV every 24 h
CRRT	60 mg/kg IV every 24 h

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Fosfomycin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Fosfomycin/Monurol®**

{Antibacterial; phosphonic acid derivative}

<b>Usual initial dose:</b>	3 g (one sachet) orally dissolved in cool or tepid (not hot) water
<b>Usual maintenance dose:</b>	None (usual R for uncomplicated cystitis is single-dose treatment)
<b>Typical maximum dose:</b>	400 mg/kg/day (for serious systemic infections)
<b>Proportion eliminated unchanged:</b>	38 % (may vary from 11 to 80 % depending on route of administration and GFR)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Renal insufficiency*      *No dosage adjustment is necessary in the elderly (single-dose treatment).*

*In patients with varying degrees of renal impairment (CrCL varying from 55 to 7 mL/min), the half-life of fosfomycin increased from 11 to 50 h. The half-life of fosfomycin during hemodialysis was 40 h.*

<b>Alternative adjustment:</b>	<i>GFR &lt;60 mL/min</i>	<i>3 g orally ×1 (no dose adjustment is necessary for single-dose treatment of uncomplicated cystitis with any level of kidney disease)</i>
	<i>CrCL &gt;80 mL/min</i>	<i>2–8 g IV every 6–8 h</i>
	<i>CrCL 40–79 mL/min</i>	<i>2–4 IV every 12 h</i>
	<i>CrCL 20–39 mL/min</i>	<i>2–4 g IV followed by 2–4 g IV every 8 h</i>
	<i>CrCL 5–19 mL/min</i>	<i>2–4 g IV followed by 1–2 g IV every 12 h</i>
	<i>CrCL &lt;5 mL/min</i>	<i>2–4 g IV followed by 1–2 g IV every 24 h</i>
	<i>Hemodialysis</i>	<i>2–4 g IV followed by 1–2 g IV after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>4 g instilled intraperitoneally with a prolonged dwell ×1 followed by 1 g intraperitoneally every 48 h</i>
	<i>CVVH</i>	<i>8 g IV every 12 h</i>

*Note: Parenteral dosage forms of fosfomycin (disodium fosfomycin injection) presently are not commercially available in North America. These are being selectively investigated and used in Europe and elsewhere for serious systemic bacterial infections.*



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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Gabapentin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Gabapentin/Neurontin®** {Antiepileptic; adjunctive analgesic}

<b>Usual initial dose:</b>	100 mg orally
<b>Usual maintenance dose:</b>	300–600 mg orally three times daily
<b>Typical maximum dose:</b>	3,600 mg/day
<b>Proportion eliminated unchanged:</b>	80 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL</i> ≥60 mL/min	600 mg sustained-release orally every evening
	<i>CrCL</i> 30–59 mL/min	600 mg sustained-release orally every 48 h
	<i>CrCL</i> <30 mL/min	Sustained-release tablets (600 mg) not recommended (℞ for restless legs)

#### *Gabapentin dosage based on renal function*

<i>CrCL</i> (mL/min)	Total daily dose (mg/day)	Dose regimen (mg)				
≥60	900–3,600	300 mg three times daily	400 mg three times daily	600 mg three times daily	800 mg three times daily	1,200 mg three times daily
>30–59	400–1,400	200 mg twice daily	300 mg twice daily	400 mg twice daily	500 mg twice daily	700 mg twice daily
>15–29	200–700	200 mg every day	300 mg every day	400 mg every day	500 mg every day	700 mg every day
<15	100–300	100 mg once daily	125 mg once daily	150 mg once daily	200 mg once daily	300 mg once daily
<i>Hemodialysis<sup>a</sup></i>		Post-hemodialysis supplemental dose (mg)				
		125	150	200	250	350

<sup>a</sup>For patients on hemodialysis, the maintenance dose should be based upon the estimates of *CrCL* as indicated in the upper portion of the table under <15 mL/min and a supplemental post-hemodialysis dose administered after each 4 h of hemodialysis as indicated in the lower portion of the table

<b>Alternative adjustment:</b>	<i>GFR</i> ≥60 mL/min	300–1,200 mg enterally every 8 h
	<i>GFR</i> 30–59 mL/min	600 mg enterally every 12 h
	<i>GFR</i> 10–29 mL/min	200–600 mg enterally every 24 h
	<i>GFR</i> <10 mL/min	100 mg enterally every 24 h
	<i>Hemodialysis</i>	100 mg enterally every 24 h or 200–300 mg enterally after hemodialysis on dialysis days only
	<i>CAPD</i>	300 mg enterally every 48 h
	<i>CRRT</i>	300 mg enterally every 12–24 h

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Gadobenate - Selected References**

Altun E, Martin DR, Wertman R, Lugo-Somolinos A, Fuller ER III, Semelka RC. Nephrogenic systemic fibrosis: change in incidence following a switch in gadolinium agents and adoption of a gadolinium policy—report from two US universities. *Radiology*. 2009;253:689–96.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Gadobenate/MultiHance™** {Gadolinium-based contrast agent}

<b>Usual initial dose:</b>	0.2 mL/kg (0.1 mmol/kg) administered as a rapid bolus IV injection
<b>Usual maintenance dose:</b>	N/A
<b>Typical maximum dose:</b>	0.2 mL/kg (0.1 mmol/kg)
<b>Proportion eliminated unchanged:</b>	78–96 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>GFR ≥30 mL/min/1.73 m<sup>2</sup></i>	<i>0.2 mL/kg (0.1 mmol/kg) IV</i>
	<i>GFR &lt;30 mL/min/1.73 m<sup>2</sup></i>	<i>0.2 mL/kg (0.1 mmol/kg) IV; in patients with renal insufficiency, acute renal failure requiring dialysis or worsening renal function has occurred, mostly within 48 h after injection. The risk of these events is higher with increasing doses of contrast. Use the lowest possible dose and evaluate renal function in patients with renal insufficiency.</i>
<b>Alternative adjustment:</b>	<i>GFR ≥30 mL/min</i>	<i>0.2 mL/kg (0.1 mmol/kg) IV</i>
	<i>GFR &lt;30 mL/min</i>	<i>Although it is unclear whether gadobenate has been causally implicated in cases of nephrogenic systemic fibrosis (NSF, a debilitating and potentially life-threatening disease characterized by progressive tissue deposition of collagen and fibroblasts affecting the skin, internal organs, and muscles), its use generally should be <b>avoided</b> unless gadolinium-based contrast agent diagnostic information is absolutely essential and not available using non-contrast enhanced magnetic resonance imaging (MRI) or other techniques.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Gadodiamide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Gadodiamide/Omniscan™**

{Gadolinium-based contrast agent}

<b>Usual initial dose:</b>	Kidney—0.1 mL/kg (0.05 mmol/kg) as a bolus IV injection CNS, intrathoracic, intra-abdominal, and pelvic cavities—0.2 mL/kg (0.1 mmol/kg) IV
<b>Usual maintenance dose:</b>	N/A
<b>Typical maximum dose:</b>	0.2 mL/kg (0.1 mmol/kg)
<b>Proportion eliminated unchanged:</b>	95 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>GFR ≥30 mL/min</i>	<i>0.1–0.2 mL/kg IV</i>
	<i>GFR &lt;30 mL/min</i>	<i>0.1–0.2 mL/kg IV. In patients with renal insufficiency, acute renal failure requiring dialysis or worsening renal function has occurred, mostly within 48 h after gadopentetate injection. The risk of these events is higher with increasing doses of contrast. Use the lowest possible dose and evaluate renal function in patients with renal insufficiency.</i>
<b>Alternative adjustment:</b>	<i>GFR ≥30 mL/min</i>	<i>0.1–0.2 mL/kg IV</i>
	<i>GFR &lt;30 mL/min</i>	<i>Not recommended; preferably avoid. Gadodiamide has been reported in most pharmacodynamic investigations, systematic reviews, cohort studies, and large case series to be associated with a comparatively high incidence of nephrogenic systemic fibrosis (NSF, a debilitating and potentially life-threatening disease characterized by progressive tissue deposition of collagen and fibroblasts affecting the skin, internal organs, and muscles). Its use has been clearly associated with this condition, and it therefore must be avoided unless gadolinium-based contrast agent diagnostic information is absolutely essential and not available using non-contrast enhanced magnetic resonance imaging (MRI) or other techniques.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Gadopentetate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Gadopentetate/Magnevist®** {Gadolinium-based contrast agent}

<b>Usual initial dose:</b>	0.2 mL/kg (0.1 mmol/kg) IV at a rate not to exceed 10 mL/15 s
<b>Usual maintenance dose:</b>	N/A
<b>Typical maximum dose:</b>	0.1 mmol/kg
<b>Proportion eliminated unchanged:</b>	92 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *GFR  $\geq 30$  mL/min/1.73 m<sup>2</sup>*

*0.1 mmol/kg (0.2 mL/kg) IV; in patients with renal insufficiency, acute renal failure requiring dialysis or worsening renal function has occurred, mostly within 48 h after gadopentetate injection. The risk of these events is higher with increasing doses of contrast. Use the lowest possible dose and evaluate renal function in patients with renal insufficiency.*

*GFR  $< 30$  mL/min/1.73 m<sup>2</sup>*

*Contraindicated*

**Alternative adjustment:**

*GFR  $\geq 30$  mL/min/1.73 m<sup>2</sup>*

*0.1 mmol/kg (0.2 mL/kg) IV*

*GFR  $< 30$  mL/min/1.73 m<sup>2</sup> and patients with acute kidney injury of any severity due to hepatorenal syndrome or in the perioperative liver transplant period*

*Not recommended; preferably avoid. Although gadopentetate has been reported in systematic reviews, cohort studies, and large case series to be associated with a comparatively modest incidence of nephrogenic systemic fibrosis (NSF, a debilitating and potentially life-threatening disease characterized by progressive tissue deposition of collagen and fibroblasts affecting the skin, internal organs, and muscles), this condition has occurred with administration of this agent, and its use therefore must be avoided unless gadolinium-based contrast agent diagnostic information is absolutely essential and not available using non-contrast enhanced magnetic resonance imaging (MRI) or other techniques.*

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Gadoteridol - Selected References**

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Gadoteridol/ProHance®**

{Gadolinium-based contrast agent}

<b>Usual initial dose:</b>	0.2 mL/kg (0.1 mmol/kg) IV as a rapid bolus (>60 mL/min) or infusion (10–60 mL/min)
<b>Usual maintenance dose:</b>	In the presence of negative or equivocal scans and in patients suspected of having poorly enhancing lesions, a second dose of 0.4 mL/kg (0.2 mmol/kg) may be given up to 30 min after the first dose
<b>Typical maximum dose:</b>	0.4 mL/kg (0.2 mmol/kg)
<b>Proportion eliminated unchanged:</b>	98 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>GFR ≥30 mL/min</i>	<i>0.2 mL/kg (0.1 mmol/kg) IV as a rapid bolus (&gt;60 mL/min) or infusion (10–60 mL/min)</i>
	<i>GFR &lt;30 mL/min</i>	<i>0.2 mL/kg (0.1 mmol/kg) IV as a rapid bolus (&gt;60 mL/min) or infusion (10–60 mL/min)</i>
<b>Alternative adjustment:</b>	<i>GFR ≥30 mL/min</i>	<i>0.2 mL/kg (0.1 mmol/kg) IV as a rapid bolus (&gt;60 mL/min) or infusion (10–60 mL/min)</i>
	<i>GFR &lt;30 mL/min/1.73 m<sup>2</sup> and patients with acute kidney injury of any severity due to hepatorenal syndrome or in the perioperative liver transplant period</i>	<i>Although gadoteridol has been reported in most pharmacodynamic investigations, systematic reviews, cohort studies, and large case series to be associated with a comparatively modest incidence of nephrogenic systemic fibrosis (NSF, a debilitating and potentially life-threatening disease characterized by progressive tissue deposition of collagen and fibroblasts affecting the skin, internal organs, and muscles), its use has been associated with this condition, and it therefore must be avoided unless gadolinium-based contrast agent diagnostic information is absolutely essential and not available using non-contrast enhanced magnetic resonance imaging (MRI) or other techniques.</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Gadoversetamide - Selected References**

Broome DR. Nephrogenic systemic fibrosis associated with gadolinium based contrast agents: a summary of the medical literature reporting. *Eur J Radiol.* 2008;66:230–4.

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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Gadoversetamide/OptiMARK™ {Gadolinium-based contrast agent}**

<b>Usual initial dose:</b>	0.2 mL/kg (0.1 mmol/kg) IV at a rate of 1–2 mL/s
<b>Usual maintenance dose:</b>	N/A
<b>Typical maximum dose:</b>	0.2 mL/kg (0.1 mmol/kg)
<b>Proportion eliminated unchanged:</b>	96 %

***Adjustment for Kidney Disease***

**FDA-approved product labeling:** *GFR ≥30 mL/min/1.73 m<sup>2</sup>*

*0.2 mL/kg (0.1 mmol/kg) IV; in patients with renal insufficiency, acute renal failure requiring dialysis or worsening renal function has occurred, mostly within 48 h after gadoversetamide injection. The risk of these events is higher with increasing doses of contrast. Use the lowest possible dose and evaluate renal function in patients with renal insufficiency.*

*GFR <30 mL/min/1.73 m<sup>2</sup>*

*Contraindicated*

**Alternative adjustment:**

*GFR ≥30 mL/min*

*0.2 mL/kg (0.1 mmol/kg) IV*

*GFR <30 mL/min*

*Not recommended; preferably avoid. Although gadoversetamide has been reported in most pharmacodynamic investigations, systematic reviews, cohort studies, and large case series to be associated with a comparatively modest incidence of nephrogenic systemic fibrosis (NSF, a debilitating and potentially life-threatening disease characterized by progressive tissue deposition of collagen and fibroblasts affecting the skin, internal organs, and muscles), its use has been associated with this condition, and it therefore must be avoided unless gadolinium-based contrast agent diagnostic information is absolutely essential and not available using non-contrast enhanced magnetic resonance imaging (MRI) or other techniques.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Gadoxetate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Gadoxetate/Eovist®** {Gadolinium-based contrast agent}

**Usual initial dose:** 0.1 mL/kg (0.025 mmol/kg) IV at a flow rate of 2 mL/s

**Usual maintenance dose:** N/A

**Typical maximum dose:** 0.1 mL/kg

**Proportion eliminated unchanged:** 44–59 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *GFR ≥30 mL/min/1.73 m<sup>2</sup>*  
*GFR <30 mL/min/1.73 m<sup>2</sup>*

*0.1 mL/kg IV*

*0.1 mL/kg IV. Warning: Gadolinium-based contrast agents (GBCAs) increase the risk for nephrogenic systemic fibrosis (NSF) among patients with impaired elimination of the drugs. The risk for NSF appears to be highest among patients with chronic severe kidney disease (GFR <30 mL/min/1.73 m<sup>2</sup>) or acute kidney injury. For patients at risk for chronically reduced renal function (e.g., age >60 years, hypertension, or diabetes), estimate the glomerular filtration rate (GFR) through laboratory testing. For patients at highest risk for NSF, do not exceed the recommended dose and allow a sufficient period of time for elimination of the drug from the body prior to re-administration.*

**Alternative adjustment:** *GFR ≥30 mL/min*  
*GFR <30 mL/min and/or acute kidney injury of any severity due to hepatorenal syndrome or in the perioperative liver transplant period*

*0.1 mL/kg IV*

*Although it is unclear whether gadoxetate has been causally implicated with nephrogenic systemic fibrosis (NSF, a debilitating and potentially life-threatening disease characterized by progressive tissue deposition of collagen and fibroblasts affecting the skin, internal organs, and muscles), its use should be avoided unless gadolinium-based contrast agent diagnostic information is absolutely essential and not available using non-contrast enhanced magnetic resonance imaging (MRI) or other techniques.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Galantamine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Galantamine/Razadyne®** {Reversible competitive acetylcholinesterase inhibitor; R for Alzheimer's disease}

**Usual initial dose:** 4 mg orally twice daily (8 mg/day)

**Usual maintenance dose:** 8–12 mg orally twice daily (16–24 mg/day) or 16–24 mg orally extended-release capsules once daily

**Typical maximum dose:** 32 mg/day

**Proportion eliminated unchanged:** 32 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Moderately impaired renal function*      *Titration should proceed cautiously; dose not to exceed 16 mg/day*

*Severe renal impairment (CrCL <9 mL/min)*      *Use not recommended; avoid*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Gallium Nitrate/Ganite™** {Hypocalcemic agent; bone resorption inhibitor}

**Usual initial dose:** 200 mg/m<sup>2</sup> IV daily  
**Usual maintenance dose:** 200 mg/m<sup>2</sup> continuous IV infusion over 24 h daily for 5 consecutive days or until normalization of serum calcium levels  
**Typical maximum dose:** 200 mg/m<sup>2</sup> IV daily  
**Proportion eliminated unchanged:** 50 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Moderate renal impairment (SCr 2.0–2.5 mg/dL)* *Frequently monitor the patient's renal status.*  
*Severe renal impairment (SCr >2.5 mg/dL)* *Contraindicated*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ganciclovir (IV) - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ganciclovir (IV)/Cytovene® IV** {Antiviral; nucleoside analog; R cytomegalovirus}

**Usual initial dose:** 5 mg/kg IV  
**Usual maintenance dose:** 5 mg/kg IV every 12 h for 7–14 days (induction), 5 mg/kg IV daily (maintenance)  
**Typical maximum dose:** 10 mg/kg/day  
**Proportion eliminated unchanged:** 95 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Ganciclovir IV dosing in renal function impairment*

CrCL (mL/min)	Induction		Maintenance	
	IV induction dose (mg/kg)	Dosing interval (h)	IV maintenance dose (mg/kg)	Dosing interval (h)
≥70	5	12	5	24
50–69	2.5	12	2.5	24
25–49	2.5	24	1.25	24
10–24	1.25	24	0.625	24
<10	1.25	Three times per week, after hemodialysis	0.625	Three times per week, after hemodialysis

**Alternative adjustment:**

*GFR >70 mL/min* 5 mg/kg IV over 1 h every 12 h for 14–21 days (induction) followed by 5 mg/kg IV every 24 h (maintenance)

*GFR 50–69 mL/min* 2.5 mg/kg IV every 12 h for 14–21 days (induction) followed by 2.5 mg/kg IV every 24 h (maintenance)

*GFR 25–49 mL/min* 2.5 mg/kg IV every 24 h for 14–21 days (induction) followed by 1.25 mg/kg IV every 24 h (maintenance)

*GFR 10–24 mL/min* 1.25 mg/kg IV every 24 h for 14–21 days (induction) followed by 0.625 mg/kg IV every 24 h (maintenance)

*GFR <10 mL/min* 1.25 mg/kg IV every 48 h

*Hemodialysis* 1.25 mg/kg IV every 48–72 h or 3 times weekly, after hemodialysis on dialysis days

*CAPD* 1.25 mg/kg IV every 48 h

*CVVH* 2.5 mg/kg IV every 24 h

*CVVHD or CVVHDF* 2.5 mg/kg IV every 12 h

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ganciclovir (Oral) - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ganciclovir (Oral)/Cytovene®** {Antiviral; nucleoside analog; R cytomegalovirus}

**Usual initial dose:** 1,000 mg orally  
**Usual maintenance dose:** 1,000 mg orally three times daily with food  
**Typical maximum dose:** 3 g/day  
**Proportion eliminated unchanged:** 95 % of absorbed dose (oral bioavailability 6–9 %)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Ganciclovir oral dosing in renal function impairment*

<i>CrCL (mL/min)</i>	<i>Ganciclovir capsule doses</i>
$\geq 70$	<i>1,000 mg 3 times daily or 500 mg every 3 hours, 6 times daily</i>
<i>50 to 69</i>	<i>1,500 mg once daily or 500 mg 3 times daily</i>
<i>25 to 49</i>	<i>1,000 mg once daily or 500 mg twice daily</i>
<i>10 to 24</i>	<i>500 mg once daily</i>
$< 10$	<i>500 mg 3 times per week following hemodialysis</i>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>1,000 mg orally three times daily</i>
<i>GFR 10–50 mL/min</i>	<i>1,000 mg orally twice daily</i>
<i>GFR &lt;10 mL/min</i>	<i>500 mg orally every 48 h</i>
<i>Hemodialysis</i>	<i>500 mg orally three times/week after dialysis</i>
<i>CAPD</i>	<i>500 mg orally every 48 h</i>
<i>CRRT</i>	<i>Not applicable (consider IV ganciclovir)</i>

*Note: Oral ganciclovir should be used only for prophylaxis (not treatment) of cytomegalovirus disease.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Gemfibrozil - Selected References

- Akoglu H, Yilmaz R, Kirkpantur A, Arici M, Altun B, Turgan C. Combined organ failure with combination antihyperlipidemic treatment: a case of hepatic injury and acute renal failure. *Ann Pharmacother*. 2007;41:143–7.
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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Gemfibrozil/Lopid®** {Antihypercholesterolemic; fibric acid derivative}

**Usual initial dose:** 600 mg orally  
**Usual maintenance dose:** 600 mg orally twice daily before meals  
**Typical maximum dose:** 1,200 mg/day  
**Proportion eliminated unchanged:** 1 % (7–14 % as conjugates)

*Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild to moderate renal impairment</i>	<i>Use with caution.</i>
	<i>Severe renal impairment</i>	<i>Contraindicated.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>600 mg orally twice daily.</i>
	<i>GFR 10–50 mL/min</i>	<i>300 mg orally twice daily for 6 weeks with careful monitoring; if no symptomatic, biochemical, or metabolic adverse effects arise, increase to 600 mg orally twice daily.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid or 300 mg orally once daily for 6 weeks with careful monitoring; if no symptomatic, biochemical, or metabolic adverse effects arise, increase to 300 mg orally twice daily.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid or 300 mg orally once daily for 6 weeks with careful monitoring; if no symptomatic, biochemical, or metabolic adverse effects arise, increase to 300 mg orally twice daily.</i>
	<i>CAPD</i>	<i>Preferably avoid or 300 mg orally once daily for 6 weeks with careful monitoring; if no symptomatic, biochemical, or metabolic adverse effects arise, increase to 300 mg orally twice daily.</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Gemifloxacin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Gemifloxacin/Factive®** {Antibacterial; fluoroquinolone}

<b>Usual initial dose:</b>	320 mg orally
<b>Usual maintenance dose:</b>	320 mg orally once daily
<b>Typical maximum dose:</b>	320 mg/day
<b>Proportion eliminated unchanged:</b>	25–40 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;40 mL/min</i>	<i>320 mg orally once daily</i>
	<i>CrCL ≤40 mL/min</i>	<i>160 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>160 mg orally every 24 h</i>
	<i>Peritoneal dialysis (CAPD)</i>	<i>160 mg orally every 24 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>320 mg orally every 24 h</i>
	<i>GFR 10–50 mL/min</i>	<i>160–320 mg orally every 24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>160 mg every 24 h</i>
	<i>Hemodialysis</i>	<i>160 mg every 24 h; administer after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>160 mg every 24 h</i>
	<i>CRRT</i>	<i>160–320 mg every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Gentamicin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Gentamicin/Garamycin®

{Antibacterial; aminoglycoside}

<b>Usual initial dose:</b>	2–7 mg/kg IV (actual body weight [ABW] or ideal [IBW] + 0.4(ABW – IBW) if ABW > IBW)
<b>Usual maintenance dose:</b>	3–5 mg/kg/day in two to three divided doses or 4–7 mg/kg IV every 24 h
<b>Typical maximum dose:</b>	10 mg/kg/day
<b>Proportion eliminated unchanged:</b>	95 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Dosage adjustment guide for patients with renal impairment<sup>a</sup> (dosage at 8-h intervals after the usual initial dose)*

<i>Serum creatinine (mg/dL)</i>	<i>CrCL (mL/min)</i>	<i>Percent of usual dose</i>
<i>≤1.0</i>	<i>&gt;100</i>	<i>100</i>
<i>1.1–1.3</i>	<i>70–100</i>	<i>80</i>
<i>1.4–1.6</i>	<i>55–70</i>	<i>65</i>
<i>1.7–1.9</i>	<i>45–55</i>	<i>55</i>
<i>2.0–2.2</i>	<i>40–45</i>	<i>50</i>
<i>2.3–2.5</i>	<i>35–40</i>	<i>40</i>
<i>2.6–3.0</i>	<i>30–35</i>	<i>35</i>
<i>3.1–3.5</i>	<i>25–30</i>	<i>30</i>
<i>3.6–4.0</i>	<i>20–25</i>	<i>25</i>
<i>4.1–5.1</i>	<i>15–20</i>	<i>20</i>
<i>5.2–6.6</i>	<i>10–15</i>	<i>15</i>
<i>6.7–8.0</i>	<i>&lt; 10</i>	<i>10</i>

*Hemodialysis: 1–1.7 mg/kg at the end of each dialysis*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>2–2.5 mg/kg IV once followed by 1.7 mg/kg every 8–12 h or 4–7 mg/kg (9 mg/kg lean body mass in obese patients) IV every 24 h<sup>a</sup></i>
	<i>GFR 10–50 mL/min</i>	<i>2–2.5 mg/kg IV once followed by 1.7 mg/kg IV every 24–48 h<sup>a</sup> (if pre-dose plasma level is within desired range, usually ≤1 mg/L)<sup>a</sup></i>
	<i>GFR &lt;10 mL/min</i>	<i>1.7 mg/kg IV every 72 h (if pre-dose plasma level is within desired range, usually ≤1 mg/L)<sup>a</sup></i>
	<i>Hemodialysis</i>	<i>1–1.7 mg/kg IV at the end of each dialysis (if pre-dose plasma level is within desired range, usually ≤1 mg/L)<sup>a</sup></i>
	<i>CAPD</i>	<i>Add to dialysate qs 4–8 mg/L<sup>a</sup></i>
	<i>CVVHD or CVVHDF</i>	<i>1.5–2.5 mg/kg IV every 24–48 h (if pre-dose plasma level is within desired range, usually ≤1 mg/L)<sup>a</sup></i>

<sup>a</sup>*Therapeutic Drug Monitoring*

**Therapeutic plasma levels:** *Peak: 6–10 mg/L (conventional dosing).*

*Trough: <2 mg/L; patients on extended-interval dosing generally should be re-dosed when levels fall below 1 mg/L.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Glipizide/Glucotrol®** {Antidiabetic; sulfonylurea}

**Usual initial dose:** 5 mg orally once daily before breakfast  
**Usual maintenance dose:** 2.5–15 mg orally once or twice daily according to blood glucose levels  
**Typical maximum dose:** 40 mg/day  
**Proportion eliminated unchanged:** 10 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *With impaired renal function, initial and maintenance dosing should be conservative to avoid hypoglycemic reactions.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>2.5–15 mg once or twice daily according to blood glucose levels.</i>
<i>GFR 10–50 mL/min</i>	<i>2.5–7.5 mg once or twice daily according to blood glucose levels.</i>
<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk of severe hypoglycemia.</i>
<i>Hemodialysis</i>	<i>Preferably avoid due to risk of severe hypoglycemia.</i>
<i>CAPD</i>	<i>Preferably avoid due to risk of severe hypoglycemia.</i>
<i>CRRT</i>	<i>Not applicable; preferably avoid due to risk of severe hypoglycemia.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Glyburide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Glyburide/Micronase<sup>®</sup>, DiaBeta<sup>®</sup>** {Antidiabetic; sulfonylurea}

<b>Usual initial dose:</b>	2.5–5 mg orally once daily before breakfast
<b>Usual maintenance dose:</b>	1.25–20 mg/day orally in single or divided doses
<b>Typical maximum dose:</b>	20 mg/day
<b>Proportion eliminated unchanged:</b>	50 % (as metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *The risk of toxic reactions may be greater in patients with impaired renal function; the initial and maintenance dosing should be conservative to avoid hypoglycemic reactions.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1.25–10 mg once or twice daily according to blood glucose levels</i>
	<i>GFR 30–50 mL/min</i>	<i>1.25–5 mg once or twice daily according to blood glucose levels</i>
	<i>GFR &lt;30 mL/min</i>	<i>Preferably avoid due to risk of severe hypoglycemia.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risk of severe hypoglycemia.</i>
	<i>CAPD</i>	<i>Preferably avoid due to risk of severe hypoglycemia.</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid due to risk of severe hypoglycemia.</i>

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Hetastarch - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**6% Hetastarch in 0.9% Sodium Chloride/  
Hespan® 6% Hetastarch in Lactated  
Electrolyte Injection/Hextend®**

{Plasma volume expander; colloid}

<b>Usual initial dose:</b>	500 mL IV
<b>Usual maintenance dose:</b>	500–1,000 mL/day IV
<b>Typical maximum dose:</b>	20 mL/kg (≈1,500 mL) per day
<b>Proportion eliminated unchanged:</b>	33 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**      *Renal disease with oliguria or anuria*      *Contraindicated*  
*not related to hypovolemia*

**Alternative adjustment:**      *Data not available*

*Note: Use of hetastarch may be of particular concern for worsening kidney function in patients with serious illness and preexisting chronic or acute kidney disease; those undergoing kidney, kidney-pancreas, or liver transplantation; and those with hypoalbuminemia and/or sepsis.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Hydrochlorothiazide/Microzide®, Hydrodiuril®** {Diuretic, thiazide}

**Usual initial dose:** 12.5–25 mg orally  
**Usual maintenance dose:** 12.5–50 mg orally once or twice daily  
**Typical maximum dose:** 100 mg/day  
**Proportion eliminated unchanged:** 65–72 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Severe renal disease Use with caution*

*Anuria Contraindicated*

**Alternative adjustment:**

*GFR >50 mL/min 12.5–50 mg orally once or twice daily*

*GFR 10–50 mL/min 12.5–25 mg orally once daily*

*GFR <10 mL/min Usually ineffective, preferably avoid*

*Hemodialysis Usually ineffective, preferably avoid*

*CAPD Usually ineffective, preferably avoid*

*CRRT Not applicable; preferably avoid*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Hydroxyethyl Starch 130/0.4 in 0.9 % Sodium Chloride - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **6 % Hydroxyethyl Starch 130/0.4 in 0.9 % Sodium Chloride /Voluven®**

**{Plasma volume expander; colloid}**

<b>Usual initial dose:</b>	10–20 mL IV infused slowly with observation for possible anaphylactoid reactions followed by IV infusion of the remainder of a 500-mL container at a relatively rapid rate (e.g., over 30 min) dependent on the patient’s blood loss, hemodynamics, and hemodilution effects
<b>Usual maintenance dose:</b>	≤50 mL/kg (3 g/kg) per day (equivalent to 3,500 mL in a 70-kg patient)
<b>Typical maximum dose:</b>	50 mL/kg/day (~3,500 mL/day)
<b>Proportion eliminated unchanged:</b>	59–70 %

### ***Adjustment for Kidney Disease***

<b>FDA-approved product labeling:</b>	<i>Renal dysfunction</i>	<i>Adjust dosage, avoid fluid overload</i>
	<i>Renal failure with oliguria or anuria not associated with hypovolemia</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>eCrCL 30–50 mL/min</i>	<i>≤500 mL/24 h IV</i>
	<i>eCrCL 15–30 mL/min</i>	<i>≤500 mL/24 h IV</i>
	<i>Hemodialysis</i>	<i>Data not available; preferably avoid due to risk for accumulation and possible nephrotoxicity</i>
	<i>CAPD</i>	<i>Data not available; preferably avoid due to risk for accumulation and possible nephrotoxicity</i>
	<i>CRRT</i>	<i>Data not available; preferably avoid due to risk for accumulation and possible nephrotoxicity</i>



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Hydroxyurea - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Hydroxyurea (Hydroxycarbamide)/ Hydrea®, Droxia®

{Antineoplastic; ribonucleotide reductase inhibitor}

<b>Usual initial dose:</b>	Malignancy, 20–30 mg/kg orally; sickle cell disease, 15 mg/kg orally
<b>Usual maintenance dose:</b>	Malignancy, 20–30 mg/kg orally once daily or 80 mg/kg orally as a single dose every third day; sickle cell disease, 15 mg/kg orally once daily
<b>Typical maximum dose:</b>	35 mg/kg/day
<b>Proportion eliminated unchanged:</b>	36 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Malignancy*

*Use with caution in patients with marked renal dysfunction. As renal excretion is a pathway of elimination, consideration should be given to decreasing dosage in patients with renal impairment. Close monitoring of hematologic parameters is advised in these patients.*

*Sickle cell disease*

*CrCL ≥60 mL/min*

*15 mg/kg orally once daily*

*CrCL <60 or end-stage renal disease*

*7.5 mg/kg orally once daily, after dialysis on hemodialysis days*

**Alternative adjustment:**

*Malignancy*

*GFR >50 mL/min*

*20–30 mg/kg orally every 24 h*

*GFR 10–50 mL/min*

*10–15 mg/kg orally every 24 h (50 % decrease)*

*GFR <10 mL/min*

*4–6 mg/kg orally every 24 h (80 % decrease)*

*Hemodialysis*

*4–6 mg/kg orally every 24 h; administer after hemodialysis on dialysis days.*

*CAPD*

*4–6 mg/kg orally every 24 h*

*CRRT*

*10–15 mg/kg orally every 24 h*

*Note: Hematological and other considerations may suggest further dosage adjustments.*

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ibandronate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Ibandronate/Boniva**<sup>®</sup>

**{Anti-osteoporotic; bisphosphonate}**

<b>Usual initial dose:</b>	2.5 mg or 150 mg orally or 3 mg IV
<b>Usual maintenance dose:</b>	2.5 mg orally once daily or 150 mg orally once monthly or 3 mg IV over 15–30 s every 3 months
<b>Typical maximum dose:</b>	150 mg/month orally or 6 mg IV over 15–60 min every 3 months
<b>Proportion eliminated unchanged:</b>	50–60 % of an IV dose within 24 h

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild or moderate renal impairment</i>	<i>No dose adjustment needed</i>
	<i>Severe renal impairment (SCr &gt;2.3 mg/dL or CrCL &lt;30 mL/min)</i>	<i>Use not recommended</i>
<b>Alternative adjustment:</b>	<i>GFR ≥30 mL/min</i>	<i>150 mg orally once monthly or 3–6 mg IV every 3 months</i>
	<i>GFR &lt;30 mL/min</i>	<i>Preferably avoid due to (1) risk (presently theoretical and/or undocumented) for renal adverse effects, (2) minimal safety evidence, and (3) only limited experience available with reduced dose regimens (1 mg IV once monthly) in patients on chronic hemodialysis</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Idarubicin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Idarubicin/Idamycin®**

**{Antineoplastic; anthracycline}**

<b>Usual initial dose:</b>	12 mg/m <sup>2</sup> IV
<b>Usual maintenance dose:</b>	12 mg/m <sup>2</sup> IV daily for 3 days
<b>Typical maximum dose:</b>	12 mg/m <sup>2</sup> /day
<b>Proportion eliminated unchanged:</b>	3–5 % in 24 h, 16 % in 4 days (8 % of active hydroxylated metabolite, idarubicinol)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal impairment</i>	<i>Dose reduction should be considered.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>12 mg/kg IV daily for 3 days</i>
	<i>GFR 10–50 mL/min</i>	<i>8 mg/kg IV daily for 3 days (~25 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>6 mg/kg IV daily for 3 days (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Data not available</i>

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ifosfamide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Ifosfamide/Ifex®**

{Antineoplastic; alkylating agent}

<b>Usual initial dose:</b>	1.2 g/m <sup>2</sup>
<b>Usual maintenance dose:</b>	1.2 g/m <sup>2</sup> IV over 1–2 h daily for 5 consecutive days every 3 weeks or after hematological recovery (with mesna)
<b>Typical maximum dose:</b>	May be limited by hematological toxicity
<b>Proportion eliminated unchanged:</b>	14 % (Stereoselective renal metabolism may contribute to production of nephrotoxic metabolites such as chloroacetaldehyde.)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Compromised renal function</i>	<i>Studies to establish optimal dose schedules in such patients have not been conducted.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1.2 g/m<sup>2</sup> IV daily for 5 days every 3 weeks or after hematological recovery</i>
	<i>GFR 10–50 mL/min</i>	<i>0.9 g/m<sup>2</sup> IV daily for 5 days every 3 weeks or after hematological recovery (25 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>0.6 g/m<sup>2</sup> IV daily for 5 days every 3 weeks or after hematological recovery (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>0.04–0.6 g/m<sup>2</sup> IV daily for 5 days every 3 weeks or after hematological recovery (~50 % decrease)</i>
	<i>CAPD</i>	<i>0.6 g/m<sup>2</sup> IV daily for 5 days every 3 weeks or after hematological recovery (50 % decrease)</i>
	<i>CRRT</i>	<i>0.9 g/m<sup>2</sup> IV daily for 5 days</i>

*Note: Urological, hematological, and/or other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Imatinib - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Imatinib/Gleevec®

{Antineoplastic; protein-tyrosine kinase inhibitor}

<b>Usual initial dose:</b>	400–600 mg orally with a meal
<b>Usual maintenance dose:</b>	400–600 mg orally once daily or 400 mg orally twice daily with meals
<b>Typical maximum dose:</b>	1,200 mg/day
<b>Proportion eliminated unchanged:</b>	5 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥60 mL/min</i>	<i>400–600 mg orally once daily with a meal or 400 mg orally twice daily with meals</i>
	<i>CrCL 40–59 mL/min</i>	<i>400–600 mg orally once daily with a meal</i>
	<i>CrCL 20–39 mL/min</i>	<i>200–300 mg orally once daily with a meal (50 % starting dose reduction; future doses may be increased as tolerated, not to exceed 400 mg/day)</i>
	<i>CrCL &lt;20 mL/min</i>	<i>100 mg orally once daily with a meal</i>
<b>Alternative adjustment:</b>	<i>eCrCL ≥60 mL/min</i>	<i>400–600 mg orally once daily with a meal or 400 mg orally twice daily with meals was generally well tolerated in a phase I study, although edema was prevalent (64 % of patients); the incidence of all other serious adverse effects was unrelated to kidney function.</i>
	<i>eCrCL 40–59 mL/min</i>	<i>400–600 mg orally once daily with a meal or 400 mg orally twice daily with meals was generally well tolerated in most patients, although edema was commonly reported (27 % of patients); investigators advised that dose adjustment was unnecessary with mild renal dysfunction.</i>
	<i>eCrCL 20–39 mL/min</i>	<i>400–600 mg orally once daily with a meal was well generally tolerated in most patients although edema was commonly reported (27 % of patients); investigators advised that dose adjustment was unnecessary with moderate renal dysfunction.</i>
	<i>eCrCL &lt;20 mL/min</i>	<i>100 mg orally once daily was generally well tolerated in two patients.</i>
	<i>Hemodialysis</i>	<i>400 mg orally once daily with a meal was effective and well tolerated in at least two patients.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Imipenem/Cilastatin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

<b>Imipenem/Cilastatin/Primaxin®</b>	<b>{Antibacterial; carbapenem}</b>
<b>Usual initial dose:</b>	500 mg IV
<b>Usual maintenance dose:</b>	500 mg IV every 6 h
<b>Typical maximum dose:</b>	4,000 mg/day
<b>Proportion eliminated unchanged:</b>	70 %

### Adjustment for Kidney Disease

#### FDA-approved product labeling:

*Imipenem-cilastatin reduced IV dosage in adult patients with impaired renal function*

CrCL (mL/min)	Body weight (kg)				
	≥70	60	50	40	30
<i>If total daily dose for normal renal function is 1 g/day, use:</i>					
≥71	250 mg q 6 h	250 mg q 8 h	125 mg q 6 h	125 mg q 6 h	125 mg q 8 h
41–70	250 mg q 8 h	125 mg q 6 h	125 mg q 6 h	125 mg q 8 h	125 mg q 8 h
21–40	250 mg q 12 h	250 mg q 12 h	125 mg q 8 h	125 mg q 12 h	125 mg q 12 h
6–20	250 mg q 12 h	125 mg q 12 h	125 mg q 12 h	125 mg q 12 h	125 mg q 12 h
<i>If total daily dose for normal renal function is 1.5 g/day, use:</i>					
≥71	500 mg q 8 h	250 mg q 6 h	250 mg q 6 h	250 mg q 8 h	125 mg q 6 h
41–70	250 mg q 6 h	250 mg q 8 h	250 mg q 8 h	125 mg q 6 h	125 mg q 8 h
21–40	250 mg q 8 h	250 mg q 8 h	250 mg q 12 h	125 mg q 8 h	125 mg q 8 h
6–20	250 mg q 12 h	250 mg q 12 h	250 mg q 12 h	125 mg q 12 h	125 mg q 12 h
<i>If total daily dose for normal renal function is 2 g/day, use:</i>					
≥71	500 mg q 6 h	500 mg q 8 h	250 mg q 6 h	250 mg q 6 h	250 mg q 8 h
41–70	500 mg q 8 h	250 mg q 6 h	250 mg q 6 h	250 mg q 8 h	125 mg q 6 h
21–40	250 mg q 6 h	250 mg q 8 h	250 mg q 8 h	250 mg q 12 h	125 mg q 8 h
6–20	250 mg q 12 h	250 mg q 12 h	250 mg q 12 h	250 mg q 12 h	125 mg q 12 h
<i>If total daily dose for normal renal function is 3 g/day, use:</i>					
≥71	1,000 mg q 8 h	750 mg q 8 h	500 mg q 6 h	500 mg q 8 h	250 mg q 6 h
41–70	500 mg q 6 h	500 mg q 8 h	500 mg q 8 h	250 mg q 6 h	250 mg q 8 h
21–40	500 mg q 8 h	500 mg q 8 h	250 mg q 6 h	250 mg q 8 h	250 mg q 8 h
6–20	500 mg q 12 h	500 mg q 12 h	250 mg q 12 h	250 mg q 12 h	250 mg q 12 h
<i>If total daily dose for normal renal function is 4 g/day, use:</i>					
≥71	1,000 mg q 6 h	1,000 mg q 8 h	750 mg q 8 h	500 mg q 6 h	500 mg q 8 h
41–70	750 mg q 8 h	750 mg q 8 h	500 mg q 6 h	500 mg q 8 h	250 mg q 6 h
21–40	500 mg q 6 h	500 mg q 8 h	500 mg q 8 h	250 mg q 6 h	250 mg q 8 h
6–20	500 mg q 12 h	500 mg q 12 h	500 mg q 12 h	250 mg q 12 h	250 mg q 12 h

*Use dosage for CrCL 6–20 mL/m in hemodialysis; give after hemodialysis on dialysis days. Patients with CrCL ≤5 mL/min should not receive imipenem unless hemodialysis is initiated within 48 h*

<b>Alternative adjustment:</b>	GFR >50 mL/min	500 mg IV every 8 h
	GFR 10–50 mL/min	250–500 mg IV every 8–12 h (~50 % decrease)
	GFR <10 mL/min	250 mg IV every 12 h (~75 % decrease)
	Hemodialysis	250–500 mg IV every 12 h, after hemodialysis on dialysis days
	CAPD	250 mg IV every 12 h or 1 g intraperitoneally every other exchange
	CVVH	250 mg IV every 6 h or 500 mg IV every 6–8 h
	CVVHD or CVVHDF	500 mg IV every 6–8 h
	Caution—	Increased seizure potential in patients with renal impairment

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Indapamide - Selected References

- Acciardo SR, Skoutakis VA. Clinical efficacy, safety, and pharmacokinetics of indapamide in renal impairment. *Am Heart J.* 1983;106:237–44.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Indapamide/Lozol®** {Diuretic; thiazide-like}

**Usual initial dose:** 2.5 mg orally  
**Usual maintenance dose:** 1.25–5 mg orally once daily  
**Typical maximum dose:** 5 mg/day  
**Proportion eliminated unchanged:** 7 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal disease</i>	<i>Use with caution.</i>
	<i>Anuria</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>2.5 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>1.25–2.5 mg orally once daily</i>
	<i>GFR &lt;10 mL/min</i>	<i>1.25–2.5 mg orally once daily (limited data available)</i>
	<i>Hemodialysis</i>	<i>1.25–2.5 mg orally once daily (limited data available)</i>
	<i>CAPD</i>	<i>Data not available; preferably avoid due to potentially limited effectiveness</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Indomethacin - Selected References

- Basivireddy J, Jacob M, Pulimood AB, Balasubramanian KA. Indomethacin-induced renal damage: role of oxygen free radicals. *Biochem Pharmacol.* 2004;67:587–99.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Indomethacin/Indocin®** {Anti-inflammatory; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 25 mg  
**Usual maintenance dose:** 25–50 mg twice or three times daily  
**Typical maximum dose:** 200 mg/day  
**Proportion eliminated unchanged:** 15 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Advanced renal disease</i>	<i>Not recommended, avoid</i>
<b>Alternative adjustment:</b>	<i>Hemodialysis</i>	<i>25 mg orally three times daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Insulins - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Insulins/Apidra® (Glulisine), Humalog® (Lispro), Humulin N® (Isophane/NPH), Humulin R® (Regular), Lantus® (Glargine), Levemir® (Detemir), Novolin N® (Isophane /NPH), Novolin R® (Regular), NovoLog® (Aspart)**

{Antidiabetic; hormone}

<b>Usual initial dose:</b>	0.2–0.4 units/kg/day subcutaneously in divided amounts; 0.1–14 units/h IV
<b>Usual maintenance dose:</b>	0.5–2 units/kg/day subcutaneously in divided amounts, often 40–60 % as basal insulin with the remainder as prandial rapid-acting insulin
<b>Typical maximum dose:</b>	Widely variable
<b>Proportion eliminated unchanged:</b>	None

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *The requirements for insulin may be reduced in patients with renal impairment.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>100 % of usual dose; monitor and titrate.</i>
	<i>GFR 10–50 mL/min</i>	<i>75 % of usual dose; monitor and titrate.</i>
	<i>GFR &lt;10 mL/min</i>	<i>50 % of usual dose; monitor and titrate.</i>
	<i>Hemodialysis</i>	<i>50 % of usual dose; no supplemental dose after dialysis; monitor and titrate.</i>
	<i>CAPD</i>	<i>50 % of usual dose; monitor and titrate.</i>
	<i>CRRT</i>	<i>75 % of usual dose; monitor and titrate.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Interferon Alfa-2b and Ribavirin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Interferon Alfa-2b and Ribavirin/Rebetron™ {Antiviral; R for hepatitis C}**

<b>Usual initial dose:</b>	Interferon alfa-2b three million units intramuscularly or subcutaneously three times weekly plus ribavirin 1,000–1,200 mg/day in two divided doses
<b>Usual maintenance dose:</b>	Interferon alfa-2b three million units intramuscularly or subcutaneously three times weekly plus ribavirin 1,000–1,200 mg/day in two divided doses
<b>Typical maximum dose:</b>	Interferon alfa-2b three million units intramuscularly or subcutaneously three times weekly plus ribavirin 1,200 mg/day in two divided doses
<b>Proportion eliminated unchanged:</b>	Interferon alfa-2b = nil; ribavirin 5–15 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;50 mL/min</i>	<i>Contraindicated (ribavirin)</i>
<b>Alternative adjustment:</b>	<i>Hemodialysis</i>	<i>Three million units subcutaneously three times weekly with ribavirin 200 mg orally once daily</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Isocarboxazid - Selected References**

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Isocarboxazid/Marplan®**

**{Antidepressant; monoamine oxidase inhibitor}**

**Usual initial dose:** 10 mg orally twice daily

**Usual maintenance dose:** 20 mg orally twice daily

**Typical maximum dose:** 60 mg/day

**Proportion Eliminated Unchanged:** Unknown (hydrolytic cleavage and further oxidation to benzoate are believed to be the foremost means of elimination)

### ***Adjustment for Kidney Disease***

**FDA-approved product labeling:** *Impaired renal function*      *Use cautiously to prevent accumulation.*

*Severe impairment of renal function*      *Contraindicated*

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Itraconazole - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Itraconazole/Sporanox®**

**{Antifungal; triazole ergosterol biosynthesis inhibitor}**

<b>Usual initial dose:</b>	Capsules, 200 mg orally three times daily with food for the first 3 days of treatment; oral solution, 100–200 mg orally once daily without food
<b>Usual maintenance dose:</b>	Capsules, 200 mg orally once or twice daily with food; oral solution, 100 mg orally twice daily without food
<b>Typical maximum dose:</b>	600 mg/day
<b>Proportion eliminated unchanged:</b>	<1 % (35 % as inactive metabolites)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal impairment</i>	<i>Caution should be exercised when this drug is administered in this patient population.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>Capsules, 200 mg orally three times daily with food for the first 3 days of treatment followed by 100–200 mg orally once or twice daily with food; oral solution, 100–200 mg (2.5 mg/kg in cystic fibrosis patients) enterally every 12 h given without food</i>
	<i>GFR 10–50 mL/min</i>	<i>Oral solution: 100 mg enterally every 12 h given without food</i>
	<i>GFR &lt;10 mL/min</i>	<i>Oral solution: 50–100 mg enterally every 12 h given without food (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>Oral solution: 100 mg enterally every 12 h given without food</i>
	<i>CAPD</i>	<i>Oral solution: 50–100 mg enterally every 12 h given as an oral solution without food</i>
	<i>CVVH</i>	<i>Oral solution: 100 mg enterally every 12 h given without food</i>
	<i>CVVHD or CVVHDF</i>	<i>Oral solution: 100–200 mg enterally every 12 h given without food</i>

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Kanamycin - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Kanamycin/Kantrex®** {Antibacterial; aminoglycoside}

**Usual initial dose:** 7.5 mg/kg IV  
**Usual maintenance dose:** 7.5 mg/kg IV every 12 h  
**Typical maximum dose:** 1,500 mg/day  
**Proportion eliminated unchanged:** 95 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** 7.5 mg/kg IV every ( $9 \times \text{SCr [mg/dL]}$ ) h<sup>a</sup>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>7.5 mg/kg IM or IV every 12–24 h<sup>a</sup></i>
<i>GFR 10–50 mL/min</i>	<i>7.5 mg/kg IM or IV every 24–72 h<sup>a</sup></i>
<i>GFR &lt;10 mL/min</i>	<i>7.5 mg/kg IM or IV every 48–72 h<sup>a</sup></i>
<i>Hemodialysis</i>	<i>3.75 mg/kg IM or IV after hemodialysis on dialysis days only<sup>a</sup></i>
<i>CAPD</i>	<i>Add to dialysate qs 15–20 mg/L<sup>a</sup></i>
<i>CRRT</i>	<i>7.5 mg/kg IM or IV every 24–72 h<sup>a</sup></i>

### *<sup>a</sup>Therapeutic Drug Monitoring*

**Therapeutic plasma levels:** *Peak: 25–35 mg/L*  
*Trough: 4–8 mg/L*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ketoprofen - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ketoprofen/Orudis®** {Anti-inflammatory; analgesic; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 50 mg orally  
**Usual maintenance dose:** 25–50 mg orally every 6–8 h  
**Typical maximum dose:** 300 mg/day  
**Proportion eliminated unchanged:** <1 % (63–75 % of dose as metabolites in urine)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mildly impaired renal function</i>	<i>Max 150 mg/day</i>
	<i>Severe/end-stage renal impairment (GFR &lt;25 mL/min/1.73 m<sup>2</sup>)</i>	<i>Max 100 mg/day</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>25–75 mg orally three times daily</i>
	<i>GFR 10–50 mL/min</i>	<i>25–50 mg orally three times daily (~25 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>12.5–25 mg orally two to three times daily (~50 % decrease)</i>
	<i>Hemodialysis</i>	<i>12.5–25 mg orally two to three times daily (~50 % decrease)</i>
	<i>CAPD</i>	<i>12.5–25 mg orally two to three times daily (~50 % decrease)</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ketorolac - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ketorolac/Toradol**<sup>®</sup> {Anti-inflammatory; analgesic; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 30–60 mg IM or IV or 20 mg orally  
**Usual maintenance dose:** 15–30 mg IM or IV every 6 h as needed for pain or 10 mg orally every 4–6 h as needed for pain  
**Typical maximum dose:** 120 mg/day IV or IM or 40 mg/day orally, not to exceed 5 days duration  
**Proportion eliminated unchanged:** 60 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renally impaired patients</i>	<i>15 mg IM or IV every 6 h as needed for pain (max 60 mg/day) or 10 mg orally once, then 10 mg orally every 4–6 h prn not &gt;40 mg/day</i>
	<i>Advanced renal impairment or patients at risk for renal failure due to volume depletion</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>15–30 mg IM or IV every 6 h, not to exceed 5 days duration</i>
	<i>GFR 10–50 mL/min</i>	<i>Preferably avoid or 7.5–15 mg IM or IV every 6 h, not to exceed 5 days duration (50 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk for gastrointestinal and renal toxicity</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risk for gastrointestinal and renal toxicity</i>
	<i>CAPD</i>	<i>Preferably avoid due to risk for gastrointestinal and renal toxicity</i>
	<i>CRRT</i>	<i>7.5–15 mg IM or IV every 6 h, not to exceed 5 days duration</i>



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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lacosamide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Lacosamide/Vimpat®** {Antiepileptic; neuronal voltage-gated sodium channel blocker; collapsing response mediator protein-2 (CRIMP-2) inhibitor}

**Usual initial dose:** 50 mg orally or IV twice daily  
**Usual maintenance dose:** 100–200 mg orally or IV twice daily  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 40 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild to moderate renal impairment (CrCL &gt;30 mL/min)</i>	<i>100–200 mg enterally or IV twice daily (no dose adjustment necessary)</i>
	<i>Severe renal impairment (CrCL ≤30 mL/min)</i>	<i>100–150 mg enterally or IV twice daily (max 300 mg/day)</i>
	<i>Hemodialysis</i>	<i>Give supplemental dose (50 % of single maintenance dose amount) after each dialysis.</i>
<b>Alternative adjustment:</b>	<i>GFR ≤30 mL/min</i>	<i>100–150 mg enterally or IV twice daily (max 300 mg/day; cardiac monitoring is recommended during dose titration and intercurrent acute illness)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lamivudine - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Lamivudine (3TC)/Epivir®** {Antiretroviral; nucleoside analog; R for hepatitis B}

**Usual initial dose:** 150 mg orally  
**Usual maintenance dose:** 150 mg orally twice daily or 300 mg once daily  
**Typical maximum dose:** 300 mg/day  
**Proportion eliminated unchanged:** 70 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Adjustment of dosage of lamivudine in adults and adolescents (≥30 kg)*

<i>CrCL (mL/min)</i>	<i>Recommended dosage of lamivudine</i>
<i>Human immunodeficiency virus (HIV-1) infection</i>	
≥50	150 mg twice daily or 300 mg once daily
30–49	150 mg once daily
15–29	150 mg first dose, then 100 mg once daily
5–14	150 mg first dose, then 50 mg once daily
<5	50 mg first dose, then 25 mg once daily
<i>Hepatitis B virus HBV infection</i>	
≥50	100 mg once daily
30–49	100 mg first dose, then 50 mg once daily
15–29	100 mg first dose, then 25 mg once daily
5–14	35 mg first dose, then 15 mg once daily
<5	35 mg first dose, then 10 mg once daily

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>150 mg orally every 12 h or 300 mg orally once daily</i>
<i>GFR 10–50 mL/min</i>	<i>150 mg orally every 24 h</i>
<i>GFR &lt;10 mL/min</i>	<i>20 mg orally every 24 h</i>
<i>Hemodialysis</i>	<i>25 mg orally once daily or 75 mg orally every other day; administer after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>10 mg orally once daily</i>
<i>CRRT</i>	<i>150 mg orally every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lanreotide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Lanreotide/Somatuline® Depot** {Somatostatin analog; R for acromegaly}

**Usual initial dose:** 90 mg every 4 weeks for 3 months administered as a deep subcutaneous injection in the superior external quadrant of the buttock

**Usual maintenance dose:** 60–120 mg subcutaneously every 4 weeks, with dose adjusted based on growth hormone (GH) and insulin-like growth factor (IGF-1) levels

**Typical maximum dose:** 120 mg every 4 weeks

**Proportion eliminated unchanged:** Unknown

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Lanreotide starting dose in patients with moderate and severe renal impairment should be 60 mg every 4 weeks for 3 months administered as a deep subcutaneous injection in the superior external quadrant of the buttock, with subsequent dosage adjusted based on growth hormone (GH) and insulin-like growth factor (IGF-1) levels as tabulated below*

<i>Patient response</i>	<i>Dose</i>
<i>GH &gt;1 to ≤2.5 ng/mL; normalized IGF-1; and/or controlled clinical symptoms</i>	<i>90 mg every 28 days</i>
<i>GH &gt;2.5 ng/ml; IGF-1 elevated; and/or clinical symptoms uncontrolled</i>	<i>120 mg every 28 days</i>
<i>GH ≤1 ng/mL; IGF-1 normal clinical symptoms controlled</i>	<i>60 mg every 28 days</i>

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lenalidomide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Lenalidomide/Revlimid®** {Immunomodulator; R for myelodysplastic syndromes, multiple myeloma, Behçet syndrome}

**Usual initial dose:** 10–25 mg orally  
**Usual maintenance dose:** Myelodysplastic syndromes, 10 mg orally once daily; multiple myeloma, 25 mg orally once daily for 21 days of repeated 28-day cycles  
**Typical maximum dose:** 25 mg/day  
**Proportion eliminated unchanged:** 65 %

### Adjustment for Kidney Disease

#### FDA-approved product labeling:

##### Lenalidomide renal function impairment starting dose

Category	Renal function	Multiple myeloma	Myelodysplastic syndrome
Moderate renal impairment	CrCL 30–59 mL/min	10 mg every 24 h	5 mg every 24 h
Severe renal impairment	CrCL <30 mL/min (not requiring dialysis)	15 mg every 48 h	5 mg every 48 h
End-stage renal disease	CrCL <30 mL/min (requiring dialysis)	5 mg once daily; on dialysis days, administer following dialysis	5 mg three times per week following each dialysis

#### Alternative adjustment:

##### Myelodysplastic syndromes

*eCrCL* ≥50 mL/min 10 mg orally every 24 h

*eCrCL* 30–49 mL/min 5 mg orally every 24 h

*eCrCL* <30 mL/min 5 mg orally every 48 h

Hemodialysis 5 mg orally three times weekly; administer after hemodialysis on dialysis days.

CRRT Data not available

##### Multiple myeloma

*eCrCL* ≥50 mL/min 25 mg orally every 24 h

*eCrCL* 30–49 mL/min 10 mg orally every 24 h

*eCrCL* <30 mL/min 15 mg orally every 48 h

Hemodialysis 15 mg orally three times weekly; administer after hemodialysis on dialysis days.

CRRT Data not available

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lepirudin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Lepirudin/Refludan®** {Antithrombotic; direct thrombin inhibitor}

**Usual initial dose:** 0.4 mg/kg IV bolus (max 44 mg)  
**Usual maintenance dose:** 0.15 mg/kg/h IV (max 16.5 mg/h)  
**Typical maximum dose:** 0.21 mg/kg/h  
**Proportion eliminated unchanged:** 40 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Lepirudin reduction of infusion rate in patients with renal impairment*

CrCL [mL/min]	SCr [mg/dL]	Adjusted infusion rate	
		% of standard initial rate	mg/kg/h
45–60	1.6–2.0	50	0.075
30–44	2.1–3.0	30	0.045
15–29	3.1–6.0	15	0.0225
<15	>6.00	Avoid or STOP infusion	-0-

*The target range (therapeutic window) for the aPTT ratio should be 1.5–2.0 times the mean of the normal laboratory range (corresponding to lepirudin plasma levels of 600–700 µg/L); monitoring should be performed at 4-h intervals until it is apparent that steady state within the target range is achieved*

*In all patients with renal insufficiency, the bolus dose is to be reduced to 0.2 mg/kg IV*

*In hemodialysis patients or in acute renal failure (CrCL <15 mL/min or SCr >6.0 mg/dL), infusion of lepirudin is to be avoided or stopped*

### Alternative adjustment:

*The target range (therapeutic window) for the aPTT ratio usually should be 1.5–2.0 times the mean of the normal laboratory range (corresponding to lepirudin plasma levels of 600–700 µg/L); monitoring should be performed at 4-h intervals until it is apparent that steady-state values within the target range are attained.*

*eCrCL >60 mL/h or SCr <1.0 mg/dL 0.08–0.10 mg/kg/h IV (no initial bolus)*

*eCrCL 30–60 mL/h or SCr 1.0–1.67 mg/dL 0.04–0.05 mg/kg/h IV (no initial bolus)*

*eCrCL 15–30 mL/h or SCr 1.68–4.80 mg/dL 0.01 mg/kg/h IV (no initial bolus)*

*eCrCL <15 mL/h or SCr >4.80 mg/dL 0.005 mg/kg/h IV (no initial bolus)*

*Hemodialysis 0.025–0.1 mg/kg IV bolus; repeat doses may be administered when aPTT values fall below 1.5 times the patient's baseline (intervals between doses may be as long as 6–12 days).*

*CVVHD 0.004–0.025 mg/kg/h continuous IV infusion (removal of lepirudin from plasma is dependent on membrane material and wide variations in rate are reported; removal is negligible with some low-flux membranes)*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Levetiracetam - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Levetiracetam/Keppra®** {Antiepileptic; synaptic vesicle protein SV2A modulator; N-type calcium current blocker}

**Usual initial dose:** 500 mg orally or IV twice daily  
**Usual maintenance dose:** 1,500 mg orally twice daily or 1,000 mg IV every 12 h  
**Typical maximum dose:** 4,000 mg/day orally or 3,000 mg/day IV  
**Proportion eliminated unchanged:** 66 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Levetiracetam dosage adjustment for adults with renal function impairment*

<i>Renal function status</i>	<i>CrCL (mL/min)</i>	<i>Oral or IV dose (mg)</i>	<i>Frequency</i>
<i>Healthy</i>	<i>&gt;80</i>	<i>500–1,500</i>	<i>Every 12 h</i>
<i>Mild</i>	<i>50–80</i>	<i>500–1,000</i>	<i>Every 12 h</i>
<i>Moderate</i>	<i>30–50</i>	<i>250–750</i>	<i>Every 12 h</i>
<i>Severe</i>	<i>&lt;30</i>	<i>250–500</i>	<i>Every 12 h</i>
<i>ESRD patients on dialysis</i>	<i>–</i>	<i>500–1,000</i>	<i>Every 24 h</i>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>500–1,000 mg orally or IV every 12 h</i>
<i>GFR 10–50 mL/min</i>	<i>250–750 mg orally or IV every 12 h</i>
<i>GFR &lt;10 mL/min</i>	<i>500–1,000 mg orally or IV every 24 h</i>
<i>Hemodialysis</i>	<i>500–1,000 mg orally or IV every 24 h plus 250–500 mg after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>500–1,000 mg orally or IV every 24 h</i>
<i>CRRT</i>	<i>250–750 mg orally or IV every 12 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Levocetirizine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Levocetirizine/Xyzal<sup>®</sup>

{Antihistamine; second-generation histamine H<sub>1</sub> blocker}

<b>Usual initial dose:</b>	5 mg orally
<b>Usual maintenance dose:</b>	2.5–5 mg orally once daily
<b>Typical maximum dose:</b>	10 mg
<b>Proportion eliminated unchanged:</b>	77 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild renal impairment (CrCL 50–80 mL/min)</i>	<i>2.5 mg orally once daily in the evening</i>
	<i>Moderate renal impairment (CrCL 30–50 mL/min)</i>	<i>2.5 mg orally every other day in the evening</i>
	<i>Severe renal impairment (CrCL 10–30 mL/min)</i>	<i>2.5 mg orally twice weekly in the evening</i>
	<i>End-stage renal disease (CrCL &lt;10 mL/min)</i>	<i>Contraindicated</i>
	<i>Hemodialysis</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>CRRT</i>	<i>Not applicable</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Levofloxacin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Levofloxacin/Levaquin®** {Antibacterial; fluoroquinolone}

**Usual initial dose:** 500 mg enterally or IV  
**Usual maintenance dose:** 250–750 mg enterally or IV every 24 h  
**Typical maximum dose:** 750 mg/day  
**Proportion eliminated unchanged:** 70 %

### Adjustment for Kidney Disease

#### FDA-approved product labeling:

*Levofloxacin dosage adjustment in adult patients with renal impairment (CrCL <50 mL/min)*

<i>Dosage in normal renal function</i>	<i>CrCL 20–49 mL/min</i>	<i>CrCL 10–19 mL/min</i>	<i>Hemodialysis or chronic ambulatory peritoneal dialysis (CAPD)</i>
750 mg every 24 h	750 mg every 48 h	750 mg initial dose, then 500 mg every 48 h	750 mg initial dose, then 500 mg every 48 h
500 mg every 24 h	500 mg initial dose, then 250 mg every 24 h	500 mg initial dose, then 250 mg every 48 h	500 mg initial dose, then 250 mg every 48 h
250 mg every 24 h	No dosage adjustment required	250 mg every 48 h. If treating uncomplicated UTI, then no dosage adjustment is required	No information on dosing adjustment is available

*No adjustment is necessary for patients with CrCL ≥50 mL/min*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500–750 mg orally or IV once followed by 250–750 mg orally or IV every 24 h</i>
	<i>GFR 10–50 mL/min</i>	<i>500–750 mg orally or IV once followed by 250–750 mg orally or IV every 24–48 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>500–750 mg orally or IV once followed by 250–500 mg orally or IV every 48 h</i>
	<i>Hemodialysis</i>	<i>500–750 mg orally or IV once followed by 250–500 mg orally or IV every 48 h; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>500–750 mg orally or IV once followed by 250–500 mg orally or IV every 48 h</i>
	<i>CVVH</i>	<i>500–750 mg IV once followed by 250 mg IV every 24 h</i>
	<i>CVVHD</i>	<i>500–750 mg IV once followed by 250–500 mg IV every 24 h</i>
	<i>CVVHDF</i>	<i>500–750 mg IV once followed by 250–750 mg IV every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lisinopril - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Lisinopril/Prinivil®, Zestril®** {Antihypertensive, vasodilator, angiotensin converting enzyme (ACE)/renin inhibitor}

**Usual initial dose:** 5–10 mg orally  
**Usual maintenance dose:** 5–40 mg orally once daily  
**Typical maximum dose:** 40 mg/day  
**Proportion eliminated unchanged:** 85 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Lisinopril dosage in renal function impairment*

<i>Renal status</i>	<i>CrCL (mL/min)</i>	<i>SCr (mg/dL)</i>	<i>Initial dose (mg/day)</i>
<i>Healthy renal function to mild impairment</i>	<i>&gt;30</i>	<i>&lt;3</i>	<i>10</i>
<i>Moderate to severe renal function impairment</i>	<i>≥10 ≤30</i>	<i>≥3.0</i>	<i>5</i>
<i>Dialysis patients</i>	<i>&lt;10</i>	<i>–</i>	<i>2.5</i>

*No adjustment is necessary for patients with CrCL ≥30 mL/min*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>5–10 mg initially followed by 5–40 mg/day</i>
<i>GFR 10–50 mL/min</i>	<i>2.5–5 mg initially followed by 5–20 mg/day (25–50 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>2.5 mg initially followed by 2.5–20 mg/day (50–75 % decrease)</i>
<i>Hemodialysis</i>	<i>2.5 mg initially followed by 2.5–20 mg/day (50–75 % decrease)</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>2.5–5 mg initially followed by 5–20 mg/day</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lithium - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Lithium/Lithane®**, Lithobid® {Antimanic agent}

**Usual initial dose:** 600 mg orally

**Usual maintenance dose:** 900–2,400 mg/day in three or four divided doses or 900–1,800 mg/day in two divided doses (sustained release); dosage must be individualized according to serum levels and clinical response.

**Typical maximum dose:** 2,400 mg/day

**Proportion eliminated unchanged:** 95 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *When kidney function is assessed, for baseline data prior to starting lithium therapy or thereafter, routine urinalysis and other tests may be used to evaluate tubular function (e.g., urine specific gravity or osmolality following a period of water deprivation or 24-h urine volume) and glomerular function (e.g., SCr or CrCL). During lithium therapy, progressive or sudden changes in renal function, even within the normal range, indicate the need for reevaluation of treatment. Chronic lithium therapy may be associated with diminution of renal concentrating ability, occasionally presenting as nephrogenic diabetes insipidus with polyuria and polydipsia. Morphologic changes with glomerular and interstitial fibrosis and nephron atrophy have been reported. Lithium should generally not be given to patients with significant renal or cardiovascular disease, severe debilitation or dehydration or sodium depletion, and patients receiving diuretics, since the risk of lithium toxicity is very high in these patients.*

*For acute mania, optimal response usually can be established with 1,800 mg/day.*

*For long-term control, desirable serum lithium concentrations usually can be achieved with 900–1,200 mg/day.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>900–1,200 mg/day orally in divided doses</i>
	<i>GFR 10–50 mL/min</i>	<i>300–600 mg/day orally in divided doses (25–50 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>150–450 mg/day orally in divided doses (50–75 % decrease)</i>
	<i>Hemodialysis</i>	<i>150–450 mg/day orally in divided doses; dose after dialysis</i>
	<i>CAPD</i>	<i>150–450 mg/day orally in divided doses</i>
	<i>CRRT</i>	<i>300–600 mg/day enterally in divided doses</i>

### Therapeutic Drug Monitoring

**Therapeutic plasma levels:** 0.6–1.2 mEq/L; draw sample 8–12 h after previous dose (just before next dose).

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lomustine - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Lomustine/CeeNU**<sup>®</sup> {Antineoplastic; alkylating agent; nitrosourea}

**Usual initial dose:** 130 mg/m<sup>2</sup> orally  
**Usual maintenance dose:** 130 mg/m<sup>2</sup> as a single oral dose every 6 weeks  
**Typical maximum dose:** 130 mg/m<sup>2</sup>  
**Proportion eliminated unchanged:** 50 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Renal abnormalities consisting of progressive azotemia, decrease in kidney size, and renal failure have been reported in patients who received large cumulative doses after prolonged therapy with lomustine. Kidney damage has also been reported occasionally in patients receiving lower total doses.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>130 mg/m<sup>2</sup> as a single oral dose every 6 weeks</i>
<i>GFR 10–50 mL/min</i>	<i>65–100 mg/m<sup>2</sup> as a single oral dose every 6 weeks (25–50 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>30–65 mg/m<sup>2</sup> as a single oral dose every 6 weeks (50–75 % decrease)</i>
<i>Hemodialysis</i>	<i>30–65 mg/m<sup>2</sup> as a single oral dose every 6 weeks; supplemental dose after dialysis not necessary</i>
<i>CAPD</i>	<i>30–65 mg/m<sup>2</sup> as a single oral dose every 6 weeks (50–75 % decrease)</i>
<i>CRRT</i>	<i>Data not available</i>

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Loracarbef - Selected References

- Amsden GW. Tables of antimicrobial agent pharmacology. In: Mandell GL, Bennett JE, Dolin R, editors. Mandell, Douglas, and Bennett's principles and practice of infectious diseases. Vol 1. 6th ed. Philadelphia: Elsevier; 2005. p. 634–700.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Loracarbef/Lorabid®

{Antibacterial; second-generation cephalosporin}

<b>Usual initial dose:</b>	400 mg orally
<b>Usual maintenance dose:</b>	200–400 mg orally every 12 h for 7–14 days
<b>Typical maximum dose:</b>	800 mg/day
<b>Proportion eliminated unchanged:</b>	85 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥50 mL/min</i>	<i>200–400 mg orally every 12 h</i>
	<i>CrCL 10–49 mL/min</i>	<i>200–400 mg every 24 h</i>
	<i>CrCL &lt;10 mL/min</i>	<i>200–400 mg orally every 3–5 days</i>
	<i>Hemodialysis</i>	<i>200–400 mg orally every 3–5 days; administer supplemental dose following hemodialysis on dialysis days.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>200–400 mg orally every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>200–400 mg orally every 24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>200–400 mg orally every 3–5 days</i>
	<i>Hemodialysis</i>	<i>200–400 mg orally every 3–5 days; administer supplemental dose following hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>200–400 mg orally every 3–5 days</i>
	<i>CRRT</i>	<i>Not applicable (consider an IV cephalosporin)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lurasidone - Selected References

- Caccia S. Pharmacokinetics and metabolism update for some recent antipsychotics. *Expert Opin Drug Metab Toxicol.* 2011;7:829–46.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Lurasidone/Latuda<sup>®</sup>

{Atypical antipsychotic}

<b>Usual initial dose:</b>	40 mg orally once daily
<b>Usual maintenance dose:</b>	40–80 mg orally once daily
<b>Typical maximum dose:</b>	80 mg/day
<b>Proportion eliminated unchanged:</b>	5 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥50 mL/min</i>	<i>40–80 mg orally once daily</i>
	<i>CrCL ≥10 to &lt;50 mL/min</i>	<i>Do not exceed 40 mg orally once daily.</i>
<b>Alternative adjustment:</b>	<i>GFR &lt;10 mL/min</i>	<i>Data not available; preferably avoid</i>
	<i>Hemodialysis</i>	<i>Data not available; preferably avoid</i>
	<i>CAPD</i>	<i>Data not available; preferably avoid</i>
	<i>CRRT</i>	<i>Data not available; preferably avoid</i>

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## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Magnesium Citrate - Selected References**

Fassler CA, Rodriguez RM, Badesch DB, Stone WJ, Marini JJ. Magnesium toxicity as a cause of hypotension and hypoventilation: occurrence in patients with normal renal function. *Arch Intern Med.* 1985;145:1604–6.

Lacy CF, Armstrong LL, Goldman MP, Lance LL, editors. *Drug information handbook: a comprehensive source for all clinicians and healthcare professionals.* 20th ed. Hudson: Lexi-Comp/American Pharmacists Association; 2011.

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Randall E Jr, Cohen MD, Spray CC Jr, Rossmeisl EC. Hypermagnesemia in renal failure: etiology and toxic manifestations. *Ann Intern Med.* 1964;61:73–88.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Magnesium Citrate/Citroma®**      {Saline laxative}

**Usual initial dose:**                      195–300 mL orally (8.72–17.45 g)

**Usual maintenance dose:**              195–300 mL orally once daily

**Typical maximum dose:**                300 mL/day

**Proportion eliminated unchanged:**    Variable, unknown

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**    *Kidney disease*                      *Warning, ask a doctor before use.*

**Alternative adjustment:**              *GFR ≥50 mL/min*                      *150–300 mL (4 mL/kg) orally once daily or PRN constipation*

*GFR 30–49 mL/min*                      *150 mL orally once daily or PRN constipation; monitor serum magnesium levels.*

*GFR <30 mL/min*                      *Preferably avoid due to potential toxicity from magnesium accumulation. Consider use of stool softener or bulk-forming or stimulant laxative.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Magnesium Hydroxide - Selected References

Alfrey AC, Terman DS, Brettschneider L, Simpson KM, Ogden DA. Hypermagnesemia after renal homotransplantation. *Ann Intern Med.* 1970;73:367–71.

Goodwin FJ, Vince FP. Hypermagnesemic encephalopathy due to antacid ingestion occurring during regular dialysis treatment. *Br J Urol.* 1970;42:586–9.

Johansson G, Backman U, Danielson BG, Fellström B, Ljunghall S, Wikstöm B. Effects of magnesium hydroxide in renal stone disease. *J Am Coll Nutr.* 1982;1:179–85.

Krumlovsky F, Del Greco F. Use of antacids in patients on chronic dialysis [letter]. *Lancet.* 1970;2:150.

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Milk of Magnesia Original [package insert]. Minneapolis: Nash-Finch Co; 2009.

Randall E Jr, Cohen MD, Spray CC Jr, Rossmeisl EC. Hypermagnesemia in renal failure: etiology and toxic manifestations. *Ann Intern Med.* 1964;61:73–88.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Magnesium Hydroxide (Milk of Magnesia) {Laxative; antacid}

<b>Usual initial dose:</b>	30 mL (2,400 mg) orally
<b>Usual maintenance dose:</b>	30–60 mL (2,400–4,800 mg) orally once daily at bedtime or in divided doses
<b>Typical maximum dose:</b>	60 mL (4,800 mg)
<b>Proportion eliminated unchanged:</b>	Variable, unknown

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Kidney disease*

*Warning, ask a doctor before use.*

**Alternative adjustment:**

*GFR  $\geq$ 50 mL/min*

*30–60 mL orally at bedtime and/or in divided doses PRN constipation*

*GFR 30–49 mL/min*

*30 mL orally at bedtime and/or PRN constipation; monitor serum magnesium levels.*

*GFR <30 mL/min*

*Preferably avoid due to potential toxicity from magnesium accumulation. Consider use of stool softener or bulk-forming or stimulant laxative.*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Magnesium/Aluminum Hydroxide and Simethicone - Selected References

- Alfrey AC Terman DS, Brettschneider L, Simpson KM, Ogden DA. Hypermagnesemia after renal homotransplantation. *Ann Intern Med.* 1970;73:367–71.
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- Randall RE Jr, Cohen MD, Spray CC Jr, Rossmeisl EC. Hypermagnesemia in renal failure: etiology and toxic manifestations. *Ann Intern Med.* 1964;61:73–88.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Magnesium/Aluminum Hydroxide and Simethicone/Maalox<sup>®</sup>, Mylanta<sup>®</sup> {Antacid; antiflatulent}

<b>Usual initial dose:</b>	15–60 mL orally
<b>Usual maintenance dose:</b>	10–20 mL between meals and at bedtime as needed or 60 mL 2 and 4 h after meals and at bedtime
<b>Typical maximum dose:</b>	300 mL/day
<b>Proportion eliminated unchanged:</b>	Variable, unknown

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Kidney disease</i>	<i>Warning, ask a doctor before use.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt; 50 mL/min</i>	<i>30 mL orally 1 and 3 h after each meal three times daily and at bedtime; or 30 mL enterally hourly as necessary to maintain gastric contents pH &gt;3.5; or 30 mL orally PRN abdominal discomfort</i>
	<i>GFR 30–49 mL/min</i>	<i>30 mL orally every 4 h PRN abdominal discomfort; monitor serum magnesium levels.</i>
	<i>GFR &lt;30 mL/min</i>	<i>Preferably avoid due to potential toxicity from magnesium accumulation. Consider use of proton pump inhibitor, dose-adjusted histamine H<sub>2</sub> antagonist, or sucralfate.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Magnesium Sulfate - Selected References

- Abraham AS, Rosenmann D, Kramer M, et al. Magnesium in the prevention of lethal arrhythmias in acute myocardial infarction. *Arch Intern Med.* 1987;147:753–5.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Magnesium Sulfate (IV), Magnesium Gluconate/Uro-Mag® {Electrolyte supplement; antispasmodic}

<b>Usual initial dose:</b>	1–4 g IV; 500–1,000 mg orally
<b>Usual maintenance dose:</b>	1–40 g daily IV; 500–1,000 mg orally twice daily
<b>Typical maximum dose:</b>	3 g/h IV; 4,000 mg/day orally
<b>Proportion eliminated unchanged:</b>	~95 %

#### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Serious impairment of renal function Give very cautiously since it is excreted almost entirely by the kidneys.*

**Alternative adjustment:** *Magnesium dosage adjustment for (a) ICU patients and (b) Non-ICU patients (magnesium replacement)*

Serum/plasma magnesium level	Glomerular filtration rate (GFR in mL/min)		
	>50	25–50	<25
<i>(a) ICU patients</i>			
1.3–1.7 mEq/L	<i>Magnesium gluconate 1,000 mg via enteral route every 6 h × 4</i> <i>If enteral route NOT available, magnesium sulfate 2 g IV × 2</i>	<i>Magnesium gluconate 1,000 mg via enteral route every 12 h × 2</i> <i>If enteral route NOT available, magnesium sulfate 2 g IV × 1</i>	<i>Magnesium gluconate 1,000 mg via enteral route every 12 h × 2</i> <i>If enteral route NOT available, magnesium sulfate 1 g IV × 1</i>
0.6–1.2 mEq/L	<i>Magnesium sulfate 2 g IV × 4</i>	<i>Magnesium sulfate 2 g IV × 2</i>	<i>Magnesium sulfate 2 g IV × 1</i>
≤0.5 mEq/L	<i>Notify MD</i>	<i>Notify MD</i>	<i>Notify MD</i>
<i>(b) Non-ICU patients</i>			
1.3–1.7 mEq/L	<i>Magnesium gluconate 1,000 mg via enteral route every 6 h × 4</i> <i>If enteral route NOT available, magnesium sulfate 2 g IV × 2</i>	<i>Magnesium gluconate 1,000 mg via enteral route every 12 h × 2</i> <i>If enteral route NOT available, magnesium sulfate 2 g IV × 1</i>	<i>Magnesium gluconate 1,000 mg via enteral route every 12 h × 2</i> <i>If enteral route NOT available, magnesium sulfate 1 g IV × 1</i>
1.0–1.2 mEq/L	<i>Magnesium sulfate 2 g IV × 3</i>	<i>Magnesium sulfate 2 g IV × 2</i>	<i>Magnesium sulfate 2 g IV × 1</i>
<1.0 mEq/L or symptomatic patient	<i>Notify MD</i>	<i>Notify MD</i>	<i>Notify MD</i>

*Note: Magnesium gluconate 500 mg tablet = 27 mg magnesium (approx = magnesium oxide 200 mg)  
Preferred IV rate £1 g/h. Maximum rate: £4 g/h (emergency)  
Maximum IV dose = 24 g in 24 h*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Mannitol - Selected References

- Barry KG. Post-traumatic renal shutdown in humans: its prevention and treatment by the intravenous infusion of mannitol. *Milit Med.* 1963;128:224–30.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Mannitol/Osmitol<sup>®</sup>

{Osmotic diuretic; genitourinary irrigant}

<b>Usual initial dose:</b>	12.5 g (200 mg/kg) IV over 5 min (test dose to assess renal function) 0.5–1.5 g/kg IV
<b>Usual maintenance dose:</b>	0.25–0.5 g/kg IV every 4–6 h
<b>Typical maximum dose:</b>	3 g/kg
<b>Proportion eliminated unchanged:</b>	90 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Well-established (not acute or impending) anuria due to severe renal disease</i>	<i>Contraindicated</i>
	<i>Progressive renal damage or dysfunction after institution of mannitol, including increasing oliguria and azotemia</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Maraviroc - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Maraviroc/Selzentry®** {Human CCR5 antagonist, HIV entry inhibitor antiretroviral}

**Usual initial dose:** 300 mg orally  
**Usual maintenance dose:** 150–600 mg orally twice daily  
**Typical maximum dose:** 1,200 mg/day  
**Proportion eliminated unchanged:** 8 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Maraviroc dose based on renal function*

	<i>Normal</i> <i>CrCL &gt;80 mL/ min</i>	<i>Mild</i> <i>CrCL 51–80 mL/ min</i>	<i>Moderate</i> <i>CrCL 30–50 mL/ min</i>	<i>Severe</i> <i>CrCL &lt;30 mL/ min</i>	<i>End-stage renal disease (ESRD)</i> <i>On regular hemodialysis</i>
<i>Concomitant medications</i>					
<i>Potent CYP3A inhibitors (with or without a CYP3A inducer)<sup>a</sup></i>	<i>150 mg twice daily</i>	<i>150 mg twice daily</i>	<i>150 mg twice daily</i>	<i>Not recommended</i>	<i>Not recommended</i>
<i>Other concomitant medications<sup>b</sup></i>	<i>300 mg twice daily</i>	<i>300 mg twice daily</i>	<i>300 mg twice daily</i>	<i>300 mg twice daily</i>	<i>300 mg twice daily</i>
<i>Potent CYP3A inducers (without a potent CYP3A inhibitor)<sup>c</sup></i>	<i>600 mg twice daily</i>	<i>600 mg twice daily</i>	<i>600 mg twice daily</i>	<i>Not recommended</i>	<i>Not recommended</i>

### Concomitant medications

*Maraviroc dose for  
normal renal function*

<sup>a</sup>*Potent CYP3A inhibitors (with or without a potent CYP3A inducer) including: Protease inhibitors (except tipra-150 mg twice daily  
navir/ritonavir)*

*Delavirdine*

*Ketoconazole, itraconazole, clarithromycin*

*Other potent CYP3A inhibitors (e.g., nefazodone, telithromycin)*

<sup>b</sup>*Other concomitant medications, including tipranavir/ritonavir, nevirapine, raltegravir, all nucleoside reverse-  
transcriptase inhibitors, and enfuvirtide* 300 mg twice daily

<sup>c</sup>*Potent CYP3A inducers (without a potent CYP3A inhibitor) including:*

*Efavirenz*

*Rifampin*

*Etravirine*

*Carbamazepine, phenobarbital, and phenytoin*

600 mg twice daily

**Alternative adjustment:** *Data not available*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Mefenamic Acid - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Mefenamic Acid/Ponstel®** {Anti-inflammatory; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 500 mg orally  
**Usual maintenance dose:** 250 mg orally every 6 h  
**Typical maximum dose:** 1,500 mg/day  
**Proportion eliminated unchanged:** 6 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Preexisting renal disease</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>250 mg orally every 6 h</i>
	<i>GFR 10–50 mL/min</i>	<i>Preferably avoid due to risk of gastrointestinal and renal toxicity.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk of gastrointestinal and renal toxicity.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risk of gastrointestinal and renal toxicity.</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Meloxicam - Selected References

- Bae J-W, Choi C-I, Jang C-G, Lee S-Y. Effects of CYP2C9\*1/\*13 on the pharmacokinetics and pharmacodynamics of meloxicam. *Br J Clin Pharmacol*. 2011;71:550–5.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Meloxicam/Mobic®** {Anti-inflammatory; nonsteroidal anti-inflammatory drug; selective cyclooxygenase (COX)-2 inhibitor}

**Usual initial dose:** 7.5 mg orally  
**Usual maintenance dose:** 7.5–15 mg orally once daily  
**Typical maximum dose:** 15 mg/day  
**Proportion eliminated unchanged:** 1 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Preexisting mild to moderate kidney disease</i>	<i>Use with caution; no dose adjustment is necessary</i>
	<i>Severe renal impairment (CrCL &lt;15 mL/min)</i>	<i>Not recommended; avoid</i>
<b>Alternative adjustment:</b>	<i>Hemodialysis</i>	<i>7.5 mg orally once daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Melphalan (IV) - Selected References

- Alberts DS, Chang SY, Chen H-SG, et al. Kinetics of intravenous melphalan. *Clin Pharmacol Ther.* 1979;26:73–80.
- Alkeran® injection [package insert]. Research Triangle Park: GlaxoSmithKline LLC; 2008.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Melphalan (IV)/Alkeran® IV {Antineoplastic; alkylating agent; nitrogen mustard}

<b>Usual initial dose:</b>	16 mg/m <sup>2</sup> IV
<b>Usual maintenance dose:</b>	16 mg/m <sup>2</sup> IV every 2 weeks times four doses then 16 mg/m <sup>2</sup> IV every 4 weeks
<b>Typical maximum dose:</b>	16 mg/m <sup>2</sup> IV
<b>Proportion eliminated unchanged:</b>	40 % (range 5–90 %)

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal insufficiency (BUN ≥30 mg/dL)</i>	<i>8 mg/m<sup>2</sup>/dose IV (50 % decrease)</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min:</i>	<i>16 mg/m<sup>2</sup> IV every 2 weeks times four doses then 16 mg/m<sup>2</sup> IV every 4 weeks</i>
	<i>GFR 10–50 mL/min</i>	<i>12 mg/m<sup>2</sup> IV every 2 weeks times four doses then 12 mg/m<sup>2</sup> IV every 4 weeks (25 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>8 mg/m<sup>2</sup> IV every 2 weeks times four doses then 8 mg/m<sup>2</sup> IV every 4 weeks (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>8 mg/m<sup>2</sup> IV every 2 weeks times four doses then 8 mg/m<sup>2</sup> IV every 4 weeks (50 % decrease)</i>
	<i>CAPD</i>	<i>8 mg/m<sup>2</sup> IV every 2 weeks times four doses then 8 mg/m<sup>2</sup> IV every 4 weeks (50 % decrease)</i>
	<i>CRRT</i>	<i>12 mg/m<sup>2</sup> IV every 2 weeks times four doses then 12 mg/m<sup>2</sup> IV every 4 weeks (50 % decrease)</i>

*Note: Patients with multiple myeloma undergoing hematopoietic stem cell transplantation may be treated with conditioning high-dose IV melphalan. Although highly controversial due to wide individual variations in drug clearance, some authorities recommend decreasing the dose of IV melphalan from 140–200 to 100 mg/m<sup>2</sup> in patients with GFR <30 mL/min.*

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Melphalan (Oral) - Selected References

- Adair CG, Bridges JM, Desai ZR. Renal function in the elimination of oral melphalan in patients with multiple myeloma. *Cancer Chemother Pharmacol*. 1986;17:185–8.
- Alberts DS, Chang SY, Chen H-SG, Evans TL, Moon TE. Oral melphalan kinetics. *Clin Pharmacol Ther*. 1979;26:737–45.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Melphalan (Oral)/Alkeran®

{Antineoplastic; alkylating agent; nitrogen mustard}

<b>Usual initial dose:</b>	6 mg (3 tablets) orally once daily times 2–3 weeks
<b>Usual maintenance dose:</b>	6 mg (3 tablets) once daily times 2–3 weeks then discontinue times 4 weeks then 2 mg orally once daily
<b>Typical maximum dose:</b>	0.25 mg/kg/day
<b>Proportion eliminated unchanged:</b>	10–30 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *It may be prudent to use a reduced dose initially.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>6 mg (3 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 2 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>4 mg (2 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 2 mg orally once daily (~25 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>3 mg (1.5 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 1 mg orally once daily (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>3 mg (1.5 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 1 mg orally once daily (50 % decrease); dose after dialysis</i>
	<i>CAPD</i>	<i>3 mg (1.5 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 1 mg orally once daily (50 % decrease)</i>
	<i>CRRT</i>	<i>4 mg (2 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 2 mg orally once daily (~25 % decrease)</i>

*Note: Hematological and other considerations may suggest further dosage adjustments.*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Memantine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Meperidine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Meperidine/Demerol®

{Analgesic, opioid  $\mu$ -receptor agonist}

<b>Usual initial dose:</b>	50–150 mg PO, IM, or subcutaneously or 10–25 mg IV
<b>Usual maintenance dose:</b>	50–150 mg PO, IM, or subcutaneously or 10–25 mg IV every 3–4 h as necessary
<b>Typical maximum dose:</b>	600 mg/day
<b>Proportion eliminated unchanged:</b>	5 % (active metabolite normeperidine predominantly eliminated in urine)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal impairment</i>	<i>Give with caution.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>50–150 mg PO, IM, or subcutaneously or 10–25 mg IV every 3 h as necessary</i>
	<i>GFR 10–50 mL/min</i>	<i>Avoid due to risk for neurotoxicity/seizures.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid due to risk for neurotoxicity/seizures.</i>
	<i>Hemodialysis</i>	<i>Avoid due to risk for neurotoxicity/seizures.</i>
	<i>CAPD</i>	<i>Avoid due to risk for neurotoxicity/seizures.</i>
	<i>CRRT</i>	<i>Avoid due to risk for neurotoxicity/seizures.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Meprobamate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Meprobamate/Miltown®**                      {Anxiolytic; carbamate derivative}

**Usual initial dose:**                              400 mg orally  
**Usual maintenance dose:**                      1,200–1,600 mg/day orally in three or four divided doses  
**Typical maximum dose:**                      2,400 mg/day  
**Proportion eliminated unchanged:**        10 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Compromised kidney function</i>	<i>Caution should be exercised.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>200–400 mg orally every 6 h</i>
	<i>GFR 10–50 mL/min</i>	<i>200–400 mg orally every 8–12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>200–400 mg orally every 12–18 h</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Not applicable, preferably avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Mercaptopurine - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Mercaptopurine/Purinethol**<sup>®</sup> {Antineoplastic; antimetabolite; purine analog}

**Usual initial dose:** 1.5–2.5 mg/kg  
**Usual maintenance dose:** 1.5–2.5 mg/kg orally once daily  
**Typical maximum dose:** 5 mg/kg/day  
**Proportion eliminated unchanged:** 22 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Impaired renal function It is probably advisable to start with lower dosages.*

**Alternative adjustment:** *GFR <50 mL/min 1.5–2.5 mg/kg orally every 48 h*

*Note: Most authorities suggest that mercaptopurine dosing may be optimized with pharmacogenetic therapeutic drug monitoring.*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Meropenem - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Meropenem/Merrem® {Carbapenem/thienamycin antibiotic}

<b>Usual initial dose:</b>	500–2,000 mg IV
<b>Usual maintenance dose:</b>	1–2 g IV every 8 h
<b>Typical maximum dose:</b>	2,000 mg IV every 8 h
<b>Proportion eliminated unchanged:</b>	66–79 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Meropenem dosing for adults with renal impairment*

<i>CrCL (mL/min)</i>	<i>Dose (mg IV)</i>	<i>Dosing interval</i>
<i>≥51</i>	<i>500–1,000</i>	<i>Every 8 h</i>
<i>26–50</i>	<i>500–1,000</i>	<i>Every 12 h</i>
<i>10–25</i>	<i>250–500</i>	<i>Every 12 h</i>
<i>&lt;10</i>	<i>500–1,000</i>	<i>Every 24 h</i>

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500–2,000 mg IV over 30 min or 1–2 g IV over 1–3 h every 8 h or 2–6 g/24 h continuous IV infusion</i>
	<i>GFR 10–50 mL/min</i>	<i>1 g IV every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>500–1,000 mg IV every 24 h</i>
	<i>Hemodialysis</i>	<i>500–1,000 mg IV every 24 h; dose after hemodialysis on dialysis days</i>
	<i>Extended daily dialysis</i>	<i>500–1,000 mg IV every 8 h</i>
	<i>CAPD</i>	<i>500–1,000 mg IV every 24 h</i>
	<i>CVVH</i>	<i>500–1,000 mg IV every 12 h</i>
	<i>CVVHD or CVVHDF</i>	<i>750–1,000 mg IV every 8 h or 1,500 mg IV every 12 h or 2 g/24 h continuous IV infusion</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Metaxalone - Selected References

- Bruce RB, Turnbull L, Newman J, Pitts J. Metabolism of metaxalone. *J Med Chem.* 1966;9:286–8.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Metaxalone/Skelaxin®** {Centrally acting skeletal muscle relaxant}

**Usual initial dose:** 800 mg orally  
**Usual maintenance dose:** 800 mg orally three to four times daily  
**Typical maximum dose:** 3,200 mg/day  
**Proportion eliminated unchanged:** 27 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Renal impairment* Use with caution.  
*Significantly impaired renal function* Contraindicated

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Metformin - Selected References

- Abe M, Okada K, Soma M. Antidiabetic agents in patients with chronic kidney disease and end-stage renal disease on dialysis: metabolism and clinical practice. *Curr Drug Metab.* 2011;12:57–69
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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Metformin/Glucophage®**

**{Biguanide antidiabetic}**

- Usual initial dose:** 850 mg orally once daily with food or 500 mg orally twice daily with meals or 500 mg extended-release orally once daily with the evening meal
- Usual maintenance dose:** 850–1,000 mg orally twice daily with meals or 1,000–2,000 mg extended-release orally once daily with the evening meal
- Typical maximum dose:** 2,550 mg/day
- Proportion eliminated unchanged:** 90 %

***Adjustment for Kidney Disease***

**FDA-approved product labeling:** *Kidney disease/abnormal CrCL (SCr ≥1.5 [males] or ≥1.4 [females]) and use in patients undergoing radiologic studies involving intra-vascular administration of iodinated contrast materials*

<b>Alternative adjustment:</b>	<i>GFR &gt;60 mL/min</i>	<i>500–1,000 mg orally twice daily with meals</i>
	<i>GFR 41–60 mL/min</i>	<i>250–750 mg orally twice daily with meals</i>
	<i>GFR 10–40 mL/min</i>	<i>Avoid due to risk for metabolic complications such as lactic acidosis.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid due to risk for metabolic complications such as lactic acidosis.</i>
	<i>Hemodialysis</i>	<i>Avoid due to risk for metabolic complications such as lactic acidosis.</i>
	<i>CAPD</i>	<i>Avoid due to risk for metabolic complications such as lactic acidosis.</i>
	<i>CVVH</i>	<i>Not applicable; avoid due to risk for metabolic complications such as lactic acidosis.</i>
	<i>CVVHD or CVVHDF</i>	<i>Not applicable; avoid due to risk for metabolic complications such as lactic acidosis.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Methadone - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Methadone/Dolophine®** {Analgescic, opioid  $\mu$ -receptor agonist}

**Usual initial dose:** 2.5–10 mg orally or IV  
**Usual maintenance dose:** 2.5–10 mg orally or IV every 8–12 h  
**Typical maximum dose:** 120 mg/day  
**Proportion eliminated unchanged:** 20 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Methadone has not been extensively evaluated in patients with renal insufficiency.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>2.5–10 mg orally or IV every 8–12 h</i>
<i>GFR 10–50 mL/min</i>	<i>2.5–10 mg orally or IV every 8–12 h</i>
<i>GFR &lt;10 mL/min</i>	<i>1.25–5 mg orally or IV every 8–12 h (25–50 % decrease)</i>
<i>Hemodialysis</i>	<i>1.25–5 mg orally or IV every 8–12 h (25–50 % decrease)</i>
<i>CAPD</i>	<i>1.25–5 mg orally or IV every 8–12 h (25–50 % decrease)</i>
<i>CRRT</i>	<i>2.5–10 mg orally or IV every 8–12 h</i>

*Note: Rate of urinary elimination and half-life of methadone vary according to urine pH; particular caution is advised in patients receiving urinary alkalinizers such as sodium bicarbonate.*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Methenamine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Methenamine/Hiprex®, Mandelamine® {Antibacterial; urinary antiseptic}

<b>Usual initial dose:</b>	1 g orally
<b>Usual maintenance dose:</b>	1 g orally twice daily after meals
<b>Typical maximum dose:</b>	4 g/day
<b>Proportion eliminated unchanged:</b>	80 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal insufficiency</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1 g orally every twice daily after meals</i>
	<i>GFR 10–50 mL/min</i>	<i>Avoid due to risk for drug and/or formaldehyde accumulation.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid due to risk for drug and/or formaldehyde accumulation.</i>
	<i>Hemodialysis</i>	<i>Avoid due to risk for drug and/or formaldehyde accumulation.</i>
	<i>CAPD</i>	<i>Avoid due to risk for drug and/or formaldehyde accumulation.</i>
	<i>CRRT</i>	<i>Not applicable; avoid.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Methocarbamol (IV) - Selected References

- Anah CO. Tetanus: conservative management made easier by combination of muscle relaxants. *Am J Trop Med Hyg.* 1974;23:930–4.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Methocarbamol (IV)/Robaxin® IV {Centrally acting skeletal muscle relaxant}

<b>Usual initial dose:</b>	1,000 mg IV
<b>Usual maintenance dose:</b>	1,000 mg IV, repeated if necessary up to twice within 24 h
<b>Typical maximum dose:</b>	3,000 mg/day
<b>Proportion eliminated unchanged:</b>	<10 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Renal impairment*      *Contraindicated (due to excipient content [polyethylene glycol 300])*

**Alternative adjustment:**      *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Methotrexate - Selected References

- Abelson HT, Fosburg MT, Beardsley GP, et al. Methotrexate-induced renal impairment: clinical studies and rescue from systemic toxicity with high-dose leucovorin and thymidine. *J Clin Oncol.* 1983;1:208–16.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Methotrexate/Rheumatrex<sup>®</sup>, Trexall<sup>™</sup>** {Antineoplastic; antimetabolite; disease-modifying antirheumatic drug}

<b>Usual initial dose:</b>	7.5 mg orally
<b>Usual maintenance dose:</b>	5–15 mg orally once weekly
<b>Typical maximum dose:</b>	30 mg/week
<b>Proportion eliminated unchanged:</b>	85 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Injection—Adequate renal function must be documented; SCr must be normal, and CrCL must be >60 mL/min before initiation of therapy.*

*Oral—Patients with renal impairment require especially careful monitoring for toxicity and require dose reduction or, in some cases, discontinuation of methotrexate administration.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>5–15 mg orally once weekly</i>
<i>GFR 10–50 mL/min</i>	<i>2.5–5 mg orally once weekly (50 % decrease; avoid high-dose therapy)</i>
<i>GFR &lt;10 mL/min</i>	<i>Avoid unless no suitable alternative exists; if indeed necessary, 2.5–5 mg orally once weekly</i>
<i>Hemodialysis</i>	<i>2.5–5 mg orally once weekly (50 % decrease); avoid high-dose therapy.</i>
<i>CAPD</i>	<i>Minimal data available. Avoid unless no suitable alternative exists; if indeed necessary, 2.5–5 mg orally once weekly</i>
<i>CRRT</i>	<i>2.5–5 mg orally once weekly (50 % decrease); avoid high-dose therapy.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Methyldopa (IV) - Selected References

- Barnett AJ, Bobik A, Carson V, Korman JS, McLean AJ. Pharmacokinetics of methyldopa: plasma levels following single intravenous, oral and multiple oral dosage in normotensive and hypertensive subjects. *Clin Exp Pharmacol Physiol*. 1977;4:331-9.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Methyldopate/Aldomet® IV**                      {Antihypertensive;  $\alpha_2$ -adrenergic agonist}

**Usual initial dose:**                                      250–500 mg IV  
**Usual maintenance dose:**                            250–500 mg IV every 6 h as necessary  
**Typical maximum dose:**                            1,000 mg IV every 6 h  
**Proportion eliminated unchanged:**              ~50 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**    *Patients with impaired renal function may respond to smaller doses.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>250–500 mg IV every 8 h</i>
<i>GFR 10–50 mL/min</i>	<i>250–500 mg IV every 8–12 h</i>
<i>GFR &lt;10 mL/min</i>	<i>250–500 mg IV every 12–24 h</i>
<i>Hemodialysis</i>	<i>250–500 mg IV every 12–24 h; administer after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>250–500 mg IV every 12–24 h</i>
<i>CRRT</i>	<i>250–500 mg IV every 8–12 h; titrate.</i>



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Methylnaltrexone - Selected References

- Amin HM, Sopchak AM, Foss JF, Esposito BF, Roizen MF, Camporesi EM. Efficacy of methylnaltrexone versus naloxone for reversal of morphine-induced depression of hypoxic ventilatory response. *Anesth Analg*. 1994;78:701–5.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Methylnaltrexone/Relistor®** {Peripherally acting opioid antagonist; R for opioid-induced constipation}

**Usual initial dose:** 0.15 mg/kg (8 mg if 38–61 kg, 12 mg if 62–114 kg) subcutaneously  
**Usual maintenance dose:** 0.15 mg/kg (8 mg if 38–61 kg, 12 mg if 62–114 kg) subcutaneously every other day  
**Typical maximum dose:** 0.15 mg/kg every other day  
**Proportion eliminated unchanged:** 60 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL ≥30 mL/min* 0.15 mg/kg (8 mg if 38–61 kg, 12 mg if 62–114 kg) subcutaneously every other day  
*CrCL <30 mL/min* 0.075 mg/kg (4 mg if 38–61 kg, 6 mg if 62–114 kg) subcutaneously every other day (50 % dose reduction)

*End-stage renal disease/dialysis* No data; avoid.

**Alternative Adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Metoclopramide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Metoclopramide/Reglan®** {Antiemetic; prokinetic; dopamine antagonist}

**Usual initial dose:** 5–10 mg orally or IV  
**Usual maintenance dose:** 10 mg orally or IV four times daily  
**Typical maximum dose:** 10 mg/kg/day  
**Proportion eliminated unchanged:** 20 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;40 mL/min</i>	<i>Initiate therapy at approximately one-half the recommended dosage.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>10 mg orally or IV four times daily or 2–10 mg/kg IV prior to administration of moderately or highly emetogenic chemotherapy agents</i>
	<i>GFR 10–50 mL/min</i>	<i>7.5 mg orally or IV four times daily (25 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>5 mg orally or IV four times daily (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>5 mg orally or IV four times daily (no supplement after dialysis; 50 % decrease)</i>
	<i>CAPD</i>	<i>5 mg orally or IV four times daily (50 % decrease)</i>
	<i>CRRT</i>	<i>7.5 mg orally or IV four times daily (25 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Midodrine - Selected References

- Alappan R, Cruz D, Abu-Alfa AK, Mahnensmith R, Perazella MA. Treatment of severe intradialytic hypotension with the addition of high dialysate calcium concentration to midodrine and/or cool dialysate. *Am J Kidney Dis.* 2001;37:294–9.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Midodrine/ProAmatine®** {Vasopressor;  $\alpha_1$ -agonist}

**Usual initial dose:** 10 mg orally  
**Usual maintenance dose:** 10 mg orally three times daily while awake  
**Typical maximum dose:** 45 mg/day  
**Proportion eliminated unchanged:** 20 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Abnormal renal function</i>	<i>Because desglymidodrine is excreted renally, dosing in patients with abnormal renal function should be cautious; initiate treatment with 2.5 mg doses (three times daily).</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>5–10 mg orally every 8 h</i>
	<i>GFR 10–50 mL/min</i>	<i>5–10 mg orally every 8 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>Data not available</i>
	<i>Hemodialysis</i>	<i>2.5 mg orally twice daily on dialysis days; 1.25 mg twice daily on non-dialysis days; titrate.</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>5–10 mg orally every 8 h; titrate.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Miglitol - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Miglitol/Glyset®** {Antidiabetic;  $\alpha$ -glucosidase inhibitor}

**Usual initial dose:** 25 mg orally three times daily with meals

**Usual maintenance dose:** 50 mg orally three times daily with meals

**Typical maximum dose:** 100 mg orally three times daily

**Proportion eliminated unchanged:** 95 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Significant renal dysfunction (SCr >2.0 mg/dL) Use not recommended; avoid.*

**Alternative adjustment:** *Data not available*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Miglustat - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Miglustat/Zavesca<sup>®</sup>

{Enzyme (glucosylceramide synthetase) inhibitor; R for type 1 Gaucher disease}

<b>Usual initial dose:</b>	100 mg orally
<b>Usual maintenance dose:</b>	100 mg orally three times daily
<b>Typical maximum dose:</b>	300 mg/day
<b>Proportion eliminated unchanged:</b>	~95 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;70 mL/min</i>	<i>100 mg orally three times daily</i>
	<i>CrCL 50–70 mL/min</i>	<i>100 mg orally twice daily</i>
	<i>CrCL 30–50 mL/min</i>	<i>100 mg orally once daily</i>
	<i>CrCL &lt;30 mL/min</i>	<i>Use not recommended; avoid.</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Milnacipran - Selected References

- Arai M. Parkinsonism associated with a serotonin and noradrenaline reuptake inhibitor, milnacipran [letter]. *J Neurol Neurosurg Psychiatry*. 2003;74:137–8.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Milnacipran/Savella™

{Antidepressant; serotonin and norepinephrine reuptake inhibitor (SNRI)}

<b>Usual initial dose:</b>	12.5 mg once on day 1, 25 mg/day (12.5 mg twice daily) on days 2 and 3, 50 mg/day (25 mg twice daily) on days 4–7, and 100 mg/day (50 mg twice daily) after day 7
<b>Usual maintenance dose:</b>	50 mg orally twice daily
<b>Typical maximum dose:</b>	200 mg/day
<b>Proportion eliminated unchanged:</b>	55 % (renally eliminated metabolites are pharmacologically inactive)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Moderate renal impairment (CrCL <math>\geq</math>30 mL/min)</i>	<i>50 mg orally twice daily; use with caution.</i>
	<i>Severe renal impairment (CrCL 5–29 mL/min)</i>	<i>25 mg orally twice daily (50 % decrease)</i>
	<i>End-stage renal disease. (CrCL &lt;5 mL/min)</i>	<i>Not recommended; avoid.</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Milrinone - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Milrinone/Primacor®

{Inotropic agent; phosphodiesterase inhibitor}

<b>Usual initial dose:</b>	50 mcg/kg; administer IV slowly over 10 min.
<b>Usual maintenance dose:</b>	0.375–0.75 mcg/kg/min IV
<b>Typical maximum dose:</b>	1.13 mg/kg/day
<b>Proportion eliminated unchanged:</b>	80 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Milrinone dosage adjustment in renally impaired patients*

<i>CrCL (mL/min)</i>	<i>Infusion rate (mcg/kg/min)</i>
5	0.20
10	0.23
20	0.28
30	0.33
40	0.38
50	0.43

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>50 mcg/kg IV followed by 0.375 mcg/kg/min IV; titrate (max 0.75 mcg/kg/min).</i>
<i>GFR 31–50 mL/min</i>	<i>0.375 mcg/kg/min IV</i>
<i>GFR 10–30 mL/min</i>	<i>0.25 mcg/kg/min IV</i>
<i>Hemodialysis</i>	<i>Data not available</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CVVH</i>	<i>0.2–0.25 mcg/kg/min IV</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Moexipril - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Moexipril/Univasc<sup>®</sup>

{Antihypertensive, vasodilator, angiotensin-converting enzyme (ACE)/renin inhibitor}

<b>Usual initial dose:</b>	7.5 mg orally once daily taken 1 h before food
<b>Usual maintenance dose:</b>	7.5–30 mg orally in one or two divided doses taken 1 h before meals
<b>Typical maximum dose:</b>	60 mg/day
<b>Proportion eliminated unchanged:</b>	40 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≤40 mL/min</i>	<i>3.75 mg once daily initially, titrated if necessary to a maximum daily dose of 15 mg</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>7.5–30 mg orally in one or two divided doses taken 1 h before meals</i>
	<i>GFR 10–50 mL/min</i>	<i>3.75–15 mg orally in one or two divided doses taken 1 h before meals (50 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>3.75–15 mg orally in one or two divided doses taken 1 h before meals (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>3.75–15 mg orally in one or two divided doses taken 1 h before meals</i>
	<i>CAPD</i>	<i>3.75–15 mg orally in one or two divided doses taken 1 h before meals</i>
	<i>CRRT</i>	<i>3.75–15 mg orally in one or two divided doses taken 1 h before meals (50 % decrease)</i>



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Morphine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Morphine/Embeda™,  
Kadian®, MS Contin®**

{Analgesic, opioid  $\mu$ -receptor agonist}

<b>Usual initial dose:</b>	2–4 mg IV or 10 mg orally
<b>Usual maintenance dose:</b>	1–2 mg IV every 6–10 min (patient-controlled analgesia, PCA); 2–4 mg IV every 2–4 h PRN; 10–30 mg orally every 4 h PRN; In opioid-tolerant patients, 30 mg orally every 12 h (escalating doses may be required)
<b>Typical maximum dose:</b>	80 mg/h (chronic pain in opioid-tolerant patient)
<b>Proportion eliminated unchanged:</b>	2–12 % (active metabolite [morphine-6-glucuronide] predominantly eliminated in urine)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Care should be exercised in administering morphine to patients with renal dysfunction, since high blood morphine levels, due to reduced clearance, may take several days to develop.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>100 % of usual dose</i>
	<i>GFR 10–50 mL/min</i>	<i>75 % of usual dose</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid or 50 % of usual dose</i>
	<i>Hemodialysis</i>	<i>Preferably avoid or 50 % of usual dose</i>
	<i>CAPD</i>	<i>Preferably avoid or 50 % of usual dose</i>
	<i>CRRT</i>	<i>75 % of usual dose; titrate.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Mycophenolate Mofetil – Selected References

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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Mycophenolate Mofetil,  
Mycophenolate Sodium/  
CellCept®, Myfortic®**

**{Immunosuppressant; antirejection agent; inosine monophosphate dehydrogenase inhibitor}**

- Usual initial dose:** 1,000 mg orally or IV (CellCept®), 720 mg orally (Myfortic®)
- Usual maintenance dose:** 1,000 mg (1,500 mg in hepatic transplant patients) orally or IV twice daily (CellCept®);  
720 mg orally at least 1 h before or 2 h after meals twice daily (Myfortic®)
- Typical maximum dose:** 3,000 mg/day (CellCept®), 2,880 mg/day (Myfortic®)
- Proportion eliminated unchanged:** 3 % (plus 60 % of absorbed dose as glucuronidated metabolite)

***Adjustment for Kidney Disease***

- FDA-approved product labeling:**
  - Severe chronic renal impairment (GFR <25 mL/min) outside the immediate posttransplant period* *Doses >1 g twice a day should be avoided. These patients should be carefully observed. No dose adjustments are needed in renal transplant patients experiencing delayed graft function postoperatively (CellCept®).*
  - Severe chronic renal impairment (GFR <25 mL/min) outside the immediate posttransplant period* *These patients should be carefully followed for potential adverse reactions due to increase in free mycophenolic acid and mycophenolic acid glucuronide (inactive metabolite) concentrations (Myfortic®).*
- Alternative adjustment:**
  - de novo renal transplant patients* *1,440 mg orally at least twice daily for 2 weeks, followed by 1,080 mg orally twice daily for 4 weeks followed by 720 mg twice daily thereafter (Myfortic®; presently, only limited data support intensified posttransplant regimens)*
  - Hemodialysis* *250–500 mg orally twice daily (CellCept®; monitor)*
  - CAPD* *1,000 mg orally twice daily (CellCept®; monitor)*

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Nabumetone - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Nabumetone/Relafen**<sup>®</sup> {Anti-inflammatory; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 1,000 mg orally  
**Usual maintenance dose:** 1,000 mg orally once daily  
**Typical maximum dose:** 2,000 mg/day  
**Proportion eliminated unchanged:** 30 % (as primary active metabolite)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥50 mL/min</i>	<i>1,000 mg orally once daily</i>
	<i>CrCL 30–49 mL/min</i>	<i>750 mg orally once daily; max 1,500 mg/day</i>
	<i>CrCL &lt;30 mL/min</i>	<i>500 mg orally once daily; max 1,000 mg/day</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1,000 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>500–1,000 mg once daily (0–50 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>500–1,000 mg once daily (0–50 % decrease)</i>
	<i>Hemodialysis</i>	<i>1,000 mg orally once daily</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Nadolol - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Nadolol/Corgard**<sup>®</sup> {Antihypertensive, vasodilator, angiotensin-converting enzyme (ACE)/renin inhibitor}

**Usual initial dose:** 40 mg orally  
**Usual maintenance dose:** 40–120 mg orally once daily  
**Typical maximum dose:** 320 mg/day  
**Proportion eliminated unchanged:** 95 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Nadolol dosage adjustment in renal failure*

<i>CrCL (mL/min)</i>	<i>Dosage interval (h)</i>
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<i>&gt;50</i>	<i>24</i>
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<i>31–50</i>	<i>24–36</i>
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<i>10–30</i>	<i>24–48</i>
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<i>&lt;10</i>	<i>40–60</i>
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<b>Alternative adjustment:</b> <i>GFR &gt;50 mL/min</i>	<i>40–240 mg orally once daily</i>
<i>GFR 10–50 mL/min</i>	<i>20–80 mg orally every 24 h (50 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>10–40 mg orally every 24 h (~75 % decrease)</i>
<i>Hemodialysis</i>	<i>10–40 mg orally three times weekly after dialysis</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>20–120 mg orally every 24 h (50 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Nalidixic Acid/NegGram®

{Antibacterial; urinary antiseptic}

<b>Usual initial dose:</b>	1 g orally
<b>Usual maintenance dose:</b>	1 g orally four times daily
<b>Typical maximum dose:</b>	4 g/day
<b>Proportion eliminated unchanged:</b>	95 % (as parent drug, fully pharmacologically active hydroxylated and, in lesser proportions, inactive carboxylated metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *This drug is known to be excreted by the kidney, and the risk of toxic reactions to this drug may be greater in patients with impaired renal function.*

*SCr <300 μmol/L (3.6 mg/dL) or CrCL >20 mL/min*      *1 g orally four times daily*

*SCr ≥300 μmol/L (3.6 mg/dL) or CrCL ≤20 mL/min*      *500 mg orally four times daily*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1 g orally four times daily</i>
	<i>GFR 10–50 mL/min</i>	<i>Avoid due to risk of acute neurological and/or metabolic complications</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid due to risk of acute neurological and/or metabolic complications</i>
	<i>Hemodialysis</i>	<i>Avoid due to risk of acute neurological and/or metabolic complications</i>
	<i>CAPD</i>	<i>Avoid due to risk of acute neurological and/or metabolic complications</i>
	<i>CRRT</i>	<i>Not applicable; avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Naproxen - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Naproxen/Aleve®, Naprosyn®

{Anti-inflammatory; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 500 mg

**Usual maintenance dose:** 250–500 mg orally twice daily

**Typical maximum dose:** 1,250 mg/day

**Proportion eliminated unchanged:** 1 % (~95 % of a dose is eliminated in urine as demethylated and glucuronidated conjugates)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL <30 mL/min Not recommended*

**Alternative adjustment:** *GFR 30–50 mL/min 125–250 mg orally twice daily, titrate carefully (50 % decrease)*

*GFR <30 mL/min Limited data; preferably avoid due to risk for gastrointestinal and renal toxicity*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Naratriptan - Selected References

Amerge® tablet film coated. Research Triangle Park: GlaxoSmithKline LLC; 2010.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Naratriptan/Amerge®

{Anti-migraine; serotonin 5-HT<sub>3</sub> receptor antagonist}

**Usual initial dose:**

2.5 mg orally taken with fluid

**Usual maintenance dose:**

2.5 mg orally taken with fluid. If the headache returns or if the patient has only partial response, the dose may be repeated once after 4 h.

**Typical maximum dose:**

5 mg/24 h

**Proportion eliminated unchanged:**

50 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Mild to moderate renal impairment*

*A lower starting dose should be considered; maximum daily dose should not exceed 2.5 mg/24 h.*

*CrCL <15 mL/min*

*Contraindicated*

**Alternative adjustment:**

*Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Nebivolol - Selected References

- Ambrosio G, Flather MD, Böhm M, et al.  $\beta$ -Blockade with nebivolol for prevention of acute ischaemic events in elderly patients with heart failure. *Heart*. 2011;97:209–14.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Nebivolol/Bystolic™

{Antihypertensive; antianginal;  $\beta$ -adrenergic receptor blocker}

**Usual initial dose:** 5 mg orally

**Usual maintenance dose:** 5–20 mg orally once daily

**Typical maximum dose:** 40 mg/day

**Proportion eliminated unchanged:** Nil (38–67 % of absorbed dose appears in urine as glucuronide metabolites in extensive and poor metabolizers, respectively)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Severe renal impairment  
(CrCL <30 mL/min)*

*Initial dose 2.5 mg once daily; upward  
titration should be performed cautiously  
if needed.*

*Hemodialysis*

*No data*

**Alternative adjustment:**

*Elderly patients*

*No dose adjustment needed*

*Hemodialysis*

*Data not available*

*CRRT*

*Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Neomycin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Neomycin/Mycifradin<sup>®</sup>, Neo-Fradin<sup>®</sup>** {Antibacterial; aminoglycoside}

**Usual initial dose:** 500–1,000 mg orally

**Usual maintenance dose:** 500–1,000 mg orally four times daily

**Typical maximum dose:** 12 g/day

**Proportion eliminated unchanged:** 95 % (oral bioavailability ~4 % with normal gastrointestinal function; substantial systemic assimilation occurs from irrigation of open or enclosed wounds)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Systemic absorption of neomycin occurs following oral administration, and toxic reactions may occur. Patients treated with neomycin should be under close clinical observation because of the potential toxicity associated with use. Neurotoxicity (including ototoxicity) and nephrotoxicity following oral use of neomycin have been reported, even when used in recommended doses. The potential for nephrotoxicity, permanent bilateral auditory ototoxicity, and sometimes vestibular toxicity is present in patients with normal renal function when treated with higher doses of neomycin and/or for longer periods than recommended. Serial, vestibular, and audiometric tests, as well as tests of renal function, should be performed (especially in high-risk patients). The risk of nephrotoxicity and ototoxicity is greater in patients with impaired renal function.*

**Alternative adjustment:**

*GFR >50 mL/min      500 mg enterally every 6 h*

*GFR ≤50      Avoid (all routes of administration including oral) due to risk for oto- and nephrotoxicity*

*Hemodialysis      Avoid (all routes of administration including oral) due to risk for oto- and nephrotoxicity*

*CAPD      Avoid (all routes of administration including oral) due to risk for oto- and nephrotoxicity*

*CRRT      Avoid (all routes of administration including oral) due to risk for oto- and nephrotoxicity*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Neostigmine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Neostigmine/Prostigmin®** {Cholinergic muscle stimulant; acetylcholinesterase inhibitor}

**Usual initial dose:** 0.5–2 mg slow IV injection  
**Usual maintenance dose:** 0.5–2 mg slow IV injection, repeated as necessary for reversal of nondepolarizing neuromuscular blockade  
**Typical maximum dose:** 5 mg  
**Proportion eliminated unchanged:** 50 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mechanical obstruction of the urinary tract</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>0.5–2 mg slow IV injection</i>
	<i>GFR 10–50 mL/min</i>	<i>0.25–1 mg slow IV injection (50 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>0.125–0.5 mg slow IV injection (75 % decrease)</i>
	<i>Hemodialysis</i>	<i>0.125–0.5 mg slow IV injection (75 % decrease)</i>
	<i>CAPD</i>	<i>0.125–0.5 mg slow IV injection (75 % decrease)</i>
	<i>CRRT</i>	<i>0.25–1 mg slow IV injection (50 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Nitrofurantoin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Nitrofurantoin/Macrochantin®, Macrobid®** {Antibacterial; urinary antiseptic}

**Usual initial dose:** 100 mg orally  
**Usual maintenance dose:** 50–100 mg orally every 6 h or 100 mg twice daily (long-acting monohydrate)  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 47 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Anuria, oliguria, significant impairment of renal function (CrCL <60 mL/min or clinically significant elevated SCr)*

*Contraindicated*

**Alternative adjustment:**

*GFR ≥60 mL/min*

*50–100 mg orally every 6 h or 100 mg twice daily (long-acting monohydrate)*

*GFR 10–59 mL/min*

*Usually ineffective; avoid*

*GFR <10 mL/min*

*Ineffective; avoid*

*Hemodialysis*

*Ineffective; avoid*

*CAPD*

*Ineffective; avoid*

*CRRT*

*Not applicable; avoid*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Nizatidine - Selected References

- Abdel-Rahman SM, Johnson FK, Connor JD, et al. Developmental pharmacokinetics and pharmacodynamics of nizatidine. *J Pediatr Gastroenterol Nutr.* 2004;38:442–51.
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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Nizatidine/Axid®** {Antacid; histamine H<sub>2</sub> receptor antagonist}

**Usual initial dose:** 300 mg orally  
**Usual maintenance dose:** 150 mg orally twice daily or 300 mg orally at bedtime  
**Typical maximum dose:** 300 mg/day  
**Proportion eliminated unchanged:** 60 %

*Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Nizatidine dosage in renal function impairment*

	<i>Dosage</i>	
	<i>Active duodenal ulcer, GERD, benign gastric ulcer</i>	<i>Maintenance therapy</i>
<i>CrCL (mL/min)</i>		
<i>20–50</i>	<i>150 mg daily</i>	<i>150 mg every other day</i>
<i>&lt;20</i>	<i>150 mg every other day</i>	<i>150 mg every 3 days</i>
<b>Alternative adjustment:</b>		
<i>GFR &gt;50 mL/min</i>	<i>150–300 mg orally at bedtime</i>	
<i>GFR 10–50 mL/min</i>	<i>150 mg orally every 24–48 h</i>	
<i>GFR &lt;10 mL/min</i>	<i>150 mg orally every 48–72 h</i>	
<i>Hemodialysis</i>	<i>150 mg orally every 48–72 h</i>	
<i>CAPD</i>	<i>150 mg orally every 48–72 h</i>	
<i>CRRT</i>	<i>Not applicable (consider IV histamine H<sub>2</sub> blocker)</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Norfloxacin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Norfloxacin/Noroxin®** {Antibacterial; fluoroquinolone}

**Usual initial dose:** 400 mg orally  
**Usual maintenance dose:** 400 mg orally every 12 h  
**Typical maximum dose:** 800 mg/day  
**Proportion eliminated unchanged:** 30 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≤30 mL/min</i>	<i>400 mg orally once daily</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>400 mg orally every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>400 mg orally every 12–24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>400 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>400 mg orally every 24 h</i>
	<i>CAPD</i>	<i>400 mg orally every 24 h</i>
	<i>CRRT</i>	<i>Not applicable (consider IV fluoroquinolone)</i>

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ofloxacin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ofloxacin/Floxin®** {Antibacterial; fluoroquinolone}

**Usual initial dose:** 400 mg orally  
**Usual maintenance dose:** 200–400 mg orally every 12 h  
**Typical maximum dose:** 800 mg/day  
**Proportion eliminated unchanged:** 80 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 20–50 mL/min</i>	<i>200–400 mg orally every 24 h</i>
	<i>CrCL &lt;20 mL/min</i>	<i>100–200 mg orally every 24 h (half the usual recommended unit dose)</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>200–400 mg orally every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>200–400 mg orally every 12–24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>200 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>400 mg orally followed by 200–400 mg orally every 24 h; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>400 mg orally followed by 200 mg orally once daily</i>
	<i>CVVH</i>	<i>400 mg orally every 8 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Oprelvekin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Oprelvekin/Neumega**<sup>®</sup> {Thrombopoiesis stimulator; recombinant human interleukin 11; R for severe thrombocytopenia}

**Usual initial dose:** 50 mcg/kg subcutaneously

**Usual maintenance dose:** 50 mcg/kg subcutaneously once daily

**Typical maximum dose:** 100 mcg/kg/day

**Proportion eliminated unchanged:** Low (metabolites predominantly excreted in urine; patients with severe renal impairment [ $\text{CrCL} \leq 30 \text{ mL/min}$ ] attain blood levels two to three times greater and show clearance values less than half of those in normal subjects)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL <30 mL/min 25 mcg/kg subcutaneously once daily*

**Alternative adjustment:** *Data not available*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Oseltamivir - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Oseltamivir/Tamiflu®**

{Antiviral; neuraminidase inhibitor; R for influenza}

<b>Usual initial dose:</b>	75 mg orally	
<b>Usual maintenance dose:</b>	<i>Influenza treatment</i>	75 mg orally every 12 h for 5 days
	<i>Influenza prophylaxis</i>	75 mg orally once daily for ≥10 days
<b>Typical maximum dose:</b>	150 mg/day	
<b>Proportion eliminated unchanged:</b>	10 % (as parent prodrug; 70 % of active de-esterified metabolite is excreted in urine)	

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 10–30 mL/min</i>	<i>Influenza treatment</i>	75 mg orally once daily for 5 days
	<i>CrCL 10–30 mL/min</i>	<i>Influenza prophylaxis</i>	75 mg orally every other day or 30 mg every day
	<i>End-stage renal disease, hemodialysis, or peritoneal dialysis</i>		No recommended dosing recommendations available
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>Influenza treatment</i>	75 mg orally every 12 h (doses as high as 150 mg every 12 h have been tried in critically ill patients with influenza A/H1N1)
		<i>Influenza prophylaxis</i>	75 mg orally once daily
	<i>GFR 10–50 mL/min</i>	<i>Influenza treatment</i>	75 mg orally once daily
		<i>Influenza prophylaxis</i>	75 mg orally every other day
	<i>GFR &lt;10 mL/min</i>	Data not available	
	<i>Hemodialysis</i>	<i>Influenza treatment</i>	30 mg orally daily on non-dialysis days or 75 mg after each dialysis (doses as high as 75 mg once or twice daily have been tried in critically ill patients with influenza A/H1N1)
		<i>Influenza prophylaxis</i>	75 mg orally every 5 days or 30 mg orally after each alternate dialysis session (limited data)
	<i>CAPD</i>	<i>Influenza treatment</i>	30 mg orally once or twice weekly
		<i>Influenza prophylaxis</i>	75 mg orally every 5 days (limited data)
	<i>CRRT</i>	<i>Influenza treatment</i>	75 mg enterally every 12 h (doses as high as 150 mg every 12 h have been tried in critically ill patients with influenza A/H1N1)
<i>Influenza prophylaxis</i>		75 mg enterally once daily	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Oxacillin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Oxacillin/Prostaphlin®** {Antibacterial; isoxazoly penicillin}

**Usual initial dose:** 2 g IV  
**Usual maintenance dose:** 500–2,000 mg IV every 4–6 h  
**Typical maximum dose:** 12 g/day  
**Proportion eliminated unchanged:** 45 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Impaired renal function*      *This drug is known to be excreted by the kidney, and the risk of toxic reactions to this drug may be greater in patients with impaired renal function. Because elderly patients are more likely to have decreased renal function, care should be taken in dose selection, and it may be useful to monitor renal function.*

**Alternative adjustment:**

<i>GFR 5 to &gt;50 mL/min</i>	<i>500–2,000 mg IV every 4 h (no change)</i>
<i>Hemodialysis</i>	<i>500–2,000 mg IV every 4 h (no change)</i>
<i>CAPD</i>	<i>500–2,000 mg IV every 4 h (no change)</i>
<i>CVVHD or CVVHDF</i>	<i>2 g IV every 4–6 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Oxaprozin - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Oxaprozin/Daypro®** {Anti-inflammatory; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 600 mg orally  
**Usual maintenance dose:** 1,200 mg orally once daily  
**Typical maximum dose:** 1,800 mg/day  
**Proportion eliminated unchanged:** 5 % (60 % of each dose as glucuronide metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

<i>Renal function impairment</i>	<i>600 mg orally once daily; if there is insufficient relief of symptoms, the dose may be cautiously increased to 1,200 mg but only with close monitoring.</i>
<i>Hemodialysis</i>	<i>600 mg orally once daily; if there is insufficient relief of symptoms, the dose may be cautiously increased to 1,200 mg but only with close monitoring.</i>

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>1,200 mg orally every 24 h</i>
<i>GFR 10–50 mL/min</i>	<i>1,200 mg orally every 24 h</i>
<i>GFR &lt;10 mL/min</i>	<i>600 mg orally every 24 h (50 % decrease)</i>
<i>Hemodialysis</i>	<i>600 mg orally every 24 h (50 % decrease)</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>600 mg orally every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Oxcarbazepine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Oxcarbazepine/Trileptal®** {Antiepileptic; adjunctive analgesic; R for bipolar disorder}

**Usual initial dose:** 300 mg orally  
**Usual maintenance dose:** 600 mg orally twice daily  
**Typical maximum dose:** 2,400 mg/day  
**Proportion eliminated unchanged:** 2–8 % (27 % of each dose is excreted in urine as 10-hydroxycarbazepine [MHD], the active monohydroxylated metabolite of oxcarbazepine)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL <30 mL/min* Initiate therapy with 150 mg orally twice daily (300 mg/day, half the usual dose) and increase slowly to achieve the desired clinical response.

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	600 mg orally every 12 h
<i>GFR 10–50 mL/min</i>	300–600 mg orally every 12 h (0–25 % decrease); monitor drug levels. <sup>a</sup>
<i>GFR &lt;10 mL/min</i>	300 mg orally every 12 h (50 % decrease); monitor drug levels. <sup>a</sup>
<i>Hemodialysis</i>	300 mg orally every 12 h (50 % decrease); monitor drug levels. <sup>a</sup>
<i>CAPD</i>	300 mg orally every 12 h (50 % decrease); monitor drug levels. <sup>a</sup>
<i>CRRT</i>	300 mg orally every 12 h (50 % decrease); monitor drug levels. <sup>a</sup>

### <sup>a</sup>*Therapeutic Drug Monitoring*

**Therapeutic plasma levels:** Trough: 12–30 mg/L



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## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Paliperidone/Invega®

{Atypical antipsychotic; benzisoxazole derivative}

<b>Usual initial dose:</b>	3 mg orally or 234 mg intramuscularly (extended-release intramuscular suspension) followed by 156 mg intramuscularly 1 week later
<b>Usual maintenance dose:</b>	6 mg orally once daily or 117 mg intramuscularly (extended-release intramuscular suspension) once monthly
<b>Typical maximum dose:</b>	12 mg/day orally
<b>Proportion eliminated unchanged:</b>	59 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Dosing must be individualized according to the patient's individual renal function status.*

*CrCL ≥50–<80 mL/min 3 mg orally once daily initially; max 6 mg daily or 156 mg intramuscularly on treatment day 1 followed by 117 mg intramuscularly 1 week later; then 78 mg intramuscularly once monthly.*

*CrCL ≥10–<50 mL/min 1.5 mg orally once daily initially; max 3 mg daily. Intramuscular use is not recommended.*

*CrCL <10 mL/min Use not recommended.*

**Alternative adjustment:**

*Data not available.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pamidronate - Selected References

- Aredia® injection [package insert]. East Hanover: Novartis Pharmaceuticals Corp; 2011.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Pamidronate/Aredia®**

**{Hypocalcemic agent; bisphosphonate}**

**Usual initial dose:** 60–90 mg IV over 2–24 h or (for Paget’s disease) 30 mg IV over 4 h daily times 3 days

**Usual maintenance dose:** After a minimum 7-day recovery, the dose may be repeated once as 60–90 mg IV over 2–24 h or (for Paget’s disease) 30 mg IV daily times 3 days. For osteolytic bone lesions of cancer, the recommended maintenance dose is 90 mg IV over 2–4 h every 3–4 weeks

**Typical maximum dose:** 90 mg

**Proportion eliminated unchanged:** 30–60 %

### ***Adjustment for Kidney Disease***

**FDA-approved product labeling:**

*SCr >3.0 mg/dL or  
CrCL < 30 mL/min*

*Use not recommended*

*Following treatment, if SCr increases by >0.5 mg/dL if previously normal or >1.0 mg/dL if previously abnormal*

*Withhold re-treatment until SCr has returned to within 10 % of the baseline value*

**Alternative adjustment:**

*eCrCL ≥ 30 mL/min*

*30–90 mg IV over 2–4 h or (for Paget’s disease) 30 mg IV over 4 h daily times 3 days; recent long-term prospective trials have demonstrated generally better biochemical and clinical outcomes when doses are limited to 30 mg IV over 2–4 h once monthly for up to 2 years in patients with multiple myeloma or 30 mg IV over 2 h approximately monthly for 2–4 doses in osteopenic patients following renal transplantation*

*eCrCL <30 mL/min*

*In extraordinary cases of acute hypercalcemia, discretionary administration of modest doses (e.g., 30 mg) of IV pamidronate in carefully selected and closely monitored patients has been successfully employed; nephrotoxicity has been reported as an infrequent but potentially serious complication*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pancuronium - Selected References

- Abrams RE, Hornbein TF. Inability to reverse pancuronium blockade in a patient with renal failure and hepatic disease. *Anesthesiology*. 1975;42:362–4.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Pancuronium/Pavulon®** {Nondepolarizing neuromuscular blocker; paralyzing agent}

**Usual initial dose:** 0.04–0.1 mg/kg  
**Usual maintenance dose:** 0.01 mg/kg IV every 25–60 min or 0.2–0.6 mcg/kg/min continuous IV infusion; monitoring of muscle twitch response to a peripheral nerve stimulator is advised  
**Typical maximum dose:** 0.15 mg/kg IV  
**Proportion eliminated unchanged:** 40 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *The elimination half-life is doubled, and the plasma clearance is reduced by approximately 60 % in patients with renal failure. The volume of distribution is variable, and in some cases elevated. The rate of recovery of neuromuscular blockade, as determined by peripheral nerve stimulation, is variable and sometimes very much slower than normal. This information should be taken into consideration if pancuronium is selected, for other reasons, to be used in a patient with renal failure. To obtain maximum clinical benefits of pancuronium and to minimize the possibility of overdose, the monitoring of muscle twitch response to a peripheral nerve stimulator is advised*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>0.04–0.1 mg/kg IV every 25–60 min</i>
<i>GFR 10–50 mL/min</i>	<i>0.02–0.05 mg/kg IV every 25–60 min (50 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk for excessively prolonged neuromuscular blockade and paralysis</i>
<i>Hemodialysis</i>	<i>Preferably avoid due to risk for excessively prolonged neuromuscular blockade and paralysis</i>
<i>CAPD</i>	<i>Preferably avoid due to risk for excessively prolonged neuromuscular blockade and paralysis</i>
<i>CRRT</i>	<i>0.02–0.05 mg/kg IV every 25–60 min (50 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Paroxetine - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

<b><u>Paroxetine/Paxil</u></b> <sup>®</sup>	<b>{Antidepressant; selective serotonin reuptake inhibitor (SSRI)}</b>
<b>Usual initial dose:</b>	20 mg orally
<b>Usual maintenance dose:</b>	20–40 mg orally once daily
<b>Typical maximum dose:</b>	60 mg/day
<b>Proportion eliminated unchanged:</b>	2 % (60 % of each dose is eliminated in urine as metabolites; metabolites that are not considered to contribute to clinical response vary in pharmacologic activity from similar to parent paroxetine [minor sulfate metabolite] to essentially inactive [the majority of glucuronidated metabolites])

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal impairment—initial dose is 10 mg/day; increases may be made if indicated; dosage should not exceed 40 mg/day</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min      20–40 mg orally once daily</i>
	<i>GFR 10–50 mL/min    10–30 mg/day orally (25–50 % decrease)</i>
	<i>GFR &lt;10 mL/min      10–20 mg/day orally (50 % decrease)</i>
	<i>Hemodialysis          10–20 mg/day orally (50 % decrease)</i>
	<i>CAPD                    10–20 mg/day orally (50 % decrease)</i>
	<i>CRRT                    10–30 mg/day orally (25–50 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Peginterferon Alfa-2a - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Peginterferon Alfa-2a/Pegasys®** {Antiviral; interferon; R for hepatitis C}

**Usual initial dose:** 180 mcg (1.0-mL vial or 0.5-mL prefilled syringe) subcutaneously

**Usual maintenance dose:** 180 mcg (1.0-mL vial or 0.5-mL prefilled syringe) once weekly for 48 weeks by subcutaneous administration in the abdomen or thigh or 800–1,200 mg administered orally in two divided doses

**Typical maximum dose:** 180 mcg/day subcutaneously or 1,200 mg/day orally

**Proportion eliminated unchanged:**

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;50 mL/min</i>	<i>Use with caution; monitor for toxicity.</i>
	<i>End-stage renal disease requiring hemodialysis</i>	<i>Dose reduction to 135 µg subcutaneously once weekly is recommended; monitor for toxicity.</i>
	<i>Note: Do not administer ribavirin to patients with CrCL &lt;50 mL/min.</i>	
<b>Alternative adjustment:</b>	<i>Hemodialysis</i>	<i>135 µg subcutaneously once weekly (with reduced dose ribavirin 200 mg orally once daily)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Peginterferon Alfa-2b - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Peginterferon Alfa-2b/** **PEG-Intron<sup>®</sup>, Sylatron<sup>™</sup>**

**{Antiviral; interferon}**

<b>Usual initial dose:</b>	Melanoma, 6 mcg/kg subcutaneously; Hepatitis C, 1 mcg/kg subcutaneously
<b>Usual maintenance dose:</b>	Melanoma: 6 mcg/kg subcutaneously once weekly for 8 doses followed by 3 mcg/kg subcutaneously once weekly for up to 3 years  Hepatitis C monotherapy for patients with compensated liver disease previously untreated with interferon alpha who are significantly intolerant of ribavirin or in whom contraindications exist (e.g., CrCL <50 mL/min): 1 mcg/kg subcutaneously once weekly for 52 weeks  Hepatitis C combination therapy: 1.5 mcg/kg subcutaneously once weekly with oral ribavirin given according to body weight for 48 weeks in patients with hepatitis C genotype 1 or who fail to achieve loss of hepatitis C RNA at 24 weeks or have previously failed therapy and 24 weeks in patients with hepatitis C genotypes 2 and 3
<b>Typical maximum dose:</b>	1.5 mcg/kg/week
<b>Proportion eliminated unchanged:</b>	Nil

### ***Adjustment for Kidney Disease***

#### **FDA-approved product labeling:**

<i>Melanoma</i>	
<i>CrCL 30–50 mL/min</i>	<i>4.5 mcg/kg subcutaneously once weekly (25 % decrease)</i>
<i>CrCL 10–29 mL/min</i>	<i>3 mcg/kg subcutaneously once weekly (50 % decrease)</i>
<i>Hepatitis C</i>	
<i>CrCL 30–50 mL/min</i>	<i>1.125 mcg/kg subcutaneously once weekly (25 % decrease)</i>
<i>CrCL 10–29 mL/min</i>	<i>0.75 mcg/kg subcutaneously once weekly (50 % decrease)</i>

*Note: Do not administer ribavirin to patients with CrCL <50 mL/min.*

#### **Alternative adjustment:**

<i>Hepatitis C</i>	
<i>Hemodialysis</i>	<i>1 mcg/kg subcutaneously once weekly (with ribavirin 200 mg orally once daily)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pemetrexed - Selected References

- Alimta<sup>®</sup> injection [package insert]. Indianapolis: Eli Lilly and Co; 2004.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Pemetrexed/Alimta®** {Antineoplastic; antimetabolite; antifolate}

**Usual initial dose:** 500 mg/m<sup>2</sup> IV over 10 min  
**Usual maintenance dose:** 500 mg/m<sup>2</sup> IV over 10 min on day 1 of each 21-day cycle  
**Typical maximum dose:** 500 mg/m<sup>2</sup> IV  
**Proportion eliminated unchanged:** 70–90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Decreased renal function will result in reduced clearance and greater exposure compared with patients with normal renal function.*

*CrCL 45–79 mL/min No dosage adjustment is needed; use with caution.*

*CrCL <45 mL/min Do not administer; avoid.*

**Alternative adjustment:** *Data not available; interindividual drug clearance varies widely, and available clinical data presently are not sufficient to recommend adequate and safe dose amounts in patients with impaired excretory kidney function.*

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Penicillamine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Penicillamine/Cuprimine<sup>®</sup>, Depen<sup>®</sup>** {Chelating agent; antirheumatic; R for Wilson's disease}

**Usual initial dose:** 250 mg orally

**Usual maintenance dose:** 500–750 mg orally once daily 1 h before or 2 h after meals (rheumatoid arthritis)

750–1,500 mg/day or as determined by measurement of urinary copper excretion (Wilson's disease)

2,000 mg/day in divided doses (cystinuria)

**Typical maximum dose:** 1,500 mg/day (4,000 mg/day for cystinuria)

**Proportion eliminated unchanged:** 40–50 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal insufficiency</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500–1,000 mg orally every 24 h 1 h before or 2 h after meals</i>
		<i>125 mg orally every other day (early diffuse systemic sclerosis)</i>
	<i>GFR 10–50 mL/min</i>	<i>Avoid due to risk of nephrotoxicity.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid due to risk of nephrotoxicity.</i>
	<i>Hemodialysis</i>	<i>250–500 mg orally every 24 h (50 % decrease)</i>
	<i>CAPD</i>	<i>Data not available; avoid due to risk of nephrotoxicity.</i>
	<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Penicillin G - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Penicillin G Potassium

(Benzylpenicillin)/Pfizerpen®

{Antibacterial; prototypical  $\beta$ -lactam}

<b>Usual initial dose:</b>	2–5 million units IV
<b>Usual maintenance dose:</b>	5–30 million units/day in 4–12 divided doses or continuous IV infusion of 20–30 million units/day
<b>Typical maximum dose:</b>	30 million units/day
<b>Proportion eliminated unchanged:</b>	79 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Impaired renal function*      *If impairment of function is suspected or known to exist, a reduction in the total dosage should be considered; frequent evaluation of electrolyte balance and renal and hematopoietic function is recommended when high doses are used.*

*CrCL  $\geq 10$  mL/min*      *Administer a full loading dose followed by one-half of the loading dose every 4 h.*

*CrCL  $< 10$  mL/min*      *Administer a full loading dose followed by one-half of the loading dose every 8 h.*

**Alternative adjustment:**

*GFR  $> 50$  mL/min*      *2.5–5 million units IV every 4–6 h or 20–30 million units/day continuous infusion*

*GFR 10–50 mL/min*      *1–4 million units IV every 4–6 h (25 % decrease)*

*GFR  $< 10$  mL/min*      *1–2.5 million units IV every 6 h (50–80 % decrease)*

*Hemodialysis*      *1–2.5 million units IV every 4–6 h, dose after dialysis (50–80 % decrease)*

*CAPD*      *0.2–2.5 million units IV every 4–6 h*

*CVVH*      *4 million units IV once followed by 2 million units IV every 4–6 h*

*CVVHD*      *4 million units IV once followed by 2–3 million units IV every 4–6 h*

*CVVHDF*      *4 million units IV once followed by 2–4 million units IV every 4–6 h*

*Note: Penicillin G is the antibiotic of first choice for every infection that is sensitive to it.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pentamidine (IV) - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Pentamidine (IV)/Pentam<sup>®</sup> 300**

**{Antiprotozoal; antiparasitic}**

<b>Usual initial dose:</b>	4 mg/kg IV
<b>Usual maintenance dose:</b>	4 mg/kg IV once daily for 14–21 days
<b>Typical maximum dose:</b>	4 mg/kg/day
<b>Proportion eliminated unchanged:</b>	2–12 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *The efficacy or safety of alternative dosing protocols has not been established for patients with impaired renal function.*

<b>Alternative adjustment:</b>	<i>GFR &gt;35 mL/min</i>	<i>3–4 mg/kg IV every 24 h</i>
	<i>GFR 10–35 mL/min</i>	<i>4 mg/kg IV every 24–48 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>4 mg/kg IV every 48 h</i>
	<i>Hemodialysis</i>	<i>4 mg/kg IV every 24–36 h; supplement 0.75 mg/kg IV after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>4 mg/kg IV every 48 h</i>
	<i>CRRT</i>	<i>4 mg/kg IV every 24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pentazocine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Pentazocine/Talwin™**

**{Analgesic; opioid  $\mu$ -receptor partial agonist}**

<b>Usual initial dose:</b>	30 mg IV, IM, or subcutaneously
<b>Usual maintenance dose:</b>	30 mg IV, IM, or subcutaneously every 3–4 h
<b>Typical maximum dose:</b>	30 mg/dose IV, 60 mg/dose IM or subcutaneously, or 360 mg/day
<b>Proportion eliminated unchanged:</b>	<13 %

### ***Adjustment for Kidney Disease***

**FDA-approved product labeling:** *Administer with caution; the effects of this drug may be greater than expected in patients with impaired renal function.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>30 mg IV every 4 h as necessary</i>
	<i>GFR 10–50 mL/min</i>	<i>20 mg IV every 4 h as necessary (25 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>15 mg IV every 4 h as necessary (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>15 mg IV every 4 h as necessary (50 % decrease)</i>
	<i>CAPD</i>	<i>Data not available; preferably avoid.</i>
	<i>CRRT</i>	<i>Data not available; preferably avoid.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pentostatin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Pentostatin/Nipent®** {Antineoplastic; antimetabolite; purine analog}

**Usual initial dose:** 4 mg/m<sup>2</sup> IV  
**Usual maintenance dose:** 4 mg/m<sup>2</sup> IV every other week  
**Typical maximum dose:** 4 mg/m<sup>2</sup>  
**Proportion eliminated unchanged:** 90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Patients with impaired renal function should be treated only when the potential benefit justifies the potential risk. Two patients with impaired renal function (CrCL 50–60 mL/min) achieved complete response without unusual adverse events when treated with 2 mg/m<sup>2</sup>.*

*CrCL >60 mL/min 4 mg/m<sup>2</sup> IV every other week*

*CrCL 50–60 mL/min 2 mg/m<sup>2</sup> IV every other week*

*CrCL <50 mL/min Minimal data; avoid*

**Alternative adjustment:** *eCrCL >60 mL/min 4 mg/m<sup>2</sup> IV every other week*

*eCrCL 41–40 mL/min 3 mg/m<sup>2</sup> IV every other week*

*eCrCL 21–40 mL/min 2 mg/m<sup>2</sup> IV every other week*

*eCrCL ≤20 mL/min Data not available*

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pentoxifylline - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Pentoxifylline/Trental®**

**{Rheologic agent; blood viscosity reducer agent}**

<b>Usual initial dose:</b>	400 mg orally
<b>Usual maintenance dose:</b>	400 mg orally three times daily with meals
<b>Typical maximum dose:</b>	1,200 mg/day
<b>Proportion eliminated unchanged:</b>	4 % (plus 50–80 % of each dose as active metabolite)

### ***Adjustment for Kidney Disease***

**FDA-approved product labeling:** *The risk of toxic reactions to this drug may be greater in patients with impaired renal function.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>400 mg orally every 8–12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>400 mg orally every 12–24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>400 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>400 mg orally every 24 h (no supplemental post-dialysis dose)</i>
	<i>CAPD</i>	<i>400 mg orally every 24 h</i>
	<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Peramivir - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Peramivir

{Antiviral}

<b>Usual initial dose:</b>	600 mg IV over 30 min
<b>Usual maintenance dose:</b>	600 mg IV over 30 min once daily for 5–10 days
<b>Typical maximum dose:</b>	600 mg IV
<b>Proportion eliminated unchanged:</b>	90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Peramivir adult renal function impairment dosage recommendations*

<i>Creatinine clearance</i>	<i>Dose (IV)</i>
<i>Mild renal impairment (CrCL 50–80 mL/min)</i>	<i>600 mg daily</i>
<i>Moderate renal impairment (CrCL 31–49 mL/min)</i>	<i>150 mg daily</i>
<i>Severe renal impairment (CrCL 10–30 mL/min)</i>	<i>100 mg daily</i>
<i>End-stage renal impairment (CrCL &lt;10 mL/min not on dialysis or renal replacement therapy)</i>	<i>100 mg on day 1, then 15 mg daily thereafter</i>
<i>End-stage renal disease on intermittent hemodialysis</i>	<i>100 mg on day 1, then 100 mg over 2 h after each hemodialysis session on dialysis days only</i>

*Dose modifications should be made, as appropriate for changes in patient renal function, changes to ultrafiltrate flow rate, or initiation, discontinuation, or changes to continuous renal replacement therapy (CRRT)*

*For renally impaired patients receiving CRRT, the peramivir dose should be selected according to the table above but using the CRRT clearance ( $Cl_{CRRT}$ ) as outlined below instead of CrCL. If the patient has residual renal function while on CRRT, an estimate of the patient's renal clearance should be added to  $Cl_{CRRT}$  in order to estimate total clearance before using the table*

*Calculation of  $Cl_{CRRT}$  where  $Q_f$  = ultrafiltration rate (mL/min) and  $Q_d$  = dialysate flow rate (mL/min):*

*For slow continuous ultrafiltration (SCUP) or continuous arteriovenous hemofiltration (CAVH) or continuous venovenous hemofiltration (CVVH):  $Cl_{CRRT} = Q_f$*

*For continuous arteriovenous hemodialysis (CAVHD) or continuous venovenous hemodialysis (CVVHD):  $Cl_{CRRT} = Q_d$*

*For continuous arteriovenous hemodiafiltration (CAVHDF) and continuous venovenous hemodiafiltration (CVVHDF):  $Cl_{CRRT} = Q_f + Q_d$*

<b>Alternative adjustment:</b>	<i>CRRT</i>	<i>600 mg IV daily</i>
	<i>Slow low-efficiency hemodialysis</i>	<i>600 mg IV daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Perindopril - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Perindopril/Aceon®** {Antihypertensive, vasodilator, angiotensin-converting enzyme (ACE)/renin inhibitor}

**Usual initial dose:** 4 mg orally  
**Usual maintenance dose:** 4–8 mg orally once daily  
**Typical maximum dose:** 16 mg/day  
**Proportion eliminated unchanged:** 90 % (as perindopril and perindoprilat)

*Adjustment for Kidney Disease:* 1 h before or at least 2 h after meals

**FDA-approved product labeling:**

<i>CrCL ≥30 mL/min</i>	<i>4 mg orally once daily; usual max 8 mg/day</i>
<i>CrCL &lt;30 mL/min</i>	<i>Safety not established; use not recommended</i>
<i>Hemodialysis</i>	<i>2 mg orally once daily; max 8 mg/day</i>

*Caution: As a consequence of inhibiting the renin-angiotensin system, changes in renal function may be anticipated in susceptible individuals. Renal function should be monitored periodically.*

*In patients who are elderly, volume-depleted (including those on diuretic therapy), or with compromised renal function, coadministration of nonsteroidal anti-inflammatory drugs (NSAIDs), including selective cyclooxygenase (COX-2) inhibitors, with angiotensin-converting enzyme (ACE) inhibitors, including perindopril, may result in deterioration of renal function, including possible acute renal failure. These effects are usually reversible. Monitor renal function periodically in patients receiving perindopril and NSAID therapy. The antihypertensive effect of ACE inhibitors, including perindopril, may be attenuated by NSAIDs, including selective COX-2 inhibitors.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>4 mg orally every 24 h 1 h before or at least 2 h after meals</i>
<i>GFR 10–50 mL/min</i>	<i>2 mg orally every 24–48 h 1 h before or at least 2 h after meals</i>
<i>GFR &lt;10 mL/min</i>	<i>2 mg orally every 48 h 1 h before or at least 2 h after meals</i>
<i>Hemodialysis</i>	<i>2 mg orally every 48 h 1 h before or at least 2 h after meals (no supplemental post-dialysis dose)</i>
<i>CAPD</i>	<i>2 mg orally every 48 h 1 h before or at least 2 h after meals</i>
<i>CRRT</i>	<i>2 mg orally every 24–48 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Phenazopyridine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Phenazopyridine/Pyridium®**                      {Interstitial cystitis analgesic}

**Usual initial dose:**                                      200 mg orally  
**Usual maintenance dose:**                            100–200 mg orally three times daily  
**Typical Maximum Dose:**                            800 mg/day  
**Proportion eliminated unchanged:**              65 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Impaired renal function, uremia</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>eCrCL ≥50 mL/min</i>	<i>100–200 mg orally every 8–12 h</i>
	<i>eCrCL &lt;50 mL/min</i>	<i>Avoid due to risk for nephrotoxicity and possible methemoglobinemia and hemolytic anemia.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Phenobarbital - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Phenobarbital/Luminal®**

{Antiepileptic; sedative}

<b>Usual initial dose:</b>	30–800 mg (20 mg/kg IV loading dose for refractory status epilepticus or [dose {mg/kg} = desired increase in plasma level {mg/L} ÷ 0.5 {V <sub>d</sub> , volume of distribution in L/kg}] with good supportive care) PO, IV, or IM
<b>Usual maintenance dose:</b>	60–100 mg orally two to three times daily PO, IM, or IV (1–3 mg/kg/day) <sup>a</sup>
<b>Typical maximum dose:</b>	2,000 mg
<b>Proportion eliminated unchanged:</b>	16 % (plus 21 % of each dose as hydroxylated metabolite; urine pH dependent)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Not available*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>30–100 mg orally every 8–12 h<sup>a</sup></i>
	<i>GFR 10–50 mL/min</i>	<i>30–100 mg orally every 8–12 h<sup>a</sup></i>
	<i>GFR &lt;10 mL/min</i>	<i>30–100 mg orally every 12–16 h<sup>a</sup></i>
	<i>Hemodialysis</i>	<i>30–100 mg orally every 12–16 h (administer supplemental dose before hemodialysis plus one-half usual dose amount after hemodialysis on dialysis days)<sup>a</sup></i>
	<i>CAPD</i>	<i>15–60 mg orally every 12–16 h (approx 50 % decrease)<sup>a</sup></i>
	<i>CRRT</i>	<i>30–100 mg orally every 8–12 h<sup>a</sup></i>

### **<sup>a</sup>Therapeutic Drug Monitoring**

**Therapeutic plasma levels:** *Trough: 15–40 mg/L*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Phenytoin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Phenytoin/Dilantin®**

{Antiepileptic}

<b>Usual initial dose:</b>	50–200 mg PO or IV (750–1,500 mg [18–20 mg/kg] IV loading dose for status epilepticus or [dose {mg/kg} = desired increase in plasma level {mg/L} ÷ 0.75 {V <sub>d</sub> , volume of distribution in L/kg}] with good supportive care)
<b>Usual maintenance dose:</b>	100 mg IV or orally three times daily
<b>Typical maximum dose:</b>	1,000 mg/day
<b>Proportion eliminated unchanged:</b>	5 % (protein binding markedly decreased in uremia)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Data not available*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>100 mg IV or orally every 8 h<sup>a</sup></i>
	<i>GFR 10–50 mL/min</i>	<i>100 mg IV or orally every 8 h<sup>a</sup></i>
	<i>GFR &lt;10 mL/min</i>	<i>50–100 mg IV or orally every 8–12 h<sup>a</sup></i>
	<i>Hemodialysis</i>	<i>50–100 mg IV or orally every 8–12 h (no supplemental post-dialysis dose)<sup>a</sup></i>
	<i>CAPD</i>	<i>50–100 mg IV or orally every 8–12 h<sup>a</sup></i>
	<i>CRRT</i>	<i>50–100 mg IV or orally every 8–12 h<sup>a</sup></i>

### **<sup>a</sup>Therapeutic Drug Monitoring**

**Therapeutic plasma levels:**

*Trough: Phenytoin total: 10–20 mg/L*

*Phenytoin free: 8–10 % of total*

*Note: In severely uremic (CrCL <10 mg/dL) and/or hypoalbuminemic patients, measure free phenytoin levels or determine corrected total phenytoin levels using the following equation:*

$$C_{\text{corrected}} = \frac{C_{\text{observed}}}{0.2 \times \text{albumin (g / dL)} + 0.1}$$

*where*

$C_{\text{observed}}$  = measured total serum phenytoin concentration

$C_{\text{corrected}}$  = serum phenytoin concentration corrected for altered protein binding in uremic patients

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Phosphate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Phosphate, Sodium or Potassium (IV);**

#### **Sodium-Potassium Phosphate/KPhos Neutral® {Electrolyte}**

<b>Usual initial dose:</b>	0.08 mmol/kg IV
<b>Usual maintenance dose:</b>	–
<b>Typical maximum dose:</b>	1 mmol/kg/day IV or potassium phosphate 1,000 mg orally four times daily
<b>Proportion eliminated unchanged:</b>	90 %

#### **Adjustment for Kidney Disease**

**FDA-approved product labeling:** *The dose and rate of administration are dependent upon the needs of the patient*

**Alternative adjustment:** *Phosphate dosage in (a) ICU patients and (b) non-ICU patients (phosphate replacement)*

<i>(a) ICU patients</i>			
	<i>Glomerular filtration rate (GFR in mL/min)</i>		
<i>Serum/plasma [PO<sub>4</sub>]</i>	<i>&gt;50</i>	<i>25–50</i>	<i>&lt;25</i>
<i>2.1–3.0 mg/dL</i>	<i>Sodium-potassium phosphate (KPhos Neutral®) 1,000 mg via enteral route every 6 h × 4.</i>	<i>Sodium-potassium phosphate (KPhos Neutral®) 1,000 mg via enteral route every 12 h × 2.</i>	<i>Sodium-potassium phosphate (KPhos Neutral®) 500 mg via enteral route every 12 h × 2.</i>
	<i>If enteral route NOT available, sodium phosphate 45 mmol IV × 1</i>	<i>If enteral route NOT available, sodium phosphate 22.5 mmol IV × 1</i>	<i>If enteral route NOT available, sodium phosphate 15 mmol IV × 1</i>
<i>1.1–2.0 mg/dL</i>	<i>Sodium phosphate 60 mmol IV × 1</i>	<i>Sodium phosphate 45 mmol IV × 1</i>	<i>Sodium phosphate 22.5 mmol IV × 1</i>
<i>≤1.0 mg/dL</i>	<i>Notify MD</i>	<i>Notify MD</i>	<i>Notify MD</i>

*Note: Sodium-potassium phosphate (KPhos Neutral®) 250 mg tablet = 8 mmol phosphate, 13 mEq sodium, 1.1 mEq potassium. Every 7.5 mmol sodium phosphate contains 10 mEq sodium*  
*Phosphate preferred IV rate ≤5 mmol/h; Maximum rate: ≤7.5 mmol/h (emergency)*  
*Phosphate maximum IV dose = 135 mmol in 24 h*  
*In renal impairment, IV sodium phosphate usually is preferred over IV potassium phosphate due to potassium content*

<i>(b) Non-ICU patients</i>			
	<i>Mild depletion [PO<sub>4</sub>] 2.1–2.4 mg/dL</i>	<i>Moderate depletion [PO<sub>4</sub>] 1.0–2.0 mg/dL</i>	<i>Severe depletion [PO<sub>4</sub>] &lt;1.0 mg/dL</i>
<i>Initial treatment</i>	<i>No treatment or sodium-potassium phosphate (KPhos Neutral®) 500 mg orally TID</i>	<i>Sodium phosphate 5–10 mmol (0.1 mmol/kg) IV over 2 h</i>	<i>Sodium phosphate 10–20 mmol (0.2 mmol/kg) IV over 4 h</i>

*Note: Sodium-potassium phosphate (KPhos Neutral®) 250 mg tablet = 8 mmol phosphate, 13 mEq sodium, 1.1 mEq potassium. Every 7.5 mmol sodium phosphate contains 10 mEq sodium*  
*Phosphate preferred IV rate ≤5 mmol/h. Maximum rate: ≤7.5 mmol/h (emergency)*  
*Phosphate maximum IV dose = 135 mmol in 24 h*  
*Unless sodium restricted, IV sodium phosphate usually is preferred over IV potassium phosphate due to potassium content and risk of resultant hyperkalemia, especially in patients with renal impairment. Potassium phosphate may be considered in the presence of hypokalemia—caution, every 1 mmol of potassium phosphate contains 1.5 mEq potassium*  
*Replacement should be given with careful clinical monitoring, including post-dose confirmation of trends toward normalization of serum electrolyte values. Levels usually should be measured 2–4 h after oral therapy or at completion of IV infusion. Treatment should be repeated or continued until the patient is asymptomatic or levels are within acceptable ranges*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Piperacillin and Tazobactam - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Piperacillin and Tazobactam/Zosyn®** {Antibacterial; extended-spectrum penicillin/  
β-lactamase inhibitor}

**Usual initial dose:** 4.5 g IV  
**Usual maintenance dose:** 3.375 g IV over 30 min every 6 h or 13.5 g/24 h continuous IV infusion  
**Typical maximum dose:** 18 g (piperacillin)/day  
**Proportion eliminated unchanged:** 68 %/80 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Piperacillin/tazobactam dosage recommendations for adults with renal function impairment*

CrCL (mL/min)	All indications (except nosocomial pneumonia)	
	Nosocomial pneumonia	Nosocomial pneumonia
>40	3.375 g every 6 h	4.5 g every 6 h
20–40	2.25 g every 6 h	3.375 g every 6 h
<20	2.25 g every 8 h	2.25 g every 6 h
Hemodialysis <sup>a</sup>	2.25 g every 12 h	2.25 g every 8 h
CAPD	2.25 g every 12 h	2.25 g every 8 h

<sup>a</sup>Administer supplemental 0.75 g following each dialysis

**Alternative adjustment:**

GFR >40 mL/min	4.5 g IV over 30 min every 6 h or 3.375 g IV over 4 h every 8 h or 10.125–18 g/24 h IV continuous infusion
GFR 20–40 mL/min	3.375 g IV over 30 min every 6 h or 3.375 g IV over 4 h every 8 h
GFR <20 mL/min	2.25 g IV over 30 min every 6 h or 3.375 g IV over 4 h every 12 h
Hemodialysis	2.25 g IV over 30 min every 8 h; administer 2.25 g IV supplemental dose after dialysis.
CAPD	2.25 g IV over 30 min every 8 h
CVVH	2.25–3.375 g IV over 30 min every 6–8 h
CVVHD	3.375–4.5 g IV over 30 min every 6 h
CVVHDF	3.375–4.5 g IV over 30 min every 6 h

*Note: GFR-based dosage recommendations are primarily based on treatment of nosocomial pneumonia or other serious infections caused by gram-negative bacteria with intermediate sensitivity to piperacillin-tazobactam.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Piroxicam - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Piroxicam/Feldene®** {Anti-inflammatory; nonsteroidal anti-inflammatory drug}

**Usual initial dose:** 20 mg orally  
**Usual maintenance dose:** 20 mg orally once daily  
**Typical maximum dose:** 40 mg/day  
**Proportion eliminated unchanged:** 10 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild to moderate renal insufficiency</i>	<i>No adjustment necessary</i>
	<i>Advanced renal disease</i>	<i>No data, not recommended</i>
	<i>Severe renal failure</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>20 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>20 mg orally once daily</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk for gastrointestinal and renal toxicity.</i>
	<i>Hemodialysis</i>	<i>Data not available; preferably avoid.</i>
	<i>CAPD</i>	<i>Data not available; preferably avoid.</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pitavastatin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Pitavastatin/Livalo®**

{Antihypercholesterolemic agent; hydroxymethylglutaryl-coenzyme A (HMG-CoA) reductase inhibitor}

<b>Usual initial dose:</b>	2 mg orally once daily
<b>Usual maintenance dose:</b>	1–4 mg orally once daily
<b>Typical maximum dose:</b>	4 mg/day
<b>Proportion eliminated unchanged:</b>	15 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Pitavastatin dosage in patients with renal impairment*

<i>Renal function</i>	<i>Initial dose</i>	<i>Maximum dose</i>
<i>eGFR <math>\geq 60</math> mL/min/1.73 m<sup>2</sup></i>	<i>2 mg once daily</i>	<i>4 mg once daily</i>
<i>eGFR 30–59 mL/min/1.73 m<sup>2</sup></i>	<i>1 mg once daily</i>	<i>2 mg once daily</i>
<i>eGFR <math>&lt; 30</math> mL/min/1.73 m<sup>2</sup> (not on dialysis)</i>	<i>Avoid</i>	<i>Avoid</i>
<i>Hemodialysis</i>	<i>1 mg once daily</i>	<i>2 mg once daily</i>

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Plerixafor - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Plerixafor/Mobozil®**

**{Hematopoietic stem cell mobilizer}**

<b>Usual initial dose:</b>	0.24 mg/kg subcutaneously
<b>Usual maintenance dose:</b>	0.24 mg/kg subcutaneously once daily for 4 days (on day 5 following 4 consecutive days of granulocyte colony stimulating factor G-CSF)
<b>Typical maximum dose:</b>	40 mg/day
<b>Proportion eliminated unchanged:</b>	70 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Recommended subcutaneous dosage of plerixafor in patients with renal function impairment*

<i>eCrCL (mL/min)</i>	<i>Plerixafor dosage</i>
<i>&gt;50</i>	<i>0.24 mg/kg once daily (not to exceed 40 mg/day)</i>
<i>≤50</i>	<i>0.16 mg/kg once daily (not to exceed 27 mg/day)</i>
<i>Hemodialysis</i>	<i>Insufficient information to make dosage recommendation</i>

**Alternative adjustment:** *Hemodialysis: 0.16 mg/kg subcutaneously X1 after 4 days of G-CSF (very limited clinical data)*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Polymyxin B - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Polymyxin B/Poly-Rx®** {Antibacterial}

<b>Usual initial dose:</b>	12,500 units/kg IV
<b>Usual maintenance dose:</b>	15,000–25,000 units/kg/day IV; infusions may be given every 12 h; however, the total daily dose must not exceed 25,000 units/kg/day.
<b>Typical maximum dose:</b>	25,000 units/kg/day
<b>Proportion eliminated unchanged:</b>	1 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Kidney impairment*      *Reduce downward from 15,000 units/kg/day IV; infusions may be given every 12 h.*

**Alternative adjustment:**      *Dose adjustments for polymyxin B presently are controversial; recent clinical pharmacokinetic data suggest that dose adjustment for renal impairment, no matter how severe, is neither necessary nor appropriate and that larger doses are associated with better outcomes. Other clinical experience suggests that usual doses should be decreased by 25–50 % when eCrCL is 20–50 mL/min and further decreased by 50–67 % when eCrCL is <20 mL/min.*

<i>eCrCL &gt;80 mL/min</i>	<i>7,500–12,500 units/kg IV every 12 h</i>
<i>eCrCL 50–80 mL/min</i>	<i>7,500–12,500 units/kg IV every 12 h</i>
<i>eCrCL 20–49 mL/min</i>	<i>5,625–9,375 units/kg IV every 12 h (25 % decrease)</i>
<i>eCrCL 10–19 mL/min</i>	<i>2,475–4,125 units/kg IV every 12 h (67 % decrease)</i>
<i>eCrCL &lt;10 mL/min</i>	<i>1,125–1,875 units/kg IV every 12 h (85 % decrease)</i>
<i>Hemodialysis</i>	<i>Data not available</i>
<i>CAPD</i>	<i>150,000 units IV every 12 h (very limited data)</i>
<i>CRRT</i>	<i>25,000 units/kg IV once followed by 8,000 units/kg IV daily (very limited data)</i>

*Note: 10,000 units of polymyxin B sulfate = 1 mg of polymyxin B base*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Polythiazide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Polythiazide/Renese**<sup>®</sup> {Diuretic; thiazide}

**Usual initial dose:** 2 mg orally  
**Usual maintenance dose:** 2–4 mg orally once daily  
**Typical maximum dose:** 4 mg/day  
**Proportion eliminated Unchanged:** 25 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal disease</i>	<i>Use with caution; cumulative effects of the drug may develop in patients with impaired renal function. May precipitate azotemia. If progressive renal impairment becomes evident, as indicated by a rising nonprotein nitrogen or blood urea nitrogen, a careful reappraisal of therapy is necessary with consideration given to withholding or discontinuing diuretic therapy.</i>
	<i>Anuria</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1–4 mg orally every 24 h</i>
	<i>GFR 10–50 mL/min</i>	<i>1–4 mg orally every 24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>Ineffective; preferably avoid.</i>
	<i>Hemodialysis</i>	<i>Ineffective; preferably avoid.</i>
	<i>CAPD</i>	<i>Ineffective; preferably avoid.</i>
	<i>CRRT</i>	<i>Not applicable; avoid.</i>

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Potassium Chloride - Selected References**

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Potassium Chloride

{Electrolyte supplement}

<b>Usual initial dose:</b>	Dosage is dependent upon the age, weight, and clinical condition of the patient as well as laboratory determinations.
<b>Usual maintenance dose:</b>	Dosage is dependent upon the age, weight, and clinical condition of the patient as well as laboratory determinations.
<b>Typical maximum dose:</b>	240 mEq/day
<b>Proportion eliminated unchanged:</b>	90 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Should be used with great care, if at all in patients with severe renal insufficiency; in patients with diminished renal function, administration of potassium chloride may result in potassium retention.*

**Alternative adjustment:** *Potassium dosage in (a) ICU patients and (b) non-ICU patients (potassium replacement)*

#### *(a) ICU patients*

Serum/plasma potassium level	Glomerular filtration rate (GFR in mL/min)		
	>50	25–50	<25
3.3–3.7 mmol/L	Potassium chloride solution 40 mEq via enteral route every 6 h × 4 or If enteral route NOT available, Potassium chloride 20 mEq IV × 2 Central or 10 mEq IV × 4 Peripheral	Potassium chloride solution 40 mEq via enteral route every 12 h × 2 If enteral route NOT available Potassium chloride, 20 mEq IV × 1 Central or 10 mEq IV × 2 Peripheral	Potassium chloride solution 20 mEq via enteral route every 12 h × 2 If enteral route NOT available, potassium chloride 10 mEq IV × 1 Central or Peripheral
2.3–3.2 mmol/L	Potassium chloride 20 mEq IV × 3 Central or 10 mEq IV × 6 Peripheral	Potassium chloride 20 mEq IV × 2 Central or 10 mEq IV × 4 Peripheral	Potassium chloride 20 mEq IV × 1 Central or 10 mEq IV × 2 Peripheral
Less than or equal to 2.2 mmol/L	Notify MD	Notify MD	Notify MD

*Note: Preferred intravenous rates: equal or less than 10 mEq/h (peripheral); equal or less than 20 mEq/h (central)*

*Maximum peripheral infusion concentration: 10 mEq/100 ml*

*Maximum rate: equal or less than 40 mEq/h (emergency); Maximum intravenous dose = 240 mEq in 24 h*

*Magnesium repletion should be concurrent or prior to potassium replacement.*

#### *(b) Non-ICU patients*

Serum/plasma potassium level	Glomerular filtration rate (GFR in mL/min)		
	>50	25–50	<25
3.3–3.7 mmol/L	Potassium chloride solution or tablet 20 mEq PO/FT every 2 h × 3	Potassium chloride solution or tablet 20 mEq PO/FT every 2 h × 2	Potassium chloride solution or tablet 20 mEq PO/FT × 1
If enteral route NOT available	Potassium chloride 10 mEq IV × 4 Peripheral	Potassium chloride 10 mEq IV × 2 Peripheral	Potassium chloride 10 mEq IV × 1 Peripheral
2.5–3.2 mmol/L	Potassium chloride solution 20 mEq PO/FT every 2 h × 4	Potassium chloride solution 20 mEq PO/FT every 2 h × 3	Potassium chloride solution 20 mEq PO/FT every 2 h × 2
If enteral route NOT available	Potassium chloride 10 mEq IV × 6 Peripheral	Potassium chloride 10 mEq IV × 4 Peripheral	Potassium chloride 10 mEq IV × 2 Peripheral
Less than or equal to .5 mmol/L	Notify MD	Notify MD	Notify MD

*Note: Preferred intravenous rates: equal or less than 10 mEq/h peripheral. Maximum dose per day = 120 mEq*

*Magnesium repletion should be completed prior to potassium replacement*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pralidoxime - Selected References

- Abbara C, Rouseau JM, Lelièvre B, et al. Pharmacokinetic analysis of pralidoxime after its intramuscular injection alone or in combination with atropine-avizafone in healthy volunteers. *Br J Pharmacol*. 2010;161:1857–97.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Pralidoxime (2-PAM)/Protopam™**

**{Antidote; cholinesterase reactivator; R for cholinesterase inhibiting nerve agent or organophosphate insecticide exposure}**

**Usual initial dose:**

1–2 g IV over 15–30 min

**Usual maintenance dose:**

After about an hour, a second dose of 1–2 g IV will be indicated if muscle weakness has not been relieved; additional doses may be given cautiously if muscle weakness persists. Ingestion of organophosphates may lead to continuing absorption; in such cases additional doses may be needed every 3–8 h; alternatively, administer a loading dose of 20–50 mg/kg (not to exceed 2,000 mg/dose) over 15–30 min followed by a continuous infusion of 10–20 mg/kg/h.

**Typical maximum dose:**

16 mg/kg (central nervous system toxicity limit)

**Proportion eliminated unchanged:**

80–90 % (as metabolites and unchanged drug)

### ***Adjustment for Kidney Disease***

**FDA-approved product labeling:**

*Renal insufficiency Dosage should be reduced.*

**Alternative adjustment:**

*Healthy adults 16 mg/kg IV over 30 min followed by continuous IV infusion of 3.2 mg/kg/h*

*Renal insufficiency Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pramipexole - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Pramipexole/Mirapex®** {Dopamine agonist; anti-Parkinsonian}

**Usual initial dose:** 125 mcg orally  
**Usual maintenance dose:** 1.5 mg orally three times daily  
**Typical maximum dose:** 6 mg/day  
**Proportion eliminated unchanged:** 80 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Pramipexole dosage in Parkinson's disease patients with renal impairment*

<i>Renal status</i>	<i>Starting dose (mg)</i>	<i>Maximum dose (mg)</i>
<i>Normal to mild impairment (CrCL &gt; 60 mL/min)</i>	<i>0.125 orally three times daily</i>	<i>1.5 mg orally three times daily</i>
<i>Moderate impairment (CrCL 35–59 mL/min)</i>	<i>0.125 orally twice</i>	<i>1.5 mg orally twice daily</i>
<i>Severe impairment (CrCL 15–34 mL/min)</i>	<i>0.125 orally once daily</i>	<i>1.5 orally once daily</i>
<i>Very severe impairment (CrCL &lt; 15 mL/min and hemodialysis patients)</i>	<i>Use has not been adequately studied in this group of patients</i>	

**Alternative adjustment:**

*CrCL 20–60 mL* For restless legs, 0.125 mg orally once daily 2 h before sleep; increase by 0.125 mg/day every 14 days to a maximum of 0.5 mg daily if necessary

*Extended release*

*CrCL > 50 mL/min* 0.375 mg orally once daily; based on efficacy and tolerability, after 5–7 days, dosages may be increased to 0.375 mg orally once daily and then by weekly increments of 0.375 mg/day to a maximum of 4.5 mg/day

*CrCL 30–50 mL/min* 0.375 mg orally every other day; after 1 week, dosage may be increased to 0.375 mg orally once daily and then by weekly increments of 0.375 mg/day to a maximum of 2.25 mg/day

*CrCL < 30 mL/min* Not recommended

*Hemodialysis* For restless legs, 0.125 mg orally once daily 2 h before sleep; increase by 0.125 mg every 2–3 days to a maximum dose of 0.75 mg daily if necessary.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pregabalin - Selected References

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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Pregabalin/Lyrica®** {Antiepileptic; adjunctive analgesic}

**Usual initial dose:** 50 mg orally  
**Usual maintenance dose:** 50–150 mg orally two to three times daily  
**Typical maximum dose:** 450 mg/day  
**Proportion eliminated unchanged:** 90 %

*Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Pregabalin dosage adjustment based on renal function*

<i>CrCL (mL/min)</i>	<i>Total pregabalin daily dose (mg/day)*</i>				<i>Dose regimen</i>
60	150	300	450	600	<i>BID or TID</i>
30–60	75	150	225	300	<i>BID or TID</i>
15–30	25–50	75	100–150	150	<i>Once daily or BID</i>
<15	25	25–50	50–75	75	<i>Once daily</i>

*Supplementary dosage following hemodialysis (mg)*

*On the 25 mg daily regimen: take one supplemental dose of 25 or 50 mg*

*On the 25–50 mg daily regimen: take one supplemental dose of 50 or 75 mg*

*On the 50–75 mg daily regimen: take one supplemental dose of 75 or 100 mg*

*On the 75 mg QD regimen: take one supplemental dose of 100 or 150 mg*

*\*Total daily dose (mg/day) should be divided as indicated by dose regimen to provide mg/dose*

**Alternative adjustment:**

*GFR >50 mL/min 50–300 mg orally every 8–12 h*

*GFR 10–50 mL/min 25–150 mg orally every 8–12 h (50 % decrease)*

*GFR <10 mL/min 25–75 mg orally once daily (75 % decrease)*

*Hemodialysis 25 mg orally every 24–48 h at bedtime; administer supplemental dose after hemodialysis on dialysis days; titrate carefully.*

*CAPD 25–75 mg orally once daily*

*CRRT Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Primidone - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Primidone/Mysoline®**

{Antiepileptic}

<b>Usual initial dose:</b>	100 mg orally
<b>Usual maintenance dose:</b>	250 mg orally three times daily
<b>Typical maximum dose:</b>	2,000 mg/day
<b>Proportion eliminated unchanged:</b>	30 % (plus 30 % of each dose excreted in urine as pharmacologically active phenethylmalonamide)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Data not available</i>	
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>250 mg orally every 12 h; may titrate to maximum 1,500 mg/day<sup>a</sup></i>
	<i>GFR 10–50 mL/min</i>	<i>250 mg orally every 12 h<sup>a</sup></i>
	<i>GFR &lt;10 mL/min</i>	<i>250 mg orally every 24 h<sup>a</sup></i>
	<i>Hemodialysis</i>	<i>250 mg orally every 24 h; administer supplemental dose after hemodialysis on dialysis days.<sup>a</sup></i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Data not available</i>

### <sup>a</sup>*Therapeutic Drug Monitoring*

<b>Therapeutic plasma levels:</b>	<i>Primidone trough:</i>	<i>5–12 mg/L</i>
	<i>Phenobarbital trough:</i>	<i>15–40 mg/L</i>

*Note that primidone clearance often increases during 4–12 weeks of continuous therapy.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Probenecid - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Probenecid/Benemid®** {Anti-gout; uricosuric agent}

**Usual initial dose:** 250 mg orally  
**Usual maintenance dose:** 500 mg orally twice daily  
**Typical maximum dose:** 2,000 mg/day  
**Proportion eliminated unchanged:** 5 % (undergoes near complete renal tubular reabsorption)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>GFR &gt;30 mL/min</i>	<i>Gout: 250 mg orally twice daily for 1 week followed by 500 mg orally twice daily thereafter. Given with penicillin: 1,000 mg orally at the time of single-dose β-lactam antibiotic administration or 2,000 mg daily in divided doses</i>
	<i>GFR ≤30 mL/min</i>	<i>May be ineffective; not recommended</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500 mg orally twice daily</i>
	<i>GFR 10–50 mL/min</i>	<i>Preferably avoid due to risk for nephrotoxicity.</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to risk for nephrotoxicity.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risk for nephrotoxicity.</i>
	<i>CAPD</i>	<i>Preferably avoid due to risk for nephrotoxicity.</i>
	<i>CRRT</i>	<i>Not applicable; avoid.</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Procainamide - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Procainamide/Pronestyl<sup>®</sup>, Procan<sup>®</sup> SR {Antiarrhythmic, class IA}**

<b>Usual initial dose:</b>	17 mg/kg (approx 1,000 mg) IV at a rate not to exceed 50 mg/min or 500 mg orally
<b>Usual maintenance dose:</b>	50 µg/kg/min (range 20–80 µg/kg/min) continuous IV infusion or 50 mg/kg/day orally (250–500 mg every 3–6 h or 1,000–2,500 mg extended release every 12 h)
<b>Typical maximum dose:</b>	5,000 mg/day
<b>Proportion eliminated unchanged:</b>	50 % (depending on acetylator phenotype, an additional 20–30 % of each dose is excreted in urine as active <i>N</i> -acetylprocainamide)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal insufficiency</i>	<i>Lesser amounts or longer intervals (than the usual dosage) may produce adequate blood concentrations and decrease the probability of dose-related adverse reactions; advancing age reduces the renal excretion of procainamide and <i>N</i>-acetylprocainamide independently of reductions in CrCL—compared to normal young adults, there is approximately 25 % reduction at age 50 and 50 % at age 75.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>500 mg orally every 4 h or 1,000–1,500 mg extended release every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>500 mg orally every 6–12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>Data not available; preferably avoid.</i>
	<i>Hemodialysis</i>	<i>Clearance and elimination are prolonged unpredictably; preferably avoid.</i>
	<i>CAPD</i>	<i>250 mg every 12 h; monitor carefully (very limited data).</i>
	<i>CRRT</i>	<i>Data not available; preferably avoid.</i>

### *Therapeutic Drug Monitoring*

<b>Therapeutic plasma levels:</b>	Procainamide trough:	4–10 mg/L
	<i>N</i> -Acetylprocainamide (NAPA) trough:	15–25 mg/L

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Pyridostigmine - Selected References

- Aquilonius S-M, Hartvig P. Clinical pharmacokinetics of cholinesterase inhibitors. *Clin Pharmacokinet.* 1986;11:236–49.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Pyridostigmine/Mestinon<sup>®</sup>, Regonol<sup>®</sup>** {Acetylcholinesterase inhibitor; R for myasthenia gravis; nondepolarizing neuromuscular blocker antagonist}

**Usual initial dose:** 60 mg orally

**Usual maintenance dose:** 60–120 mg orally every 4–6 h (average dose 600 mg (10 tablets)/day spaced to provide maximum relief) or 180–540 mg extended release once or twice daily; for reversal of neuromuscular blocking effects of nondepolarizing muscle relaxants, 0.1–0.25 mg/kg IV (with anticholinergic comedication; monitoring with use of a peripheral nerve stimulator-induced twitch response is recommended)

**Typical maximum Dose:** 1,500 mg/day

**Proportion eliminated unchanged:** 75 %

### Adjustment for Kidney Disease

<b>FDA-approved product labeling:</b>	<i>Renal disease</i>	<i>Lower doses may be required; treatment should be based on titration of drug dosage to effect.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>30–60 mg orally every 4–6 h or 90–360 mg extended release once or twice daily; for myasthenic crisis, 1–4 mg/h continuous IV infusion (very limited data)</i>
	<i>GFR 10–50 mL/min</i>	<i>15–30 mg orally every 4–6 h or 90–180 mg extended release once or twice daily (~65 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>10–30 mg orally every 4–6 h or 45–90 mg extended release once or twice daily (~80 % decrease)</i>
	<i>Hemodialysis</i>	<i>10–30 mg orally every 4–6 h or 45–90 mg extended release once or twice daily (~80 % decrease); no supplemental post-dialysis dose</i>
	<i>CAPD</i>	<i>10–30 mg orally every 4–6 h or 45–90 mg extended release once or twice daily (~80 % decrease)</i>
	<i>CRRT</i>	<i>15–30 mg orally every 4–6 h or 90–180 mg extended release once or twice daily (~65 % decrease)</i>

*Note: Completeness of oral absorption varies widely as do plasma levels required for adequate control of myasthenic symptoms. Accordingly, required oral dosages are broadly variable.*

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Quinapril - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Quinapril/Accupril®** {Antihypertensive, vasodilator, angiotensin-converting enzyme (ACE)/renin inhibitor}

**Usual initial dose:** 5 mg orally  
**Usual maintenance dose:** 10–40 mg/day orally in one or two divided doses  
**Typical maximum dose:** 80 mg/day  
**Proportion eliminated unchanged:** 40 % (as quinaprilat)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Recommended starting doses of quinapril based on clinical and pharmacokinetic data from patients with renal impairment*

<i>CrCL (mL/min)</i>	<i>Maximum recommended initial daily dose</i>
<i>&gt;60</i>	<i>10 mg</i>
<i>30–60</i>	<i>5 mg</i>
<i>10–30</i>	<i>2.5 mg</i>
<i>&lt;10</i>	<i>Insufficient data for dosage recommendation</i>
<b>Alternative adjustment:</b> <i>GFR &gt;50 mL/min</i>	<i>20–40 mg orally every 12–24 h</i>
<i>GFR 10–50 mL/min</i>	<i>2.5–5 mg orally every 24 h, titrate</i>
<i>GFR &lt;10 mL/min</i>	<i>2.5 mg orally every 24 h, titrate</i>
<i>Hemodialysis</i>	<i>2.5 mg orally every 24 h, titrate; no supplemental dose after dialysis required</i>
<i>CAPD</i>	<i>2.5 mg orally every 24 h, titrate</i>
<i>CRRT</i>	<i>2.5–5 mg orally every 24 h, titrate</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Quinidine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Quinidine/Quinidex<sup>®</sup>, Quinaglute<sup>®</sup>**

**{Antiarrhythmic, class IA; antimalarial}**

**Usual initial dose:**

For arrhythmia, 400 mg orally (sulfate) or 648 mg orally (gluconate)

For *Plasmodium falciparum* malaria, 10–24 mg/kg IV over 2–4 h (gluconate)

**Usual maintenance dose:**

For arrhythmia, 200 mg orally every 6 h or 324 mg (gluconate) orally every 8–12 h

For *P. falciparum* malaria, 12 mg/kg IV over 4 h every 8 h or 20 µg/kg/min continuous IV infusion

**Typical maximum dose:**

3,000 mg/day

**Proportion eliminated unchanged:**

35 % (as parent drug [~20 %] and equally and partially pharmacologically active metabolites; directly pH dependent)

### **Adjustment for Kidney Disease**

**FDA-approved product labeling:**

*Renal dysfunction causes the elimination of quinidine to be slowed. This can lead to quinidine toxicity if dosage is not appropriately reduced*

**Alternative adjustment:**

*GFR >50 mL/min 200 mg orally every 6 h (sulfate) or 324 mg orally every 8–12 h (gluconate) (100 % of usual dose)<sup>a</sup>*

*GFR 10–50 mL/min 200 mg orally every 6 h (sulfate) or 324 mg orally every 8–12 h (gluconate) (100 % of usual dose)<sup>a</sup>*

*GFR <10 mL/min 100 mg orally every 4 h (sulfate) or 162 mg orally every 8 h (gluconate) (~75 % of usual dose)<sup>a</sup>*

*Hemodialysis 100 mg orally every 4 h (sulfate) or 162 mg orally every 8 h (gluconate) (~75 % of usual dose); dose after dialysis<sup>a</sup>*

*CAPD 100 mg orally every 4 h (sulfate) or 162 mg orally every 8 h (gluconate) (~75 % of usual dose)<sup>a</sup>*

*CRRT 200 mg orally every 6 h (sulfate) or 324 mg orally every 8–12 h (gluconate) (100 % of usual dose)<sup>a</sup>*

*<sup>a</sup>Note: Careful therapeutic drug monitoring is recommended. Specific assays, using either benzene extraction or (preferably) reverse-phase high-pressure liquid chromatography, should be utilized. A typical therapeutic trough concentration range is 2–6 mg/L*

*Although serum quinidine levels can be conveniently assayed and monitored, the electrocardiographic QTC interval is considered a better predictor of quinidine-induced ventricular arrhythmias. The total daily dosage should be reduced if (1) the QRS complex widens to 130 % of its pretreatment duration; (2) the QTC interval widens to 130 % of its pretreatment duration and is then longer than 500 ms; (3) P waves disappear; or (4) the patient develops significant tachycardia, symptomatic bradycardia, or hypotension*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Quinine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Quinine/Qualaquin®**

**{Antimalarial}**

<b>Usual initial dose:</b>	648 mg orally
<b>Usual maintenance dose:</b>	648 mg orally every 8 h with food for 7 days
<b>Typical maximum dose:</b>	1,944 mg/day
<b>Proportion eliminated unchanged:</b>	20 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe chronic renal impairment</i>	<i>648 mg orally followed 12 h later by 324 mg orally every 12 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>Severe or complicated malaria: loading dose 20 mg/kg IV over 4 h, followed by 10 mg/kg IV every 8 h for 48 h or until patient is able to swallow, followed by 10 mg/kg IV every 12 h or until patient is able to swallow</i>  <i>Uncomplicated malaria: 10 mg/kg (≈648 mg) orally every 8 h to complete 5–7 days quinine in total</i>
	<i>GFR 10–50 mL/min</i>	<i>648 mg (10 mg/kg) orally every 12 h (33 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>648 mg orally every 24 h (in cases of severe malaria, empiric doses as large as 648 mg [10 mg/kg] every 8 h have been used successfully with attainment of effective plasma quinine levels)</i>
	<i>Hemodialysis</i>	<i>648 mg orally every 24 h; dose after dialysis (in cases of severe malaria, 10 mg/kg every 8 h or 15 mg/kg every 12 h has been successfully used with attainment of effective plasma quinine levels)</i>
	<i>CAPD</i>	<i>648 mg orally every 24 h</i>
	<i>CRRT</i>	<i>648 mg orally every 8–12 h or 15–20 mg/kg/day in divided doses</i>

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ramipril - Selected References

- Altace® capsule [package insert]. Bristol: Monarch Pharmaceuticals Inc; 2011.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ramipril/Altace®** {Antihypertensive, vasodilator, angiotensin-converting enzyme (ACE)/renin inhibitor}

**Usual initial dose:** 2.5 mg orally twice daily

**Usual maintenance dose:** 5 mg orally twice daily

**Typical maximum dose:** 20 mg/day

**Proportion eliminated unchanged:** 60 % (as parent drug and metabolites, primarily active ramiprilat)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Changes in renal function may be anticipated in susceptible individuals.*

*CrCL ≥40 mL/min 2.5–20 mg/day orally in one or two doses*

*SCr >2.5 mg/dL or CrCL <40 mL/min 1.25 mg orally twice daily (25 % of usual dose), titrate*

### **Alternative adjustment:**

*GFR >50 mL/min 5–10 mg orally every 24 h*

*GFR 10–50 mL/min 2.5–7.5 mg orally every 24 h (25–50 % decrease)*

*GFR <10 mL/min 1.25–5 mg orally every 24 h (75 % decrease)*

*Hemodialysis 1.25–5 mg orally every 24 h; dose after dialysis*

*CAPD 1.25–5 mg orally every 24 h*

*CRRT 2.5–7.5 mg orally every 24 h, titrate*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ranitidine (Enteral) - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Ranitidine (Enteral)/Zantac®**

{Antacid; histamine H<sub>2</sub> receptor antagonist}

<b>Usual initial dose:</b>	150 mg orally
<b>Usual maintenance dose:</b>	150 mg orally twice daily or 300 mg orally after the evening meal or at bedtime
<b>Typical maximum dose:</b>	600 mg/day
<b>Proportion eliminated unchanged:</b>	80 % (30 % of an oral dose appears unchanged in urine)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;50 mL/min</i>	<i>150 mg orally every 24 h. Should the patient's condition require, the frequency of dosing may be increased to every 12 h or even further with caution.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>150–300 mg orally at bedtime</i>
	<i>GFR 10–50 mL/min</i>	<i>75 mg orally twice daily or 150 mg orally every 24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>75 mg orally twice daily or 150 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>75 mg orally twice daily or 150 mg orally every 24 h; give after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>75 mg orally twice daily or 150 mg orally every 24 h</i>
	<i>CRRT</i>	<i>150 mg orally every 12–24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ranitidine (IV)/Zantac® IV** {Antacid; histamine H<sub>2</sub> receptor antagonist}

**Usual initial dose:** 50 mg IV  
**Usual maintenance dose:** 50 mg IV every 6–8 h or 6.25 mg/h continuous IV infusion  
**Typical maximum dose:** 400 mg/day  
**Proportion eliminated unchanged:** 80 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;50 mL/min</i>	<i>50 mg IV every 18–24 h. Should the patient's condition require, the frequency of dosing may be increased to every 12 h or even further with caution.</i>
	<i>Hemodialysis</i>	<i>50 mg IV every 18–24 h; dose after dialysis</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>50 mg IV every 8 h</i>
	<i>GFR 10–50 mL/min</i>	<i>50 mg IV every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>50 mg IV every 24 h</i>
	<i>Hemodialysis</i>	<i>50 mg IV every 24 h; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>50 mg IV every 24 h</i>
	<i>CRRT</i>	<i>50 mg IV every 12 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ranolazine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Ranolazine/Ranexa®**

**{Antianginal}**

<b>Usual initial dose:</b>	500 mg orally twice daily
<b>Usual maintenance dose:</b>	1,000 mg orally twice daily
<b>Typical maximum dose:</b>	2,000 mg/day
<b>Proportion eliminated unchanged:</b>	7 % (70 % as metabolites of uncertain activity)

### ***Adjustment for Kidney Disease***

**FDA-approved product labeling:**

*In patients with varying degrees of renal impairment, ranolazine plasma levels increased up to 50 %. Blood pressure increases by about 15 mmHg in patients with severe renal impairment. The pharmacokinetics of ranolazine has not been assessed in patients on dialysis.*

**Alternative adjustment:**

*In patients with kidney disease, factors other than reduced GFR contribute to the increase in plasma ranolazine concentrations.*

*eCrCL 30–80 mL/min      500 mg orally twice daily; use with cautious electrocardiographic monitoring; titrate carefully.*

*eCrCL <30 mL/min      Minimal data available; preferably avoid*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Repaglinide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Repaglinide/Prandin®** {Antidiabetic; meglitinide derivative; insulin secretagogue}

**Usual initial dose:** 0.5 mg with each meal

**Usual maintenance dose:** 0.5–4 mg orally with meals two, three, or four times a day

**Typical maximum dose:** 16 mg/day

**Proportion eliminated unchanged:** 8 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild to moderate renal dysfunction</i>	<i>Initial dose adjustment does not appear to be necessary.</i>
	<i>Severe renal function impairment</i>	<i>Initiate therapy with 0.5 mg orally with meals; subsequently patient's dose should be carefully titrated.</i>
	<i>CrCL &lt;20 mL/min</i>	<i>No data</i>
	<i>Hemodialysis</i>	<i>No data</i>
<b>Alternative adjustment:</b>	<i>eCrCL &gt;80 mL/min</i>	<i>1–4 mg orally three times daily with meals</i>
	<i>eCrCL 30–80 mL/min</i>	<i>0.5–2 mg orally three times daily with meals; initiate with low doses, titrate carefully, and monitor for hypoglycemia.</i>
	<i>eCrCL 5–30 mL/min</i>	<i>0.5–2 mg orally three times daily with meals; initiate with low doses, titrate carefully, and monitor for hypoglycemia.</i>
	<i>Hemodialysis</i>	<i>0.5–2 mg orally three times daily with meals; administer after hemodialysis on dialysis days; initiate with low doses, titrate carefully, and monitor for hypoglycemia.</i>
	<i>CRRT</i>	<i>Not applicable; avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Reserpine - Selected References

- Abrahams DG, Wilson C. Effect of hypotensive drugs on renal function in chronic renal disease. *Lancet*. 1957;1:68–74.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Reserpine/Serpasil®** {Antihypertensive; central monoamine-depleting agent; Rauwolfia alkaloid}

**Usual initial dose:** 0.5 mg orally once daily

**Usual maintenance dose:** 0.1–0.25 mg orally once daily

**Typical maximum dose:** 1 mg/day

**Proportion eliminated unchanged:** 1 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Caution should be exercised when treating hypertensive patients with renal insufficiency since they adjust poorly to lowered blood pressure levels.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>0.1–0.25 mg orally once daily</i>
<i>GFR 10–50 mL/min</i>	<i>0.1–0.25 mg orally once daily</i>
<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid due to often delayed and unreliable responses</i>
<i>Hemodialysis</i>	<i>Preferably avoid due to often delayed and unreliable responses</i>
<i>CAPD</i>	<i>Preferably avoid due to often delayed and unreliable responses</i>
<i>CRRT</i>	<i>Not applicable; preferably avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ribavirin (Oral) - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ribavirin (Oral)/Rebetol<sup>®</sup>,  
RibaPak<sup>®</sup>, Ribasphere<sup>®</sup>, Copegus<sup>®</sup>** {Antiviral; R for hepatitis C}

**Usual initial dose:** 400 mg orally  
**Usual maintenance dose:** 800–1,200 mg/day orally in two divided doses with food  
**Typical maximum dose:** 1,200 mg/day  
**Proportion eliminated unchanged:** 5–15 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** Recommended dosing for (a) Rebetol, RibaPak, Ribasphere: CrCL <50 mL/min and (b) Copegus: CrCL ≤50 mL/min

#### (a) Rebetol, RibaPak, Ribasphere

Body weight	Ribavirin dose
≤75 kg	400 mg (2 capsules) orally every AM and 600 mg (3 capsules) orally every PM
>75 kg	600 mg (3 capsules) orally every AM and 600 mg (3 capsules) orally every PM
CrCL <50 mL/min	Contraindicated

#### (b) Copegus

	Interferon alfa-2a (Pegasys) dose	Ribavirin (Copegus) dose <sup>a</sup>	Duration
Hepatitis C Genotypes 1, 4	180 µg	<75 kg = 1,000 mg ≥75 kg = 1,200 mg	48 week
Hepatitis C Genotypes 2, 3	180 µg	800 mg	24 week

CrCL ≤50 mL/min: Do not use ribavirin

<sup>a</sup>Administer orally in two divided doses

**Alternative adjustment:** *eCrCL ≤60 mL/min* Patient safety note: See contraindication above as listed in US product labeling; potentially conflicting dose recommendations tabulated below are taken from a pilot study of 19 patients with hepatitis C infection and chronic kidney disease treated with ribavirin (Rebetol) and interferon alfa-2b (Bruchfeld et al. 2002) as well as recently published clinical practice guidelines. Plasma level monitoring is recommended.

Target ribavirin concentration at steady state

	6 µmol/L	10 µmol/L	14 µmol/L
<i>eCrCL</i> 60 mL/min	400 mg/day	600 mg/day	800 mg/day
<i>eCrCL</i> 40 mL/min	200 mg/day	400 mg/day	600 mg/day
<i>eCrCL</i> 20 mL/min	200 mg/day	400 mg/200 mg	400 mg/day alternate days

Hemodialysis 200 mg orally once daily  
 Kidney transplant Avoid unless fibrosing cholestatic hepatitis develops  
 CAPD Avoid  
 CRRT 400–600 mg orally twice daily

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Rifabutin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Rifabutin/Mycobutin**<sup>®</sup> {Antitubercular}

**Usual initial dose:** 300 mg orally  
**Usual maintenance dose:** 300 mg orally once daily  
**Typical maximum dose:** 300 mg/day  
**Proportion eliminated unchanged:** 11 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;30 mL/min</i>	<i>150 mg orally once daily (50 % decrease)</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>300 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>300 mg orally once daily</i>
	<i>GFR &lt;10 mL/min</i>	<i>300 mg orally once daily</i>
	<i>Hemodialysis</i>	<i>300 mg orally once daily</i>
	<i>CAPD</i>	<i>150–300 mg orally once daily</i>
	<i>CRRT</i>	<i>300 mg orally once daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Rifampin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Rifampin/Rifadin®** {Antitubercular; antibacterial}

**Usual initial dose:** 600 mg orally or IV  
**Usual maintenance dose:** 10 mg/kg not to exceed 600 mg orally or IV once daily  
**Typical maximum dose:** 600 mg/day  
**Proportion eliminated unchanged:** 8–33 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;50 mL/min</i>	<i>10 mg/kg not to exceed 600 mg orally or IV once daily (100 % of usual dose)</i>
	<i>Hemodialysis</i>	<i>10 mg/kg not to exceed 600 mg orally or IV once daily (100 % of usual dose)</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose)</i>
	<i>GFR 10–50 mL/min</i>	<i>5–10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose)</i>
	<i>GFR &lt;10 mL/min</i>	<i>5–10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose)</i>
	<i>Hemodialysis</i>	<i>5–10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose); no supplemental dose after dialysis required</i>
	<i>CAPD</i>	<i>5–10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose)</i>
	<i>CVVH</i>	<i>300–600 mg IV every 12–24 h</i>
	<i>CVVHD</i>	<i>300–600 mg IV every 12–24 h</i>
	<i>CVVHDF</i>	<i>300–600 mg IV every 12–24 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Rimantadine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Rimantadine/Flumadine®**

**{Antiviral}**

**Usual initial dose:** 100 mg orally

**Usual maintenance dose:** 100 mg orally twice daily for 7 days or, for influenza prophylaxis, for the duration of the period of peak influenza activity in the community

**Typical maximum dose:** 200 mg/day

**Proportion eliminated unchanged:** 19 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal insufficiency</i>	<i>Monitor for adverse effects and adjust dose as necessary.</i>
	<i>Elderly nursing home patients</i>	<i>100 mg orally once daily</i>
	<i>CrCL ≤10 mL/min</i>	<i>100 mg orally once daily</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>100 mg orally twice daily</i>
	<i>GFR 10–50 mL/min</i>	<i>100 mg orally once daily</i>
	<i>GFR &lt;10 mL/min</i>	<i>100 mg orally once daily</i>
	<i>Hemodialysis</i>	<i>100 mg orally once daily (supplemental dose after dialysis not required or recommended)</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>100 mg orally twice daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Risedronate - Selected References

- Actonel<sup>®</sup> tablet film coated [package insert]. Rockaway: Warner Chilcott (US) LLC; 2011.
- Atelvia<sup>™</sup> tablet delayed release [package insert]. Rockaway: Warner Chilcott (US) LLC; 2011.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Risedronate/Actonel®, Atelvia™**

**{Anti-osteoporotic, bisphosphonate}**

**Usual initial dose:** 5–150 mg orally taken at least 30 min before the first food or drink of the day; do not lie down for 30 min.

**Usual maintenance dose:** One 5-mg tablet orally taken daily or  
One 35-mg tablet or one 35-mg delayed-release tablet orally taken once a week or  
One 75-mg tablet orally taken on two consecutive days for a total of two tablets each month or  
One 150-mg tablet orally taken once a month

**Typical maximum dose:** 150 mg/month; usual maximal initial treatment duration=5 years

**Proportion eliminated unchanged:** 87 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL <30 mL/min*      *Not recommended because of lack of clinical experience*

**Alternative adjustment:** *eCrCL 15–30 mL/min*      *5 mg orally once daily*

*Hemodialysis*      *Data not available; preferably avoid*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Risperidone (Oral) - Selected References

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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Risperidone/Risperdal<sup>®</sup>,  
Risperdal<sup>®</sup> Consta**

{Atypical antipsychotic; benzisoxazole derivative}

<b>Usual initial dose:</b>	1 mg orally twice daily
<b>Usual maintenance dose:</b>	2–8 mg/day orally in one or two divided doses or 25 mg IM every 2 weeks
<b>Typical maximum dose:</b>	16 mg/day
<b>Proportion eliminated unchanged:</b>	4–30 % (plus approx 40 % of each dose as metabolites including 8–30 % of the dose as active 9-hydroxyrisperidone [paliperidone])

*Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe renal impairment</i>	<i>The recommended initial dose is 0.5 mg twice daily. Dosage increases in these patients should be in increments of no more than 0.5 mg twice daily. Increases to dosages above 1.5 mg twice daily should generally occur at intervals of at least 1 week. In some patients, slower titration may be medically appropriate.</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1–3 mg orally twice daily</i>
	<i>GFR 10–50 mL/min</i>	<i>0.5–2 mg orally twice daily or 12.5 mg IM every 2 weeks</i>
	<i>GFR &lt;10 mL/min</i>	<i>0.5–2 mg orally once daily; begin with modest doses and titrate carefully.</i>
	<i>Hemodialysis</i>	<i>0.5–4 mg orally once daily; supplemental dose after dialysis is not necessary; begin with modest doses and titrate carefully.</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Rivaroxaban - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Rivaroxaban/Xarelto®**

{Direct thrombin inhibitor; antithrombotic}

<b>Usual initial dose:</b>	20 mg orally
<b>Usual maintenance dose:</b>	10–20 mg orally once daily with the evening meal
<b>Typical maximum dose:</b>	20 mg/day
<b>Proportion eliminated unchanged:</b>	36 %

### *Adjustment for Kidney Disease*

#### **FDA-approved product labeling:**

*Nonvalvular atrial fibrillation*

*CrCL >50 mL/min 20 mg orally once daily with the evening meal*

*CrCL 15–50 mL/min 15 mg orally once daily with the evening meal; observe closely and promptly evaluate any signs or symptoms of blood loss; patients who develop acute renal failure while on rivaroxaban should discontinue treatment.*

*CrCL <15 mL/min Avoid due to an expected increase in rivaroxaban exposure and pharmacodynamic effects in this population*

*Prophylaxis of deep vein thrombosis*

*CrCL ≥30 mL/min 10 mg orally once daily with the evening meal (at least 6 h after surgery for 35 days in patients undergoing hip replacement surgery or 12 days for patients undergoing knee replacement surgery)*

*CrCL <30 mL/min Avoid due to an expected increase in rivaroxaban exposure and pharmacodynamic effects in this population, i.e., bleeding*

#### **Alternative adjustment:**

*GFR >50 mL/min 20 mg orally once daily with the evening meal (atrial fibrillation); 2.5–5 mg orally once daily (prevention of recurrent cardiovascular events in patients with acute coronary syndrome)*

*GFR 30–50 mL/min 15 mg orally once daily with the evening meal (atrial fibrillation)*

*GFR <30 mL/min Data not available, preferably avoid*

*Hemodialysis Data not available; preferably avoid*

*CAPD Data not available; preferably avoid*

*CRRT Data not available; preferably avoid*

*Note: Due to exclusion of patients with GFR <30 mL/min in clinical trials and lack of experience, rivaroxaban use usually should be discouraged in these individuals in favor of unfractionated heparin, parenteral direct thrombin inhibitors, or warfarin. Patients with moderate renal impairment (CrCL 30–49 mL/min) and atrial fibrillation treated with rivaroxaban have been found to have an incidence of ischemic stroke similar to that in patients treated with warfarin, whereas this incidence was significantly reduced with rivaroxaban in patients with normal renal function.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Rosuvastatin/Crestor**<sup>®</sup> {Antihypercholesterolemic agent; hydroxymethylglutaryl-coenzyme A (HMG-CoA) reductase inhibitor}

**Usual initial dose:** 5 mg orally  
**Usual maintenance dose:** 5–20 mg orally once daily  
**Typical maximum dose:** 40 mg/day  
**Proportion eliminated unchanged:** 10 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Severe renal impairment (CrCL <30 mL/min) not on hemodialysis—dosing should be started at 5 mg once daily and not exceed 10 mg once daily.*

**Alternative adjustment:**

<i>eGFR 50–80 mL/min</i>	<i>5–20 mg orally once daily</i>
<i>eGFR 30–49 mL/min</i>	<i>5–20 mg orally once daily</i>
<i>eGFR &lt;30 mL/min</i>	<i>5 mg orally once daily; titrate as necessary up to 10 mg orally once daily.</i>
<i>Hemodialysis</i>	<i>2.5–10 mg orally once daily</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ruxolitinib - Selected References

Harrison C, Kiladjan J-J, Al-Ali HK, et al. JAK inhibition with ruxolitinib versus best available therapy for myelofibrosis. *N Engl J Med.* 2012;366:787–98.

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Ruxolitinib/Jakafi™**

{Janus tyrosine kinase 1–2 inhibitor; R for myelofibrosis}

<b>Usual initial dose:</b>	15–20 mg orally
<b>Usual maintenance dose:</b>	15 mg orally twice daily for patients with a platelet count between 100 and $200 \times 10^9/L$ or 20 mg orally twice daily for patients with a platelet count $>200 \times 10^9/L$ ; increase dose based on response to maximum.
<b>Typical maximum dose:</b>	25 mg orally twice daily
<b>Proportion eliminated unchanged:</b>	0.11 % (plus 74 % of the absorbed dose as active metabolites which confer 18 % of the pharmacodynamic actions of ruxolitinib)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 30–50 mL/min</i>	<i>Reduce starting dose 10 mg orally twice daily in patients with a platelet count between 100 and <math>150 \times 10^9/L</math>; dose modifications should be made with careful monitoring of safety and efficacy; avoid if platelet count is <math>&lt;100 \times 10^9/L</math>.</i>
	<i>CrCL 15–29 mL/min</i>	<i>Reduce starting dose 10 mg orally twice daily in patients with a platelet count between 100 and <math>150 \times 10^9/L</math>; dose modifications should be made with careful monitoring of safety and efficacy; avoid if platelet count is <math>&lt;100 \times 10^9/L</math>.</i>
	<i>Hemodialysis</i>	<i>15 mg orally twice daily for patients with a platelet count between 100 and <math>200 \times 10^9/L</math> or 20 mg orally twice daily for patients with a platelet count <math>&gt;200 \times 10^9/L</math>; dose modifications should be made with careful monitoring of safety and efficacy; administer after hemodialysis on dialysis days.</i>
	<i>CrCL <math>&lt;15</math> mL/min (not requiring hemodialysis)</i>	<i>Avoid</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Salsalate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Salsalate/Disalicylic Acid, Disalcid<sup>®</sup>, Amigesic<sup>®</sup>** {Anti-inflammatory}

**Usual initial dose:** 1,500 mg orally  
**Usual maintenance dose:** 1,500 mg orally twice daily  
**Typical maximum dose:** 4,000 mg/day  
**Proportion eliminated unchanged:** 1 % (on a molar basis, 84 % of each dose is hydrolyzed to salicylic acid, the active anti-inflammatory compound; approximately 10 % of formed salicylic acid is eliminated unchanged in urine)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Impaired renal function*      *Renal patients are at greatest risk for toxicity including renal papillary necrosis, acute renal decompensation, and other renal injury; close monitoring of renal function is advisable.*

*Advanced renal disease*      *Use not recommended due to lack of information available from controlled clinical studies*

**Alternative adjustment:**

*Hemodialysis:*      *1,500 mg orally once followed by 750 mg orally twice daily; administer supplemental 500 mg following hemodialysis on dialysis days.*

### *Therapeutic drug monitoring*

**Therapeutic plasma levels:**

*Usual therapeutic (anti-inflammatory) serum salicylate trough concentration = 150–300 mg/L*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Saxagliptin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Saxagliptin/Onglyza™**

{Antidiabetic; dipeptidyl peptidase-4 inhibitor}

<b>Usual initial dose:</b>	2.5 mg orally
<b>Usual maintenance dose:</b>	2.5–5 mg orally once daily
<b>Typical maximum dose:</b>	10 mg/day
<b>Proportion eliminated unchanged:</b>	24 % plus 36 % as active metabolite (5-hydroxy saxagliptin)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;50 mL/min</i>	<i>2.5–5 mg orally once daily</i>
	<i>CrCL ≤50 mL/min</i>	<i>2.5 mg orally once daily</i>
	<i>Hemodialysis</i>	<i>2.5 mg orally once daily; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>No data</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;55 mL/min</i>	<i>2.5–5 mg orally once daily</i>
	<i>GFR ≤55 mL/min</i>	<i>2.5 mg orally once daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Silodosin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Sildenafil/Rapaflo™** {Adrenergic  $\alpha_1$  blocker; R for benign prostatic hypertrophy}

**Usual initial dose:** 8 mg orally

**Usual maintenance dose:** 8 mg orally once daily with a meal

**Typical maximum dose:** 8 mg/day

**Proportion eliminated unchanged:** 33 % (primarily as active glucuronide conjugate metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL 51–80 mL/min* 8 mg orally once daily with food

*CrCL 30–50 mL/min* 4 mg orally once daily with food

*CrCL <30 mL/min* Contraindicated

**Alternative adjustment:** *Data not available*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sitagliptin - Selected References

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- Lerner JM, Babura R, Edwards CMB. Renal impairment with sitagliptin: is there a need for active monitoring of potential renal toxicity? *Br J Hosp Med.* 2011;72:412–3.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Sitagliptin/Januvia®**

{Antidiabetic; dipeptidyl peptidase-4 inhibitor}

<b>Usual initial dose:</b>	100 mg orally
<b>Usual maintenance dose:</b>	100 mg orally once daily
<b>Typical maximum dose:</b>	100 mg/day
<b>Proportion eliminated unchanged:</b>	79 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL <math>\geq 50</math> mL/min or SCr <math>\leq 1.7</math> mg/dL in men or SCr <math>\leq 1.5</math> mg/dL in women</i>	<i>100 mg orally once daily</i>
	<i>CrCL 30–50 mL/min or SCr 1.7–3 mg/dL in men or SCr 1.5–2.5 mg/dL in women</i>	<i>50 mg orally once daily</i>
	<i>CrCL <math>&lt; 30</math> mL/min or SCr <math>&gt; 3</math> mg/dL in men or SCr <math>&gt; 2.5</math> mg/dL in women or ESRD requiring hemodialysis or peritoneal dialysis</i>	<i>25 mg orally once daily; may be given without regard to time of dialysis</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sodium Citrate and Citric Acid - Selected References

- Bauer E, Derfler K, Juokhadar C, Drumi W. Citrate kinetics in patients receiving long-term hemodialysis therapy. *Am J Kidney Dis.* 2005;46:903–7.
- Cytra-2 oral solution [package insert]. Madison: Cypress Pharmaceutical Inc; 2011.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Sodium Citrate and Citric Acid/Bicitra®, Cytra-2 {Systemic alkalizer}**

<b>Usual initial dose:</b>	10–30 mL diluted in 30–90 mL of water orally
<b>Usual maintenance dose:</b>	10–30 mL diluted in 30–90 mL of water orally after meals and at bedtime daily
<b>Typical maximum dose:</b>	120 mL/day
<b>Proportion eliminated unchanged:</b>	5 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Low urinary output*

*Use with caution; periodic examinations and determinations of serum electrolytes, particularly sodium bicarbonate level, should be carried out.*

*Severe renal impairment*

*Contraindicated*

**Alternative adjustment:**

*GFR 20–59 mL/min*

*1 mL (1 mEq)/kg/day orally in three divided doses (limited data)*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Solifenacin - Selected References

- Callegari E, Malhotra B, Bungay PJ, et al. A comprehensive non-clinical evaluation of the CNS penetration potential of antimuscarinic agents for the treatment of overactive bladder. *Br J Clin Pharmacol*. 2011;72:235–46.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Solifenacin/Vesicare®** {Anticholinergic agent; R for overactive bladder or urge incontinence}

**Usual initial dose:** 5 mg orally  
**Usual maintenance dose:** 5–10 mg orally once daily  
**Typical maximum dose:** 10 mg/day  
**Proportion eliminated unchanged:** 15 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL ≥30 mL/min* 5–10 mg orally once daily  
*CrCL <30 mL/min* 5 mg orally once daily

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sorafenib - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Sorafenib/Nexavar®** {Antineoplastic; tyrosine kinase and vascular endothelial growth factor (VEGF) inhibitor}

**Usual initial dose:** 400 mg orally  
**Usual maintenance dose:** 400 mg orally twice daily without food  
**Typical maximum dose:** 800 mg/day  
**Proportion eliminated unchanged:** 19 % (as active and inactive metabolites)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *No dosage adjustment is necessary in patients with mild, moderate, or severe renal impairment not undergoing dialysis.*

**Alternative adjustment:**

<i>eCrCL ≥60 mL/min</i>	<i>400 mg orally twice daily without food</i>
<i>eCrCL 40–59 mL/min</i>	<i>400 mg orally twice daily without food</i>
<i>eCrCL 20–39 mL/min</i>	<i>200 mg orally twice daily without food</i>
<i>eCrCL &lt;20 mL/min</i>	<i>Insufficient data; dose not defined</i>
<i>Hemodialysis</i>	<i>200 orally once or twice daily (Note: At least one patient has been reported to tolerate extended treatment with 400 mg orally twice daily with no clinical, biochemical, or hematological evidence of toxicity.)</i>

*Note: Neurological, hematological, cardiovascular, or other considerations may suggest further dosage adjustments.*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sotalol - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Sotalol/Betapace<sup>®</sup>, Betapace AF<sup>®</sup>, Sorine<sup>®</sup>** {Antiarrhythmic, class II/III}

**Usual initial dose:** 80 mg orally twice daily or 75 mg IV over 5 h  
**Usual maintenance dose:** 120–160 mg orally twice daily or 75 mg IV over 5 h every 12 h  
**Typical maximum dose:** 640 mg/day orally or 150 mg/day IV  
**Proportion eliminated unchanged:** 90 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:**

*Sotalol dosing for (a) ventricular arrhythmias in renal function impairment and (b) atrial fibrillation in renal function impairment*

<i>CrCL (mL/min)</i>	<i>Dosage</i>
<i>(a)</i>	
>60	80 mg orally or 75 mg IV over 5 h every 12 h
30–59	80 mg orally or 75 mg IV over 5 h every 24 h
10–29	80 mg orally every 36–48 h (IV use not recommended)
<10	Oral dose should be individualized (IV use not recommended)
<i>(b)</i>	
>60	80 mg orally or 75 mg IV over 5 h every 12 h
40–60	80 mg orally or 75 mg IV over 5 h every 24 h
<40	Contraindicated
<i>GFR &gt;50 mL/min</i>	80–160 mg orally every 12 h
<i>GFR 10–50 mL/min</i>	80–160 mg orally every 24–48 h
<i>GFR &lt;10 mL/min</i>	80–160 mg orally every 48–72 h
<i>Hemodialysis</i>	80–160 mg orally every 48–72 h; administer after hemodialysis on dialysis days.
<i>CAPD</i>	80–160 mg orally every 48–72 h
<i>CRRT</i>	80–160 mg orally every 24–48 h; titrate.

**Alternative adjustment:**

*Note: Electrocardiographic considerations such as QT interval prolongation may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Spironolactone - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Spironolactone/Aldactone®** {Diuretic; aldosterone antagonist}

<b>Usual initial dose:</b>	25 mg orally
<b>Usual maintenance dose:</b>	12.5–200 mg orally once daily
<b>Typical maximum dose:</b>	400 mg/day
<b>Proportion eliminated unchanged:</b>	30 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Anuria, acute renal insufficiency, significant impairment of renal excretory function</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>25–100 mg orally every 12–24 h</i>
	<i>GFR 30–50 mL/min</i>	<i>12.5–25 mg orally every 12–24 h</i>
	<i>GFR &lt;30 mL/min</i>	<i>Preferably avoid due to risk for hyperkalemia.</i>
	<i>Hemodialysis</i>	<i>Preferably avoid due to risk for hyperkalemia.</i>
	<i>CAPD</i>	<i>Preferably avoid due to risk for hyperkalemia.</i>
	<i>CRRT</i>	<i>Preferably avoid due to risk for hyperkalemia.</i>

*Note: Preliminary studies in patients with chronic kidney disease and other comorbidities suggest that spironolactone may be associated with certain cardio- and reno-protective effects; additional clinical trial experience is necessary before spironolactone may be considered generally safe for use in these patients.*

*Note also: In patients with heart failure, dosage usually should be limited to 25 mg orally once daily due to risks for serious electrolyte disorders with higher dosages.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Stavudine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Stavudine (d4T)/Zerit®** {Nucleoside reverse transcriptase inhibitor antiretroviral}

**Usual initial dose:** 15 mg orally (body weight <60 kg); 20 mg (weight ≥60 kg)  
**Usual maintenance dose:** 30 mg orally twice daily (weight <60 kg); 40 mg orally twice daily (weight ≥60 kg)  
**Typical maximum dose:** 80 mg/day  
**Proportion eliminated unchanged:** 70 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Stavudine dosage adjustment for renal impairment*

<i>CrCL (mL/min)</i>	<i>Recommended dose</i>	
	<i>Patient weight ≥60 kg</i>	<i>Patient weight &lt;60 kg</i>
>50	40 mg every 12 h	30 mg every 12 h
26–50	20 mg every 12 h	15 mg every 12 h
10–25	20 mg every 24 h	15 mg every 24 h

*Hemodialysis: 15 mg orally every 24 h (weight <60 kg); 20 mg orally every 24 h (weight ≥60 kg); dose after hemodialysis on dialysis days*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>30 mg orally every 12 h (if &lt;60 kg); 40 mg every 12 h (if ≥60 kg)</i>
<i>GFR 21–50 mL/min</i>	<i>15 mg orally every 12–24 h (if &lt;60 kg); 20 mg every 12–24 h (if ≥60 kg)</i>
<i>GFR 10–20 mL/min</i>	<i>15 mg orally every 24 h (if &lt;60 kg); 20 mg every 24 h (if ≥60 kg)</i>
<i>Hemodialysis</i>	<i>15 mg orally every 24 h (if &lt;60 kg); 20 mg every 24 h (if ≥60 kg); administer after hemodialysis on dialysis days.</i>
<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>30 mg orally every 12 h (if &lt;60 kg); 40 mg every 12 h (if ≥60 kg)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Streptomycin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Streptomycin

{Antibacterial; aminoglycoside}

<b>Usual initial dose:</b>	15 mg/kg (max 1,000 mg) IM
<b>Usual maintenance dose:</b>	15 mg/kg (max 1,000 mg) IM once daily or 25–30 mg/kg (max 1,500 mg) IM twice weekly
<b>Typical maximum dose:</b>	1,500 mg/day
<b>Proportion eliminated unchanged:</b>	90 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Extreme caution must be exercised in selecting a dosage regimen in the presence of preexisting renal insufficiency. In patients >60 years of age, the drug should be used at a reduced dosage due to increased risk of toxicity.*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>15 mg/kg (max 1,000 mg) IM or IV over 30 min every 24 h; after definite clinical improvement is noted—often within 2 weeks—dosage should be reduced to 750–1,000 mg IM given 2–3 times weekly, and if mycobacterial sputum smears are negative, streptomycin usually may be dropped from combination antimycobacterial treatment regimens.</i>
	<i>GFR 10–50 mL/min</i>	<i>15 mg/kg (max 1,000 mg) IM or IV over 30 min every 24–72 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>15 mg/kg (max 1,000 mg) IM or IV over 30 min every 72–96 h</i>
	<i>Hemodialysis</i>	<i>1,000 mg IM or IV over 30 min every 72–96 h; administer 500–1,000 mg IM after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>Add to dialysate qs 20–40 mg/L</i>
	<i>CRRT</i>	<i>15 mg/kg (max 1,000 mg) IM or IV over 30 min every 24–72 h; monitor levels.</i>

*Note: Renal function should be monitored carefully; patients with renal impairment and/or nitrogen retention should receive reduced dosages.*

*The peak serum concentration in individuals with kidney disease should not exceed 20–25 mg/L, and trough concentrations generally should be ≤4 mg/L. Usual maximum total dose over a course of therapy is 120 g, unless no other therapeutic options exist.*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sulfadoxine and Pyrimethamine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Sulfadoxine and Pyrimethamine/** **Fansidar®**

**{Antimalarial}**

**Usual initial dose:**

*Treatment* of acute malaria (caution, drug resistance is common in some areas), two to three tablets (1,000–1,500 mg sulfadoxine/50–75 mg pyrimethamine) swallowed whole, not chewed, with plenty of fluids after a meal as a single dose; *prevention* of malaria (caution, not recommended due to risks of severe exfoliative dermatological reactions), one tablet (500 mg sulfadoxine/25 mg pyrimethamine) swallowed whole, not chewed, with plenty of fluids after a meal beginning 1 or 2 days before arrival in an endemic area

**Usual maintenance dose:**

Prevention of malarial—one tablet (500 mg sulfadoxine/25 mg pyrimethamine) orally once weekly or two tablets (1,000 mg sulfadoxine/50 mg pyrimethamine) orally every 2 weeks swallowed whole, not chewed, with plenty of fluids after a meal during the stay in an endemic area and continuing for 4–6 weeks after return

**Typical maximum dose:**

Three tablets (1,500 mg sulfadoxine/75 mg pyrimethamine)

**Proportion eliminated unchanged:**

Specific data not available; both sulfadoxine and pyrimethamine are eliminated mainly via the kidneys.

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Impaired renal function*

*The risk of toxic reactions may be greater in these patients.*

*Renal failure*

*Repeated prophylactic (prolonged) use is contraindicated.*

**Alternative adjustment:**

*Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sulfamethoxazole and Trimethoprim (Enteral) - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sulfamethoxazole and Trimethoprim (Enteral)/

Co-trimoxazole, TMP-SMX, Bactrim™, Septra®, Sulfatrim® {Antibacterial; sulfonamide}

<b>Usual initial dose:</b>	800/160 mg orally
<b>Usual maintenance dose:</b>	800/160 mg (1 DS tablet, 2 SS tablets, or 20-mL suspension) enterally every 12 h for 10–14 days
<b>Typical maximum dose:</b>	20 mg (trimethoprim)/kg/day
<b>Proportion eliminated unchanged:</b>	85 %/67 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Sulfamethoxazole and trimethoprim dosage for patients with impaired renal function*

<i>CrCL (mL/min)</i>	<i>Recommended dosage regimen</i>
<i>&gt;30</i>	<i>Usual standard regimen</i>
<i>15–30</i>	<i>One-half the usual regimen</i>
<i>&lt;15</i>	<i>Use not recommended</i>

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>800/160 mg enterally every 12 h for 10–14 days</i>  <i>Serious/life-threatening infections, 12–20 mg (trimethoprim)/kg/day in two to three divided doses</i>  <i>Prophylaxis of Pneumocystis carinii infection, 150 mg (trimethoprim)/m<sup>2</sup>/day in two divided doses on 3 consecutive days each week</i>
	<i>GFR 10–50 mL/min</i>	<i>800/160 mg enterally once followed by 400/80 mg enterally every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid unless no suitable alternative exists; if necessary, 800/160 mg enterally once followed by 400/80 mg enterally every 24 h</i>
	<i>Hemodialysis</i>	<i>800/160 mg enterally once followed by 400/80 mg enterally every 24 h; administer after hemodialysis on dialysis days.</i>
	<i>CAPD</i>	<i>800/160 mg enterally every 24 h or add parenteral sulfamethoxazole-trimethoprim to each bag of intraperitoneal dialysate to attain concentrations of sulfamethoxazole 80 mg/L and trimethoprim 16 mg/L three to four times daily for up to 2 weeks</i>
	<i>CRRT</i>	<i>2.5–7.5 mg (trimethoprim)/kg enterally every 12 h</i>

*Note: Some authorities suggest that due to attainment of low, potentially subtherapeutic drug concentrations in urine, sulfamethoxazole-trimethoprim should be avoided for the treatment of urinary tract infections in patients with GFR <50 mL/min/1.73 m<sup>2</sup>.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sulfamethoxazole and Trimethoprim (IV) - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Sulfamethoxazole and Trimethoprim (IV)/**

**Co-trimoxazole, TMP-SMX, Bactrim™, Septra® {Antibacterial}**

<b>Usual initial dose:</b>	10 mg (trimethoprim)/kg IV
<b>Usual maintenance dose:</b>	<i>Pneumocystis carinii pneumonia:</i> 5 mg (trimethoprim)/kg IV every 6–8 h (15–20 mg [trimethoprim]/kg/day) for 14–21 days  <i>Severe urinary tract infections and shigellosis:</i> 8–10 mg (trimethoprim)/kg/day IV in two to four equally divided doses for up to 14 days
<b>Typical maximum dose:</b>	20 mg (trimethoprim)/kg/day
<b>Proportion eliminated unchanged:</b>	85 %/67 %

### **Adjustment for Kidney Disease**

**FDA-approved product labeling:** *Sulfamethoxazole and trimethoprim dosage for patients with impaired renal function*

<i>CrCL (mL/min)</i>	<i>Recommended dosage regimen</i>
<i>&gt;30</i>	<i>Usual standard regimen</i>
<i>15–30</i>	<i>One-half the usual regimen</i>
<i>&lt;15</i>	<i>Use not recommended</i>

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>4–5 mg (trimethoprim)/kg IV every 6 h (16–20 mg [trimethoprim]/kg/day)</i>
	<i>GFR 10–50 mL/min</i>	<i>4–5 mg (trimethoprim)/kg IV every 12 h (8–10 mg [trimethoprim]/kg/day)</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid unless no suitable alternative exists; if necessary, 2.5–5 mg (trimethoprim)/kg IV every 24 h</i>
	<i>Hemodialysis</i>	<i>2.5–5 mg (trimethoprim)/kg IV every 24 h; administer after hemodialysis on dialysis days.</i>
	<i>CVVH</i>	<i>2.5–7.5 mg (trimethoprim)/kg IV every 12 h</i>
	<i>CVVHD</i>	<i>4–5 mg (trimethoprim)/kg IV every 6–8 h</i>
	<i>CVVHDF</i>	<i>4–5 mg (trimethoprim)/kg IV every 6–8 h</i>

*Note: Authorities suggest that due to attainment of low, potentially subtherapeutic drug concentrations in urine, sulfamethoxazole-trimethoprim should be avoided for the treatment of urinary tract infections in patients with GFR <50 mL/min/1.73 m<sup>2</sup>.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sunitinib - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Sunitinib/Sutent®

{Antineoplastic; tyrosine kinase and vascular endothelial growth factor (VEGF) inhibitor}

**Usual initial dose:**

50 mg orally

**Usual maintenance dose:**

*Gastrointestinal stromal tumor (GIST) or renal cell carcinoma (RCC)—50 mg orally once daily for 4 weeks on treatment followed by 2 weeks off*

*Progressive, well-differentiated pancreatic neuroendocrine tumor (pNET)—37.5 mg orally once daily continuously without a scheduled off-treatment period*

**Typical maximum dose:**

50 mg/day

**Proportion eliminated unchanged:**

<12 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Renal impairment*      *No dose modification is necessary in patients with diminished excretory kidney function, except as noted below.*

**Alternative adjustment:**      *CrCL ≥30 mL/min*      *GIST and RCC, 50 mg orally once daily for 4 weeks on treatment followed by 2 weeks off; pNET, 37.5 mg orally once daily continuously*

*CrCL <30 mL/min*      *GIST and RCC, 50 mg orally once daily for 4 weeks on treatment followed by 2 weeks off; pNET, 37.5 mg orally once daily continuously (no change)*

*Hemodialysis*      *GIST and RCC, 50 mg orally once daily for 4 weeks on treatment followed by 2 weeks off; pNET, 37.5 mg orally once daily continuously; doses may be administered without regard to time of dialysis.*

*Note: Due to decreased systemic assimilation, total exposure to both sunitinib and its active metabolite may be diminished by approximately 50 % in patients receiving chronic hemodialysis as compared to those with normal renal function; in these patients, initial dosages should be the same as in those with normal kidneys, but subsequent doses may be gradually increased up to twofold (to 75–100 mg/day) based on overall patient tolerability.*



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## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tadalafil/Adcirca™** {Phosphodiesterase-5 enzyme inhibitor; R for pulmonary arterial hypertension}

**Usual initial dose:** 40 mg orally  
**Usual maintenance dose:** 40 mg orally once daily  
**Typical maximum dose:** 40 mg/day  
**Proportion eliminated unchanged:** 36 % (primarily as metabolites)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &gt;80 mL/min</i>	<i>40 mg orally once daily</i>
	<i>CrCL 51–80 mL/min</i>	<i>20 mg orally once daily; may increase to 40 mg once daily based on individual tolerability</i>
	<i>CrCL 31–50 mL/min</i>	<i>20 mg orally once daily; may increase to 40 mg once daily based on individual tolerability</i>
	<i>CrCL &lt;30 mL/min</i>	<i>Avoid</i>
	<i>Hemodialysis</i>	<i>Avoid</i>
	<i>CRRT</i>	<i>Data not available</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tamsulosin/Flomax®** {Adrenergic  $\alpha$ 1 blocker; R for benign prostatic hypertrophy}

**Usual initial dose:** 0.4 mg orally  
**Usual maintenance dose:** 0.4–0.8 mg orally once daily  
**Typical maximum dose:** 0.8 mg/day  
**Proportion eliminated unchanged:** 9 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL <math>\geq</math>10 mL/min</i>	<i>0.4–0.8 mg/day</i>
	<i>CrCL &lt;10 mL/min</i>	<i>Has not been studied in patients with end-stage renal disease</i>
<b>Alternative adjustment:</b>	<i>eCrCL <math>\geq</math>10 mL/min</i>	<i>0.4–0.8 mg/day</i>
	<i>eCrCL &lt;10 mL/min</i>	<i>0.4 mg/day</i>
	<i>Hemodialysis</i>	<i>0.4 mg/day (very limited data)</i>
	<i>CRRT</i>	<i>Not applicable; preferably avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tapentadol - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tapentadol/Nucynta<sup>®</sup>, Nucynta ER<sup>®</sup>** {Analgesic; opioid  $\mu$ -receptor agonist}

**Usual initial dose:** 50 mg orally

**Usual maintenance dose:** 50–100 mg orally every 4–6 h as necessary depending on pain intensity or 50 mg extended-release [ER] tablet orally every 12 h (opioid-naïve patients) or 100–250 mg orally every 12 h (patients currently receiving chronic opioid therapy)

**Typical maximum dose:** 600 mg/day

**Proportion eliminated unchanged:** 3 % (~80 % of the absorbed dose is eliminated in urine as pharmacologically inactive glucuronide metabolites)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Mild to moderate renal impairment</i>	<i>Tapentadol exposure increases in renal impairment; use with caution: (immediate-release/film-coated tablets) 50–100 mg orally every 4–6 h as necessary depending on pain intensity or (extended-release [ER] tablet) 50 mg orally every 12 h (for opioid-naïve patients) or 100–250 mg orally every 12 h (for patients currently receiving chronic opioid therapy)</i>
	<i>Severe renal impairment</i>	<i>Use not recommended due to lack of data in this population</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Telavancin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Telavancin/Vibativ™** {Antibacterial; glycopeptide}

**Usual initial dose:** 10 mg/kg IV  
**Usual maintenance dose:** 10 mg/kg IV every 24 h  
**Typical maximum dose:** 15 mg/kg/day  
**Proportion eliminated unchanged:** 76 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Televancin dosage adjustment in adult patients with renal impairment*

CrCL (mL/min)	Telavancin dosage
>50	10 mg/kg every 24 h
30–50	7.5 mg/kg every 24 h
10–29	10 mg/kg every 48 h
<10	Insufficient data to make specific dosage adjustment recommendations
Hemodialysis	Insufficient data to make specific dosage adjustment recommendations

### Alternative adjustment:

**GFR <10 mL/min** *Presently (January 2012), too few data are available to enable determination of appropriate dose levels. To increase its solubility, telavancin injection contains hydroxypropyl-β-cyclodextrin (HPCD)—as compared with patients without renal impairment, systemic clearance of this solvent has been shown to be significantly diminished, leading to accumulation. Until such time as clinical trial data are available to confirm safety, telavancin probably should be avoided in these patients*

**Hemodialysis** *Presently (February 2012), too few data are available to enable determination of appropriate dose levels. Following administration of 7.5 mg/kg IV, 6 % of the administered dose was recovered in dialysate following 4 h of hemodialysis. In vitro experiments have shown that continuous hemodialysis may be sufficient to prevent HPCD accumulation*

**CRRT** *Presently (February 2012), too few data are available to enable determination of appropriate dose levels. A bovine blood model using a polysulfone hemodiafilter reported a mean telavancin sieving coefficient ranging from 0.25 to 0.31. In vitro experiments have shown that CRRT may be sufficient to prevent HPCD accumulation*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Telithromycin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Telithromycin/Ketek®

{Antibacterial; ketolide}

<b>Usual initial dose:</b>	800 mg orally
<b>Usual maintenance dose:</b>	800 mg orally once every 24 h for 7–10 days
<b>Typical maximum dose:</b>	800 mg/day
<b>Proportion eliminated unchanged:</b>	18 % in healthy subjects, 6 % in patients with severe renal impairment

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL <math>\geq 30</math> mL/min</i>	<i>800 mg orally once every 24 h for 7–10 days</i>
	<i>CrCL <math>&lt; 30</math> mL/min</i>	<i>600 mg orally once daily</i>
	<i>CrCL <math>&lt; 30</math> mL/min with coexisting hepatic impairment</i>	<i>400 mg orally once daily</i>
	<i>Hemodialysis</i>	<i>600 mg orally once daily; administer after hemodialysis on dialysis days</i>
<b>Alternative adjustment:</b>	<i>GFR <math>&gt; 50</math> mL/min</i>	<i>800 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>800 mg orally once daily (no adjustment needed)</i>
	<i>GFR <math>&lt; 10</math> mL/min</i>	<i>600 mg orally once daily (no adjustment needed)</i>
	<i>Hemodialysis</i>	<i>600 mg orally once daily; administer after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>Data not available</i>
<i>CRRT</i>	<i>800 mg orally once daily (no adjustment needed unless clearance <math>&lt; 30</math> mL/min, then 600 mg orally once daily)</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tenofovir - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tenofovir/Viread®** {Antiretroviral; nucleoside reverse transcriptase inhibitor}

**Usual initial dose:** 300 mg orally  
**Usual maintenance dose:** 300 mg orally once daily  
**Typical maximum dose:** 300 mg/day  
**Proportion eliminated unchanged:** 75 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Tenofovir dosage adjustment for patients with altered creatinine clearance*

<i>CrCL (mL/min)</i>	<i>Tenofovir dosage</i>
$\geq 50$	300 mg every 24 h
30–49	300 mg every 48 h
10–29	300 mg every 72–96 h
<10	No data
Hemodialysis	300 mg every 7 days or after ~12 h of hemodialysis
CRRT	No data

<b>Alternative adjustment:</b> <i>GFR &gt;50 mL/min</i>	300 mg orally every 24 h
<i>GFR 30–50 mL/min</i>	Preferably avoid unless no suitable alternative exists; if indeed necessary, 300 mg orally every 48 h
<i>GFR 10–29 mL/min</i>	Preferably avoid unless no suitable alternative exists; if indeed necessary, 300 mg orally every 72–96 h
<i>GFR &lt;10 mL/min</i>	Data not available
Hemodialysis	Preferably avoid unless no suitable alternative exists; if indeed necessary, 300 mg orally every 7 days or after ~12 h of emodialysis
CAPD	Data not available
CRRT	Data not available

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Terbinafine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Terbinafine/Lamisil®**

{Antifungal}

**Usual initial dose:** 250 mg orally

**Usual maintenance dose:** 250 mg orally once daily for 6 weeks (fingernail onychomycosis) or 12 weeks (toenail onychomycosis)

**Typical maximum dose:** 500 mg/day

**Proportion eliminated unchanged:** Nil (80 % of an absorbed dose is eliminated in urine as metabolites with minimal antifungal activity)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** CrCL <50 mL/min

*The clearance of terbinafine is decreased by approximately 50 % compared to normal volunteers*

**Alternative adjustment:** SCr >300 µmol/L (>3.6 mg/dL)

*125 mg orally once daily for 6–12 weeks*

*Note: Limited data suggest that terbinafine may be successfully used in renal transplant recipients with stable renal function and superficial or certain invasive fungal infections in doses of 250 mg orally once daily (monitor for liver function and possible drug-drug interactions with immunosuppressants, antidepressants, and other medicines)*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Terbutaline - Selected References

- Andersson K-E, Nyberg L. Pharmacokinetics of terbutaline therapy. *Eur J Respir Dis.* 1984;65(Suppl 134):165–70.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

<b>Terbutaline/Bricanyl®</b>	{Bronchodilator; $\beta_2$ -adrenergic agonist}
<b>Usual initial dose:</b>	0.25 mg subcutaneously or 5 mg orally
<b>Usual maintenance dose:</b>	0.25 mg subcutaneously; may repeat in 15–30 min or 5 mg orally every 6 h during three times daily during the hours that the patient is usually awake (reduce to 2.5 mg orally three times daily if side effects are particularly disturbing)
<b>Typical maximum dose:</b>	0.5 mg subcutaneously/4-h period or 15 mg/day orally
<b>Proportion eliminated unchanged:</b>	55 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *There are no reports of any clinical pharmacokinetic studies investigating dose proportionality, effect of food, or special population studies with terbutaline*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>0.25 mg subcutaneously; may repeat in 15–30 min or 17.5–30 <math>\mu</math>g/min continuous IV infusion or 5 mg orally every 6 h three times daily during the hours that the patient is usually awake (reduce to 2.5 mg orally three times daily if side effects are particularly disturbing)</i>
	<i>GFR 10–50 mL/min</i>	<i>0.125 mg subcutaneously; may repeat in 15–30 min or 8.75–15 <math>\mu</math>g/min continuous IV infusion (50 % decrease); avoid oral administration</i>
	<i>GFR &lt;10 mL/min</i>	<i>Data not available; preferably avoid</i>
	<i>Hemodialysis</i>	<i>7 <math>\mu</math>g/kg subcutaneously</i>
	<i>CAPD</i>	<i>Data not available; preferably avoid</i>
	<i>CRRT</i>	<i>0.25 mg subcutaneously; may repeat in 15–30 min or 17.5–30 <math>\mu</math>g/min IV; avoid oral administration</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tetracycline - Selected References

- Abramowicz M, Zuccotti G, Pflomm J-M, et al., editors. Handbook of antimicrobial therapy. 19th ed. New Rochelle: The Medical Letter; 2011.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tetracycline/Sumycin®, Aureomycin™ {Antibacterial}

<b>Usual initial dose:</b>	250 mg
<b>Usual maintenance dose:</b>	250–500 mg orally two to four times daily
<b>Typical maximum dose:</b>	2,000 mg/day
<b>Proportion eliminated unchanged:</b>	60 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *If renal impairment exists, even usual oral or parenteral doses may lead to excessive systemic accumulation of the drug and possible liver toxicity. Under such conditions, lower than usual total doses are indicated, and, if therapy is prolonged, serum level determinations of the drug may be advisable*

<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>250–500 mg orally every 8–12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 250–500 mg orally every 12–24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 250–500 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 250–500 mg orally every 24 h</i>
	<i>CAPD</i>	<i>Preferably avoid unless no suitable alternative exists; if indeed necessary, 250–500 mg orally every 24 h</i>
	<i>CRRT</i>	<i>Not applicable; avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Thiopental - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Thiopental/Pentothal<sup>®</sup>

{General anesthetic; antiepileptic; short-acting barbiturate}

**Usual initial dose:**

Rapid induction of anesthesia: 3–4 mg/kg IV in two to four fractional doses  
Seizures/refractory status epilepticus: 3–5 mg/kg IV followed by 1–2 mg/kg every 2–3 min until seizures are controlled (maximum 10 mg/kg)

Increased intracranial pressure in neurosurgical patients: 1.5–3.5 mg/kg IV

**Usual maintenance dose:**

Anesthesia: 25–50 mg IV as needed or whenever the patient moves

Seizures: 3–5 mg/kg/h as a continuous IV infusion

**Typical maximum dose:**

10 mg/kg

**Proportion eliminated unchanged:**

Minimal; pharmacologically inactive biotransformation products are eliminated in urine

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Renal dysfunction, increased blood urea nitrogen*

*Relatively contraindicated*

**Alternative adjustment:**

*GFR >50 mL/min*

*3–4 mg/kg IV*

*GFR 10–50 mL/min*

*3–4 mg/kg IV (100 % of usual dose)*

*GFR <10 mL/min*

*2–3 mg/kg IV (~75 % of usual dose)*

*Hemodialysis*

*Data not available*

*CAPD*

*Data not available*

*CRRT*

*3–4 mg/kg IV (100 % of usual dose)*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Ticarcillin and Clavulanate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Ticarcillin and Clavulanate/Timentin®** {Antibacterial; extended-spectrum penicillin/ $\beta$ -lactamase inhibitor}

**Usual initial dose:** 3.1 g IV  
**Usual maintenance dose:** 3.1 g IV every 4–6 h  
**Typical maximum dose:** 18.6 g/day  
**Proportion eliminated unchanged:** 70 %/45 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Ticarcillin/clavulanate administration in renal function impairment*

<i>CrCL (mL/min)</i>	<i>Dosage</i>
>60	3.1 g every 4 h
30–60	2 g every 4 h
10–30	2 g every 8 h
<10	2 g every 12 h
<10 with hepatic function impairment	2 g every 24 h
Peritoneal dialysis	3.1 g every 12 h
Hemodialysis	2 g every 12 h supplemented with 3.1 g after each dialysis

**Alternative adjustment:**

*GFR >50 mL/min* 3.1 g IV every 4 h or 9.3–12.4 g/24 h continuous IV infusion  
*GFR 10–50 mL/min* 3.1 g IV every 8–12 h  
*GFR <10 mL/min* 2 g IV every 12 h  
*Hemodialysis* 2 g IV every 12 h; administer supplemental 3.1 g IV after hemodialysis on dialysis days  
*CAPD* 3.1 g IV every 12 h or add to peritoneal dialysate qs 320 mg/L in each exchange for 10 days  
*CVVH* 2 g IV every 6–8 h  
*CVVHD* 3.1 g IV every 6–8 h  
*CVVHDF* 3.1 g IV every 6 h

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tiludronate/Skelid®** {Hypocalcemic agent; bisphosphonate; R for Paget's disease}

**Usual initial dose:** 400 mg orally  
**Usual maintenance dose:** 400 mg orally once daily 2 h before breakfast for 3 months  
**Typical maximum dose:** 800 mg/day  
**Proportion eliminated unchanged:** 60 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥30 mL/min</i>	<i>400 mg orally once daily before breakfast for 3 months</i>
	<i>CrCL &lt;30 mL/min</i>	<i>Not recommended due to lack of clinical experience</i>
<b>Alternative adjustment:</b>	<i>eCrCL ≥30 mL/min</i>	<i>400–600 mg orally once daily before breakfast for 3 months</i>
	<i>eCrCL &lt;30 mL/min</i>	<i>Data not available; preferably avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tinzaparin - Selected References

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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Tinzaparin/Innohep® {Antithrombotic; low-molecular-weight heparin}**

<b>Usual initial dose:</b>	175 units/kg subcutaneously
<b>Usual maintenance dose:</b>	175 units/kg subcutaneously every 24 h for at least 6 days and until the patient is adequately anticoagulated with warfarin and INR is at least 2.0 on two consecutive days
<b>Typical maximum dose:</b>	175 units/kg/day
<b>Proportion eliminated unchanged:</b>	90 %

***Adjustment for Kidney Disease***

<b>FDA-approved product labeling:</b>	<i>Renal insufficiency (CrCL &gt;60 mL/min)</i>	<i>Elderly patients and patients with renal insufficiency may show reduced elimination of tinzaparin. It should be used with care in these patients</i>
	<i>CrCL ≤ 60 mL/min</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>CrCL ≤ 60 mL/min</i>	<i>175 units/kg subcutaneously every 24 h</i>
	<i>Hemodialysis</i>	<i>To prevent thrombosis of the extracorporeal/access circuit, 75 units/kg IV just before each hemodialysis and, to provide continuous thromboprophylaxis, 75 units/kg subcutaneously once daily on off-dialysis days</i>  <i>For hemodialysis catheter lock, 2,000 units per catheter line</i>
		<i>Note: The above dose and/or route recommendations for use in patients with renal impairment are contrary to FDA-approved labeling. Although low-molecular-weight heparins generally are contraindicated in severe kidney disease, tinzaparin, with its higher-than-average molecular weight distribution and correspondingly reduced potential for bioaccumulation in patients with renal impairment, is a possible exception. In Europe, it is the number one most prescribed agent for prevention of access thrombosis. Discouraging, however, is the fact that a large-scale randomized trial (IRIS) that compared treatment of deep vein thrombosis in elderly patients with renal insufficiency with either tinzaparin or heparin was terminated prematurely due to a higher rate of mortality in the tinzaparin group (11.5 %) as compared to heparin (6.3 %, p = 0.035). The preponderance of death in tinzaparin-treated patients was not attributable to recurrent thrombosis or bleeding. Rather, the mortality difference appeared to be due to overrepresentation of cardiovascular disease, malignancy, serious infections, and leg paralysis in the tinzaparin group</i>
	<i>CRRT</i>	<i>Data not available</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tirofiban - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Tirofiban/Aggrastat®** {Glycoprotein IIb/IIIa antagonist; platelet aggregation inhibitor}

**Usual initial dose:** 0.4 mcg/kg/min IV for 30 min

**Usual maintenance dose:** 0.1 mcg/kg/min IV

**Typical maximum dose:** 0.1 mcg/kg/min

**Proportion eliminated unchanged:** 65 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL* ≥30 mL/min 0.4 mcg/kg/min IV for 30 min and then 0.1 mcg/kg/min  
*CrCL* <30 mL/min Patients with severe renal insufficiency should receive half the usual rate of infusion

**Alternative adjustment:** Acute coronary syndrome  
*eCrCL* <30 mL/min 0.2 mcg/kg/min IV for 30 min followed by 0.05 mcg/kg/min continuous IV infusion (50 % decrease); infusion should be continued through angiography and for 12–24 h after angioplasty, with IV heparin, according to the manufacturers' weight-based rate table for 50 mcg/mL infusion solutions

#### *Tirofiban dosage adjustment by weight*

Patient weight (kg)	Most patients ( <i>CrCL</i> ≥30 mL/min)		Severe renal impairment ( <i>CrCL</i> <30 mL/min)	
	30-min loading infusion rate (mL/h)	Maintenance infusion rate (mL/h)	30-min loading infusion rate (mL/h)	Maintenance infusion rate (mL/h)
30–37	16	4	8	2
38–45	20	5	10	3
46–54	24	6	12	3
55–62	28	7	14	4
63–70	32	8	16	4
71–79	36	9	18	5
80–87	40	10	20	5
88–95	44	11	22	6
96–104	48	12	24	6
105–112	52	13	26	7
113–120	56	14	28	7
121–128	60	15	30	8
129–137	64	16	32	8
138–145	68	17	34	9
146–153	72	18	36	9

#### Platelet preservation in cardiogenic shock/CRRT

CVVHD 0.2 mcg/kg/min IV for 30 min followed by 0.05 mcg/kg/min continuous IV infusion (limited data)

#### Anticoagulation during cardiopulmonary bypass (CPB)

*eCrCL* <50 mL/min 10 mcg/kg IV bolus followed by 0.15 mcg/kg/min continuous IV infusion until 1 h before conclusion of CPB (limited data)

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tizanidine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tizanidine/Zanaflex®** {Antispasmodic;  $\alpha_2$ -adrenergic agonist}

**Usual initial dose:** 4 mg orally  
**Usual maintenance dose:** 8 mg orally every 6–8 h as necessary  
**Typical maximum dose:** 36 mg/day  
**Proportion eliminated unchanged:** 60 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL  $\geq$ 25 mL/min 8 mg orally every 6–8 h as necessary*  
*CrCL <25 mL/min Use with caution as clearance is reduced by more than 50 %. In these patients, during titration, the individual doses should be reduced. If higher doses are required, individual doses rather than dosing frequency should be increased. These patients should be monitored closely for the onset or increase in severity of the common adverse events (dry mouth, somnolence, asthenia, and dizziness) as indicators of potential overdose*

**Alternative adjustment:** *Hemodialysis 2 mg orally once daily; titrate according to response and tolerance*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tobramycin - Selected References

- Abramowicz M, Zuccotti G, Pflomm J-M, et al., editors. Handbook of antimicrobial therapy. 19th ed. New Rochelle: The Medical Letter; 2011.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

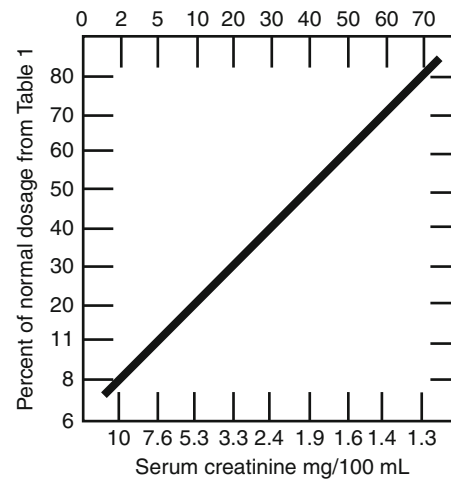
### Tobramycin/Nebcin®

{Antibacterial; aminoglycoside}

<b>Usual initial dose:</b>	2–7 mg/kg IV (actual body weight [ABW] or ideal [IBW] + 0.4(ABW – IBW) if ABW > IBW)
<b>Usual maintenance dose:</b>	3–5 mg/kg/day IV in two to three divided doses*
<b>Typical maximum dose:</b>	10 mg/kg/day
<b>Proportion eliminated unchanged:</b>	95 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** CrCL  $\leq 70$  mL/min *Following a loading dose (1 mg/kg), the amount of an adjusted dose can be determined by multiplying the normal dose (above) by the percent of normal dose (to be given in the usual two to three divided daily dose regimen) from the nomogram (Fig. 19.1)*



**Fig. 19.1** Reduced dosage nomogram. Scales have been adjusted to facilitate dosage calculations

<b>Alternative adjustment:</b>	GFR $> 50$ mL/min	2–2.5 mg/kg IV once followed by 1.7 mg/kg every 8–12 h or 4–7 mg/kg (9 mg/kg lean body mass in obese patients) IV every 24 h*
	GFR 10–50 mL/min	2–2.5 mg/kg IV once followed by 1.7 mg/kg IV every 24–48 h* (if pre-dose plasma level is within desired range, usually $\leq 1$ mg/L)*
	GFR $< 10$ mL/min	1.7 mg/kg IV every 72 h (if pre-dose plasma level is within desired range, usually $\leq 1$ mg/L)*
	Hemodialysis	1–1.7 mg/kg IV at the end of each dialysis (if pre-dose plasma level is within desired range, usually $\leq 1$ mg/L) or 1.5 mg/kg IV given within the first 30 min of high-flux hemodialysis*
	CAPD	Add to dialysate qs 4–8 mg/L for multiple exchanges or add 5 mg/kg to a single exchange dwelled for a minimum of 6 h*
	CVVHD or CVVHDF	1.5–2.5 mg/kg IV every 24–48 h (if pre-dose plasma level is within desired range, usually $\leq 1$ mg/L)*

### \*Therapeutic drug monitoring

<b>Therapeutic plasma levels:</b>	Peak:	6–10 mg/L (conventional dosing)
	Trough:	$< 2$ mg/L; patients on extended-interval dosing generally should be re-dosed when levels fall below 1 mg/L

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tolmetin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

<b><u>Tolmetin/Tolectin</u></b> <sup>®</sup>	{Anti-inflammatory; analgesic; nonsteroidal anti-inflammatory drug}
<b>Usual initial dose:</b>	400 mg orally
<b>Usual maintenance dose:</b>	400–600 mg orally three times daily
<b>Typical maximum dose:</b>	1,800 mg/day
<b>Proportion eliminated unchanged:</b>	10 % (plus 72 % of each absorbed dose as the primary oxidative metabolite)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Acute interstitial nephritis, with hematuria and proteinuria, and occasionally nephritic syndrome has been reported in patients treated with tolmetin. Renal toxicity also has been seen in patients in whom renal prostaglandins have a compensatory role in the maintenance of renal perfusion. In these patients, administration of an NSAID may cause a dose-dependent reduction in prostaglandin formation and, secondarily, in renal blood flow, which may precipitate overt renal decompensation. Patients at greatest risk of this reaction are those with impaired renal function, heart failure, and liver dysfunction, those taking diuretics and ACE inhibitors, and the elderly*

*Advanced renal disease*    *No information is available; use is not recommended*

**Alternative adjustment:**

*GFR >50 mL/min*    *400 mg orally three times daily*

*GFR 10–50 mL/min*    *400 mg orally three times daily*

*GFR <10 mL/min*    *400 mg orally three times daily*

*Hemodialysis*    *Data not available*

*CAPD*    *Data not available*

*CRRT*    *Not applicable; preferably avoid*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tolterodine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tolterodine/Detrol**<sup>®</sup> {Anticholinergic agent; Ⓡ for overactive bladder or urge incontinence}

**Usual initial dose:** 2 mg orally

**Usual maintenance dose:** 1–2 mg orally twice daily or 2–4 mg LA orally once daily

**Typical maximum dose:** 4 mg/day

**Proportion eliminated unchanged:** 1–2 % (plus 3–12 % of the absorbed dose as active oxidative metabolite)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥30 mL/min</i>	<i>1–2 mg orally twice daily or 2–4 mg LA once daily</i>
	<i>CrCL 10–30 mL/min</i>	<i>1 mg twice daily or 2 mg LA once daily</i>
	<i>CrCL &lt;10 mL/min</i>	<i>No data; use not recommended</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tolvaptan - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tolvaptan/Samsca™** {Vasopressin receptor antagonist; R for hypovolemic/euvolemic hyponatremia}

**Usual initial dose:** 15 mg orally once daily

**Usual maintenance dose:** 30–60 mg orally once daily

**Typical maximum dose:** 60 mg/day

**Proportion eliminated unchanged:** 1 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL ≥80 mL/min</i>	<i>15–60 mg orally once daily</i>
	<i>CrCL 10–79 mL/min</i>	<i>15–60 mg orally once daily</i>
	<i>CrCL &lt;10 mL/min</i>	<i>No data, not recommended</i>
	<i>Hemodialysis</i>	<i>No data, not recommended</i>
	<i>Anuria</i>	<i>Contraindicated; no benefit can be expected</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Topiramate - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Topiramate/Topamax®** {Antiepileptic; adjunctive analgesic; R for alcoholism or migraine}

**Usual initial dose:** 25 mg orally twice daily  
**Usual maintenance dose:** 100–200 mg orally twice daily (epilepsy) or 50 mg orally twice daily (migraine)  
**Typical maximum dose:** 1,600 mg/day  
**Proportion eliminated unchanged:** 70 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *The major route of elimination of unchanged topiramate and its metabolites is via the kidney. Dosage adjustment may be required in patients with reduced renal function.*

*CrCL ≤70 mL/min* 50–100 mg orally twice daily (epilepsy) or 25 mg orally twice daily (migraine) (50 % decrease)

*Hemodialysis* A supplemental dose of topiramate may be required. The actual adjustment should take into account (1) the duration of dialysis period, (2) the clearance rate of the dialysis system being used, and (3) the effective clearance of topiramate in the patient being dialyzed

**Alternative adjustment:**

*GFR >50 mL/min* 200 mg orally every 12 h  
*GFR 10–50 mL/min* 100 mg orally every 12 h (50 % decrease)  
*GFR <10 mL/min* 25–50 mg enterally every 12 h (75 % decrease)  
*Hemodialysis* 50 mg orally every 12 h; dose after hemodialysis on dialysis days (50 % decrease)  
*CAPD* 25–50 mg orally every 12 h (75 % decrease)  
*CVVHDF* 100–200 mg enterally every 12 h

## **Dosage Adjustment of Medications Eliminated by the Kidneys**

### **Topotecan (Oral) - Selected References**

Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.

Brogden RN, Wiseman LR. Topotecan: a review of its potential in advanced ovarian cancer. *Drugs*. 1998;56:709–23.

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Herben VMM, ten Bokkel Huinink WW, Beijnen JH. Clinical pharmacokinetics of topotecan. *Clin Pharmacokinet*. 1996;31:85–102.

Hycamtin® capsule [package insert]. Research Triangle Park: GlaxoSmithKline; 2011.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Topotecan (Oral)/Hycamtin®** {Antineoplastic; topoisomerase inhibitor}

**Usual initial dose:** 2.3 mg/m<sup>2</sup>

**Usual maintenance dose:** 2.3 mg/m<sup>2</sup> orally once daily for five consecutive days repeated every 21 days

**Typical maximum dose:** 2.3 mg/m<sup>2</sup>/day

**Proportion eliminated unchanged:** 20 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 50–80 mL/min</i>	<i>2.3 mg/m<sup>2</sup> orally once daily for five consecutive days repeated every 21 days</i>
	<i>CrCL 30–49 mL/min</i>	<i>1.8 mg/m<sup>2</sup> orally once daily for five consecutive days repeated every 21 days</i>
	<i>CrCL &lt;30 mL/min</i>	<i>Insufficient data are available to provide a dosage recommendation; risk of toxic reactions may be greater in patients with impaired renal function</i>

**Alternative adjustment:** *Data not available*

*Note: Hematological and other considerations may suggest further dosage adjustments.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Topotecan (IV) - Selected References

Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.

Brogden RN, Wiseman LR. Topotecan: a review of its potential in advanced ovarian cancer. *Drugs*. 1998;56:709–23.

Dennis MJ, Beijnen JH, Grochow LB, van Warmerdam LJC. An overview of the clinical pharmacology of topotecan. *Semin Oncol*. 1997;24(Suppl 5):S5–12.

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van Warmerdam LJC, Verweij J, Schellens JHM, et al. Pharmacokinetics and pharmacodynamics of topotecan administered daily for 5 days every 3 weeks. *Cancer Chemother Pharmacol*. 1995;35:237–45.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Topotecan (IV)/Hycamtin® IV** {Antineoplastic; topoisomerase inhibitor}

**Usual initial dose:** 1.5 mg/m<sup>2</sup> IV

**Usual maintenance dose:** 1.5 mg/m<sup>2</sup> IV daily for five consecutive days, starting on day 1 of a 21-day course (ovarian cancer, non-small cell lung cancer); in the absence of tumor progression, a minimum of four courses is recommended

**Typical maximum dose:** 1.5 mg/m<sup>2</sup>/day

**Proportion eliminated unchanged:** 50 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** CrCL 40–60 mL/min 1.5 mg/m<sup>2</sup> IV daily for five consecutive days, starting on day 1 of a 21-day course (ovarian cancer, non-small cell lung cancer) (no change/adjustment needed)

CrCL 20–39 mL/min 0.75 mg/m<sup>2</sup> IV daily for five consecutive days starting on day 1 of a 21-day course (cervical cancer or ovarian cancer, non-small cell lung cancer)

CrCL <20 mL/min Insufficient data are available to provide a dosage recommendation

**Alternative adjustment:** GFR 40–59 mL/min 1–1.5 mg/m<sup>2</sup> IV daily for 5 consecutive days starting on day one of a 21-day course (extensively pretreated patients may require further dose reductions)

GFR 20–39 mL/min 0.5–1 mg/m<sup>2</sup> IV daily for 5 consecutive days starting on day one of a 21-day course (extensively pretreated patients may require further dose reductions)

GFR <20 mL/min Data not available; preferably avoid

Hemodialysis Data not available; preferably avoid

CAPD Data not available; preferably avoid

CRRT 0.75 mg/m<sup>2</sup> IV on days 1, 2, and 3 followed by cisplatin on day 1 repeated every 21 days

*Note: Hematological and other considerations may suggest further dosage adjustments*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tositumomab and <sup>131</sup>I-Tositumomab - Selected References

Bexxar<sup>®</sup> dosimetric and therapeutic kit [package insert]. Seattle: Corixa Corp, 2004.

Davies AJ. A review of tositumomab and I<sup>131</sup> tositumomab radioimmunotherapy for the treatment of follicular lymphoma. *Expert Opin Biol Ther.* 2005;5:577–88.

Kaminski MS, Tuck M, Estes J, et al. <sup>131</sup>I-tositumomab therapy as initial treatment for follicular lymphoma. *N Engl J Med.* 2005;352:441–9.

Kaminski MS, Radford JA, Gregory SA, et al. Re-treatment with I-131 tositumomab in patients with non-Hodgkin's lymphoma who had previously responded to I-131 tositumomab. *J Clin Oncol.* 2005;23:7985–93.

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Scheidhauer K, Wolf I, Baumgartl H-J, et al. Biodistribution and kinetics of <sup>131</sup>I-labelled anti-CD20 MAB IDEC-C2B8 (rituximab) in relapsed non-Hodgkin's lymphoma. *Eur J Nucl Med.* 2002;29:1276–82.

Wahl RL. Tositumomab and <sup>131</sup>I therapy in non-Hodgkin's lymphoma. *J Nucl Med.* 2005;46(Suppl):128–40.

## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tositumomab and <sup>131</sup>I-Tositumomab/Bexxar®** {Antineoplastic; monoclonal antibody; radiopharmaceutical}

**Usual initial dose:** Dosimetric step—450 mg IV (tositumomab) and 35 mg IV (<sup>131</sup>I-tositumomab)

**Usual maintenance dose:** Therapeutic step—450 mg IV (tositumomab) and 35 mg IV (<sup>131</sup>I-tositumomab) with detailed adjustment according to gamma camera dose calibrator procedures and biodistribution studies

**Typical maximum dose:** 450 mg IV (tositumomab) and 35 mg IV (<sup>131</sup>I-tositumomab)

**Proportion eliminated unchanged:** 98 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*<sup>131</sup>I- tositumomab and iodine-131 are excreted primarily by the kidneys. Impaired renal function may decrease the rate of excretion of the radiolabeled iodine and increase patient exposure to the radioactive component of the tositumomab and <sup>131</sup>I-tositumomab therapeutic regimen. There are no data regarding the safety of administration of the tositumomab and <sup>131</sup>I-tositumomab therapeutic regimen in patients with impaired renal function*

**Alternative adjustment:**

*Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tramadol - Selected References

- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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- Quetglas EG, Azanza R, Cardenas E, Sádaba B, Campanero MA. Stereoselective pharmacokinetic analysis of tramadol and its main phase I metabolites in healthy subjects after intravenous and oral administration of racemic tramadol. *Biopharm Drug Dispos*. 2007;28:19–33.
- Sachdeva DK, Jolly BT. Tramadol overdose requiring prolonged opioid antagonism [letter]. *Am J Emerg Med*. 1997;15:217–8.
- Scott LJ, Perry CM. Tramadol: a review of its use in postoperative pain. *Drugs*. 2000;60:139–76.
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- Ultram® tablet, coated [package insert]. Raritan: PriCara Division of Ortho-McNeil-Janssen Pharmaceuticals Inc; 2009.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Tramadol/Ultram®**

{Analgesic, centrally acting}

**Usual initial dose:** 25 mg orally

**Usual maintenance dose:** 25 mg orally every morning, increasing by 25 mg/day every 3 days to 100 mg/day (25 mg orally four times daily); thereafter, the total daily dose may be increased by 50 mg as tolerated every 3 days to reach 200 mg/day (50 mg four times daily); after titration, 50–100 mg can be administered *prn* for pain relief every 4–6 h, not to exceed 400 mg/day

**Typical maximum dose:** 400 mg/day

**Proportion eliminated unchanged:** 95 %

### **Adjustment for Kidney Disease**

**FDA-approved product labeling:** *Impaired renal function results in a decreased rate and extent of excretion of tramadol and its active metabolite*

*CrCL <30 mL/min* 50–100 mg orally every 12 h as needed; maximum 200 mg/day

*Hemodialysis* 50–100 mg orally every 12 h as needed; maximum 200 mg/day; dose after hemodialysis on dialysis days

**Alternative adjustment:** *GFR >50 mL/min* 50–100 mg orally every 4–6 h as needed for pain relief, not to exceed 400 mg/day

*GFR 10–50 mL/min* 50–100 mg orally every 6–12 h as needed for pain

*GFR <10 mL/min* 50 mg orally every 12 h as needed for pain

*Hemodialysis* 50 mg orally every 12 h as needed for pain; administer after hemodialysis on dialysis days

*CAPD* 50 mg orally every 12 h as needed for pain

*CRRT* Not applicable; preferably avoid

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Trandolapril - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Trandolapril/Mavik®

{Antihypertensive, vasodilator, angiotensin converting enzyme (ACE)/renin inhibitor}

<b>Usual initial dose:</b>	1 mg orally once daily in nonblack and 2 mg orally once daily in black patients
<b>Usual maintenance dose:</b>	2–4 mg orally once daily
<b>Typical maximum dose:</b>	8 mg/day
<b>Proportion eliminated unchanged:</b>	33 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt; 30 mL/min</i>	<i>Recommended starting dose is 0.5 mg daily; subsequently titrate to the optimal response</i>
<b>Alternative adjustment:</b>	<i>GFR &gt; 50 mL/min</i>	<i>1–4 mg orally once daily</i>
	<i>GFR 10–50 mL/min</i>	<i>0.5–4 mg orally once daily</i>
	<i>GFR &lt; 10 mL/min</i>	<i>0.5–2 mg orally once daily (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>0.5–2 mg orally once daily (50 % decrease)</i>
	<i>CAPD</i>	<i>0.5–2 mg orally once daily (50 % decrease)</i>
	<i>CRRT</i>	<i>1–4 mg orally once daily</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tranexamic Acid - Selected References

- Al Ameen T, West M. Tranexamic acid treatment of life-threatening hematuria in polycystic kidney disease. *Int J Nephrol*. 2011;2011:203579. doi: [10.4061/2011/203579](https://doi.org/10.4061/2011/203579).
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tranexamic Acid/Lysteda®, Cyklokapron®

{Hemostatic agent; antifibrinolytic}

<b>Usual initial dose:</b>	1,300 mg orally or 10 mg/kg IV
<b>Usual maintenance dose:</b>	1,300 mg orally three times daily (max duration 5 days) or 10 mg/kg IV three to four times daily
<b>Typical maximum dose:</b>	3,900 mg/day orally
<b>Proportion eliminated unchanged:</b>	95 %

### *Adjustment for Kidney Disease*

#### **FDA-approved product labeling:**

*Tranexamic acid dosage adjustment for patients with renal impairment*

<i>SCr (mg/dL<sup>a</sup>)</i>	<i>Adjusted dose</i>	<i>Total daily dose (mg)</i>	<i>Maximum duration</i>
<i>&gt;1.4 to ≤2.8</i>	<i>1,300 mg twice daily</i>	<i>2,600</i>	<i>5 days</i>
<i>&gt;2.8 to ≤5.7</i>	<i>1,300 mg once daily</i>	<i>1,300</i>	<i>5 days</i>
<i>&gt;5.7</i>	<i>650 mg once daily</i>	<i>650</i>	<i>5 days</i>

<i>SCr (mg/dL<sup>a</sup>)</i>	<i>IV tranexamic acid dosage</i>
<i>1.36–2.83</i>	<i>10 mg/kg twice daily</i>
<i>2.83–5.66</i>	<i>10 mg/kg daily</i>
<i>&gt;5.66</i>	<i>10 mg/kg every 48 h or 5 mg/kg every 24 h</i>

<sup>a</sup>Not calibrated or traceable to isotope dilution mass spectrometry (IDMS) standards

#### **Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>10 mg/kg/dose IV three to four times daily</i>
<i>GFR 10–50 mL/min</i>	<i>6.25 mg/kg/dose IV three to four times daily (75 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>2.5 mg/kg/dose IV three to four times daily (90 % decrease)</i>
<i>Hemodialysis</i>	<i>Avoid unless no suitable alternative exists; if indeed necessary, 5 mg/kg IV every 24 h</i>
<i>CAPD</i>	<i>Avoid unless no suitable alternative exists; if indeed necessary, 5 mg/kg IV every 24 h</i>
<i>CRRT</i>	<i>6.25 mg/kg/dose IV up to four times daily (75 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Triamterene - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

<b><u>Triamterene/Dyrenium®</u></b>	<b>{Diuretic; potassium-sparing agent}</b>
<b>Usual initial dose:</b>	50 mg orally
<b>Usual maintenance dose:</b>	100 mg orally twice daily after meals
<b>Typical maximum dose:</b>	300 mg/day
<b>Proportion eliminated unchanged:</b>	4 % (plus 51 % of the absorbed dose as active primary hydroxylated sulfate conjugate metabolite)

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Severe or progressive kidney disease or anuria/ CrCL &lt;10 mL/min</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>50–150 mg every 12 h</i>
	<i>GFR 10–50 mL/min</i>	<i>Avoid due to risk for hyperkalemia and cardiac irregularities</i>
	<i>GFR &lt;10 mL/min</i>	<i>Avoid due to risk for hyperkalemia and cardiac irregularities</i>
	<i>Hemodialysis</i>	<i>Avoid due to risk for hyperkalemia and cardiac irregularities</i>
	<i>CAPD</i>	<i>Avoid due to risk for hyperkalemia and cardiac irregularities</i>
	<i>CRRT</i>	<i>Not applicable; avoid</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Trimethoprim - Selected References

- Ahlmén J, Brorson J-E. Pharmacokinetics of trimethoprim given in single daily doses for three days. *Scand J Infect Dis.* 1982;14:143–5.
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- Perazella MA. Trimethoprim-induced hyperkalemia: clinical data, mechanism, prevention and management. *Drug Saf.* 2000;22:227–36.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Trimethoprim/Primsol®, Proloprim®** {Antibacterial; purine biosynthesis blocker}

<b>Usual initial dose:</b>	100 mg orally
<b>Usual maintenance dose:</b>	100 mg orally every 12 h or 200 mg orally every 24 h for 10 days
<b>Typical maximum dose:</b>	15–20 mg/kg/day
<b>Proportion eliminated unchanged:</b>	75 %

#### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 15–30 mL/min</i>	<i>50 mg orally every 12 h</i>
	<i>CrCL &lt;15 mL/min</i>	<i>Not recommended</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>100 mg orally every 12 h or 200 mg orally every 24 h</i>
	<i>GFR 31–50 mL/min</i>	<i>100 mg orally every 12 h</i>
	<i>GFR 10–20 mL/min</i>	<i>100 mg orally every 12–24 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>100 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>100 mg orally every 24 h; administer after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>100 mg orally every 24 h</i>
	<i>CRRT</i>	<i>2.5–5 mg/kg enterally every 12 h (mild infections) or 10 mg/kg enterally every 12 h (severe infections)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Trimetrexate - Selected References

- Allegra CJ, Jenkins J, Weiss RB, et al. A phase I and pharmacokinetic study of trimetrexate using a 24-hour continuous-infection schedule. *Invest New Drugs*. 1990;8:159–66.
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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Trimetrexate/Neutrexin®** {Antiparasitic; folate antagonist; antineoplastic; R for *Pneumocystis carinii* pneumonia in immunocompromised patients}

**Usual initial dose:** 45 mg/m<sup>2</sup> IV  
**Usual maintenance dose:** 45 mg/m<sup>2</sup> IV once daily over 60 min (must be administered with concurrent leucovorin protection)  
**Typical maximum dose:** 45 mg/m<sup>2</sup>/day  
**Proportion eliminated unchanged:** 30 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>SCr &gt;2.5 mg/dL</i>	<i>Interrupt therapy; avoid</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>45 mg/m<sup>2</sup> IV every 24 h (with concurrent leucovorin)</i>
	<i>GFR 10–50 mL/min</i>	<i>Data not available</i>
	<i>GFR &lt;10 mL/min:</i>	<i>Avoid due to risk for hematological toxicity</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>Data not available</i>

*Note: Hematological and other considerations may suggest further dosage adjustments*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Tromethamine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Tromethamine/THAM®** {Alkalinizing agent; H<sup>+</sup> acceptor}

**Usual initial dose:** 300–700 mL IV (total mL equivalent to weight [kg] × base deficit [mEq/L] × 1.1)

**Usual maintenance dose:** 500–1,000 mL IV

**Typical maximum dose:** 15 mL/kg/h (~1,100 mL over 1 h)

**Proportion eliminated unchanged:** 75 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal disease or reduced urinary output</i>	<i>Extreme care should be exercised because of potential hyperkalemia and the possibility of decrease of excretion of tromethamine. Use cautiously with electrocardiographic monitoring and frequent serum potassium determinations</i>
	<i>Uremia and anuria</i>	<i>Contraindicated</i>
<b>Alternative adjustment:</b>	<i>Data not available</i>	

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Trospium - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Trospium/Sanctura**<sup>®</sup> {Anticholinergic agent; R for overactive bladder or urge incontinence}

**Usual initial dose:** 20 mg orally

**Usual maintenance dose:** 20 mg orally twice daily at least 1 h before meals or given on an empty stomach

**Typical maximum dose:** 60 mg/day

**Proportion eliminated unchanged:** 70 % of an absorbed dose (bioavailability ≈ 10 %)

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL <30 mL/min 20 mg orally once daily at bedtime*

**Alternative adjustment:** *Data not available*

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Valacyclovir - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Valacyclovir/Valtrex®** {Antiviral}

<b>Usual initial dose:</b>	1,000 mg orally
<b>Usual maintenance dose:</b>	500–1,000 mg orally two to three times daily
<b>Typical maximum dose:</b>	8,000 mg/day
<b>Proportion eliminated unchanged:</b>	46 %

#### *Adjustment for Kidney Disease*

#### **FDA-approved product labeling:** *Valacyclovir dosage recommendations for adults with renal impairment*

<i>Indications</i>	<i>Normal dosage regimen (CrCL ≥50 mL/min)</i>	<i>CrCL (mL/min)</i>		
		<i>30–49</i>	<i>10–29</i>	<i>&lt;10</i>
<i>Cold sores (Herpes labialis): do not exceed 1 day of treatment</i>	<i>Two 2-g doses taken 12 h apart</i>	<i>Two 1-g doses taken 12 h apart</i>	<i>Two 500-mg doses taken 12 h apart</i>	<i>500 mg single dose</i>
<i>Genital herpes: initial episode</i>	<i>1 g every 12 h</i>	<i>No reduction</i>	<i>1 g every 24 h</i>	<i>500 mg every 24 h</i>
<i>Genital herpes: recurrent episode</i>	<i>500 mg every 12 h</i>	<i>No reduction</i>	<i>500 mg every 24 h</i>	<i>500 mg every 24 h</i>
<i>Genital herpes: suppressive therapy</i>				
<i>Immunocompetent patients</i>	<i>1 g every 24 h</i>	<i>No reduction</i>	<i>500 mg every 24 h</i>	<i>500 mg every 24 h</i>
<i>Alternate dose for immunocompetent patients with recurrences/year</i>	<i>500 mg every 24 h</i>	<i>No reduction</i>	<i>500 mg every 48 h</i>	<i>500 mg every 48 h</i>
<i>HIV-infected patients</i>	<i>500 mg every 12 h</i>	<i>No reduction</i>	<i>500 mg every 24 h</i>	<i>500 mg every 24 h</i>
<i>Herpes zoster</i>	<i>1 g every 8 h</i>	<i>1 g every 12 h</i>	<i>1 g every 24 h</i>	<i>500 mg every 24 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;75 mL/min</i>	<i>1,000 mg orally every 8 h; 2,000 mg orally four times daily for prophylaxis of cytomegalovirus disease following kidney transplantation</i>		
	<i>GFR 51–75 mL/min</i>	<i>1,000 mg orally every 8–12 h; 1,500 mg orally four times daily for prophylaxis of cytomegalovirus disease following kidney transplantation</i>		
	<i>GFR 25–50 mL/min</i>	<i>1,000 mg orally every 12 h; 1,500 mg orally three times daily for prophylaxis of cytomegalovirus disease following kidney transplantation</i>		
	<i>GFR 10–24 mL/min</i>	<i>1,000 mg orally every 24 h; 1,500 mg orally two times daily for prophylaxis of cytomegalovirus disease following kidney transplantation</i>		
	<i>GFR &lt;10 mL/min</i>	<i>500 mg orally every 24 h; 1,500 mg orally every 24 h for prophylaxis of cytomegalovirus disease following kidney transplantation</i>		
	<i>Hemodialysis</i>	<i>500 mg orally every 24 h; dose after hemodialysis on dialysis days</i>		
	<i>CAPD</i>	<i>500 mg orally every 24 h</i>		
	<i>CRRT</i>	<i>Not applicable; (consider IV acyclovir)</i>		

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Valganciclovir - Selected References

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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Valganciclovir/Valcyte®** {Antiviral; nucleoside analog; R for cytomegalovirus}

- Usual initial dose:** 900 mg orally
- Usual maintenance dose:** 900 mg orally one to two times daily
- Typical maximum dose:** 1,800 mg/day
- Proportion eliminated unchanged:** 90 %

*Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Valganciclovir dose modifications in patients with impaired renal function*

<i>CrCL (mL/min)</i>	<i>Initial dosage</i>	<i>Maintenance/prevention dosage</i>
≥60	900 mg twice daily	900 mg once daily
40–59	450 mg twice daily	450 mg once daily
25–39	450 mg once daily	450 mg every 2 days
10–24	450 mg every 2 days	450 mg twice weekly
<10 (on hemodialysis)	Not recommended	Not recommended

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>900 mg orally twice daily (induction); 900 mg orally once daily (maintenance)</i>
<i>GFR 10–50 mL/min</i>	<i>450 mg orally every 24–48 h</i>
<i>GFR &lt;10 mL/min</i>	<i>450 mg orally twice weekly</i>
<i>Hemodialysis</i>	<i>Minimal data available; preferably avoid (consider IV ganciclovir)</i>
<i>CAPD</i>	<i>Minimal data available; preferably avoid</i>
<i>CVVHF</i>	<i>450 mg enterally every 48 h (consider IV ganciclovir)</i>

*Note: Following kidney transplantation, preemptive therapy and prophylaxis appear similarly effective for management of cytomegalovirus disease. Preliminary data suggest that prophylactic valganciclovir regimens as low as 450 mg orally once daily may be effective.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Vancomycin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Vancomycin/Vancocin® (IV)** {Antibacterial, glycopeptide bacterial cell wall biosynthesis inhibitor}

**Usual initial dose:** 25–30 mg/kg actual body weight IV  
**Usual maintenance dose:** 15–20 mg/kg IV every 8–12 h  
**Typical maximum dose:** 60 mg/kg/day  
**Proportion eliminated unchanged:** 90 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *Vancomycin dosage for patients with impaired renal function*

CrCL (mL/min)	Dose
100	1,545 mg per 24 h
90	1,390 mg per 24 h
80	1,235 mg per 24 h
70	1,080 mg per 24 h
60	925 mg per 24 h
50	770 mg per 24 h
40	620 mg per 24 h
30	465 mg per 24 h
20	310 mg per 24 h
10	155 mg per 24 h

**Alternative adjustment:** *Vancomycin initial dosage regimens for patients with impaired renal function*

eGFR (mL/min/1.73 m <sup>2</sup> )	Actual body weight (kg)			
	<60	60–80	81–100	>100
>90	750 mg q8h	1,000 mg q8h	1,250 mg q8h	1,500 mg q8h
50–90	750 mg q12h	1,000 mg q12h	1,250 mg q12h	1,000 mg q8h
15–49	750 mg q24h	1,000 mg q24h	1,250 mg q24h	1,500 mg q24h
<15, CRRT, hemodialysis	750 mg See below for dosing frequency	1,000 mg	1,250 mg	1,500 mg

#### Intermittent hemodialysis:

Give one dose at 15 mg/kg actual body weight (rounded to nearest 250 mg).

Check a random vancomycin level 2 h after hemodialysis.

If random level is ≤20 mcg/mL, repeat dose.

If random level is >20 mcg/mL, do not re-dose; repeat level after next dialysis.

Patients with eGFR <15, CRRT, or unstable renal function (e.g., acute renal failure):

Give one dose at 15 mg/kg actual body weight (rounded to nearest 250 mg).

Check a random vancomycin level 24 h after the dose.

If random level is ≤20 mcg/mL, repeat dose.

If random level is >20 mcg/mL, do not re-dose; repeat random level in 12 h.

#### Therapeutic monitoring:

Goal trough is 10–20 mcg/mL in general inpatient population.

Patients with pulmonary and CSF infections require higher troughs of 15–20 mcg/mL.

For patients dosed every 8–12 h, check trough 30 min prior to fourth dose.

For patients dosed every 24 h, check trough 30 min prior to third dose.

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Vandetanib - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Vandetanib/Caprelsa**<sup>®</sup> {Antineoplastic, tyrosine kinase [including epidermal growth factor receptor (EGFR), vascular endothelial growth factor (VEGF), and rearranged during transfection (RET)] inhibitor}

**Usual initial dose:** 300 mg orally

**Usual maintenance dose:** 300 mg orally once daily; tablets should be swallowed whole (not crushed) or, if they cannot be taken whole, tablets may be dispersed in a glass containing 60 mL of non-carbonated water and stirred for approximately 10 min (will not completely dissolve, no other liquids should be used, dispersion should be swallowed or instilled through nasogastric or gastrostomy tubes immediately, and any residues in the glass should be mixed again with an additional 120 mL of non-carbonated water and swallowed)

**Typical maximum dose:** 1,200 mg/day (increases in prevalence of QTc prolongation and other serious adverse effects are observed with doses >300 mg/day with minimal efficacy differences)

**Proportion eliminated unchanged:** 25 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** CrCL <50 mL/min

*Starting dose should be reduced to 200 mg orally once daily.*

**Alternative adjustment:** *Data not available*



## Dosage Adjustment of Medications Eliminated by the Kidneys

### Varenicline - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Varenicline/Chantix®** {Smoking cessation aid, nicotine  $\alpha_4\beta_2$ -receptor partial agonist}

**Usual initial dose:** 0.5 mg orally once daily after meals

**Usual maintenance dose:** Following a 1 week titration, 1 mg orally twice daily after meals

**Typical maximum dose:** 2 mg/day

**Proportion eliminated unchanged:** 92 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *CrCL <30 mL/min* 0.5 mg once daily titrated as needed to  
0.5 mg twice daily  
*Hemodialysis* 0.5 mg once daily

**Alternative adjustment:** *Data not available*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Venlafaxine - Selected References

- Amsterdam JD, Hooper MB, Amchin J. Once- versus twice-daily venlafaxine therapy in major depression: a randomized, double-blind study. *J Clin Psychiatry*. 1998;59:236–40.
- Aronoff GA, Bennett WM, Berns JS, et al. Drug prescribing in renal failure: dosing guidelines for adults and children. 5th ed. Philadelphia: American College of Physicians; 2007.
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**Dosage Adjustment of Medications Eliminated by the Kidneys**

**Venlafaxine/Effexor®** {Antidepressant; serotonin and norepinephrine reuptake inhibitor (SNRI)}

**Usual initial dose:** 75 mg/day administered in two or three divided doses or (XR capsules) once daily taken with food

**Usual maintenance dose:** 150–225 mg/day administered in two or three divided doses or (XR capsules) once daily taken with food

**Typical maximum dose:** 350 mg/day

**Proportion eliminated unchanged:** 5 % plus 29 % of each dose as active metabolite

*Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 10–70 mL/min</i>	<i>112.5–150 mg/day in two to three divided doses (25 % decrease)</i>
	<i>Hemodialysis</i>	<i>75–112.5 mg/day in two to three divided doses (50 % decrease)</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>37.5–225 mg (ER) orally every 24 h (~25 % decrease)</i>
	<i>GFR 10–50 mL/min</i>	<i>37.5–187.5 mg (ER) orally every 24 h (50 % decrease)</i>
	<i>GFR &lt;10 mL/min</i>	<i>37.5–187.5 mg (ER) orally every 24 h (50 % decrease)</i>
	<i>Hemodialysis</i>	<i>37.5–187.5 mg (ER) orally every 24 h (50 % decrease)</i>
	<i>CAPD</i>	<i>37.5–187.5 mg (ER) orally every 24 h (50 % decrease)</i>
	<i>CRRT</i>	<i>37.5–187.5 mg (ER) orally every 24 h (50 % decrease)</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Vigabatrin - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Vigabatrin/Sabril®** {Antiepileptic,  $\gamma$ -aminobutyric acid transaminase (GABA-T) inhibitor}

**Usual initial dose:** 500 mg twice orally daily  
**Usual maintenance dose:** 1,500 mg orally twice daily  
**Typical maximum dose:** 6,000 mg/day  
**Proportion eliminated unchanged:** 65 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>Renal impairment</i>	<i>A lower dose is necessary in patients with mild, moderate, and severe renal impairment.</i>
	<i>CrCL &gt;50 to 80 mL/min</i>	<i>1,125 mg orally twice daily (25 % decrease)</i>
	<i>CrCL &gt;30 to 50 mL/min</i>	<i>750 mg orally twice daily (50 % decrease)</i>
	<i>CrCL &gt;10 to &lt;30 mL/min</i>	<i>375 mg orally twice daily (75 % decrease)</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>1,000–2,000 mg orally every 24 h</i>
	<i>GFR 10–50 mL/min</i>	<i>1,000–2,000 mg orally every 48 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>1,000–2,000 mg orally every 48–72 h</i>
	<i>Hemodialysis</i>	<i>500 mg orally every 72 h; administer after hemodialysis on dialysis days</i>
	<i>CAPD</i>	<i>1,000–2,000 mg orally every 48–72 h</i>
	<i>CRRT</i>	<i>1,000–2,000 mg enterally every 48 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Voriconazole - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Voriconazole/VFEND®** {Antifungal; triazole ergosterol biosynthesis inhibitor}

**Usual initial dose:** 6 mg/kg IV every 12 h for the first 24 h or 200 mg orally

**Usual maintenance dose:** 4 mg/kg IV or 200 mg orally every 12 h

**Typical maximum dose:** 12 mg/kg/day

**Proportion eliminated unchanged:** <2 %

### Adjustment for Kidney Disease

**FDA-approved product labeling:** *CrCL <50 mL/min* Accumulation of the IV vehicle, sulfobutylether 7-beta-cyclodextrin (SBECD), occurs. Oral voriconazole should be administered to these patients, unless an assessment of the benefit/risk to the patient justifies the use of IV voriconazole. Serum creatinine levels should be monitored closely in these patients, and, if increases occur, consideration should be given to changing to oral voriconazole therapy.

*Because standard doses result in highly variable voriconazole exposure, monitoring plasma concentrations in seriously ill patients may be recommended to assure attainment of trough levels above inhibitory concentrations for most pathogenic fungi ( $\geq 1$  mg/L) and avoid toxicity.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>6 mg/kg IV for the first 24 h followed by 4 mg/kg IV every 12 h or 200 mg enterally every 12 h</i>
<i>GFR <math>\leq</math>50 mL/min</i>	<i>200 mg enterally every 12 h (avoid IV administration)</i>
<i>Hemodialysis</i>	<i>200 mg enterally every 12 h (IV administration not recommended)</i>
<i>CAPD</i>	<i>200 mg enterally every 12 h (avoid IV administration)</i>
<i>CVVH</i>	<i>400 mg enterally every 12 h for the first 24 h, then 4 mg/kg or 200 mg orally every 12 h or 6 mg/kg IV for the first 24 h followed by 4 mg/kg IV every 12 h (limited data suggest IV administration is safe, although possible vehicle accumulation was not studied)</i>
<i>CVVHD or CVVHDF</i>	<i>400 mg enterally every 12 h for the first 24 h, then 4 mg/kg or 200 mg orally every 12 h (IV administration not clinically confirmed as safe)</i>

*Note: Patients weighing <40 kg should receive half the usually recommended dose.*



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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Zalcitabine - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

**Zalcitabine/Hivid<sup>®</sup>, ddC** {Antiretroviral, nucleoside analog reverse transcriptase inhibitor}

**Usual initial dose:** 0.75 mg orally  
**Usual maintenance dose:** 0.75 mg orally every 8 h  
**Typical maximum dose:** 2.25 mg/day  
**Proportion eliminated unchanged:** 80 %

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL 10–40 mL/min</i>	<i>0.75 mg orally every 12 h</i>
	<i>CrCL &lt;10 mL/min</i>	<i>0.75 mg orally every 24 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>0.75 mg orally every 8 h</i>
	<i>GFR 10–50 mL/min</i>	<i>0.75 mg orally every 12 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>0.75 mg orally every 24 h</i>
	<i>Hemodialysis</i>	<i>Data not available</i>
	<i>CAPD</i>	<i>Data not available</i>
	<i>CRRT</i>	<i>0.75 mg orally every 12 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Zidovudine/Retrovir®

{Antiretroviral, nucleoside analog reverse transcriptase inhibitor}

<b>Usual initial dose:</b>	300 mg orally or 1 mg/kg IV over 1 h
<b>Usual maintenance dose:</b>	600 mg/day orally in divided doses (preferably fasting) or 1 mg/kg IV over 1 h every 4 h (five to six times daily)
<b>Typical maximum dose:</b>	600 mg/day orally or 6 mg/kg/day IV
<b>Proportion eliminated unchanged:</b>	14–29 % (plus 62 % of 2', 3'-dideoxy-5'-glucuronylthymidine metabolite [devoid of antiviral activity but perhaps associated with unwanted adverse effects])

### *Adjustment for Kidney Disease*

<b>FDA-approved product labeling:</b>	<i>CrCL &lt;15 mL/min</i>	<i>100 mg orally or 1 mg/kg IV every 6–8 h</i>
	<i>Hemodialysis</i>	<i>100 mg orally or 1 mg/kg IV every 6–8 h</i>
	<i>CAPD</i>	<i>100 mg orally or 1 mg/kg IV every 6–8 h</i>
<b>Alternative adjustment:</b>	<i>GFR &gt;50 mL/min</i>	<i>200 mg orally every 8 h</i>
	<i>GFR 10–50 mL/min</i>	<i>200 mg orally every 8 h</i>
	<i>GFR &lt;10 mL/min</i>	<i>100 mg orally every 8 h</i>
	<i>Hemodialysis</i>	<i>100 mg orally every 8 h</i>
	<i>CAPD</i>	<i>100 mg orally every 8 h</i>
	<i>CRRT</i>	<i>200 mg enterally every 8 h</i>

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Zoledronic Acid - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### **Zoledronic Acid/Reclast<sup>®</sup>, Zometa<sup>®</sup>** {Anti-osteoporotic, hypocalcemic agent; bisphosphonate}

<b>Usual initial dose:</b>	4–5 mg IV
<b>Usual maintenance dose:</b>	4 mg IV once weekly (hypercalcemia) or 4 mg IV every 3–4 weeks (bone metastases) or 5 mg IV once a year (osteoporosis/Paget's disease of bone)
<b>Typical maximum dose:</b>	5 mg/dose
<b>Proportion eliminated unchanged:</b>	39 %

#### *Adjustment for Kidney Disease*

**FDA-approved product labeling:** *Recommended zoledronic acid dose for patients with multiple myeloma and metastatic bone lesions with mild-to-moderate renal function impairment*

<i>CrCL (mL/min)</i>	<i>Recommended dose</i>
>60	4 mg IV every 3–4 weeks
50–60	3.5 mg IV every 3–4 weeks
40–49	3.3 mg IV every 3–4 weeks
30–39	3 mg IV every 3–4 weeks
<30 and/or acute renal impairment	Not recommended

#### *Osteoporosis/Paget's disease*

<i>CrCL ≥35 mL/min</i>	<i>5 mg IV over 15 min once a year</i>
<i>CrCL &lt;35 mL/min and/or evidence of acute renal impairment</i>	<i>Contraindicated</i>

#### **Alternative adjustment:**

*Definitive data not available*

*For osteoporosis, anecdotal data suggest that for patients with stage 3–5 chronic kidney disease (GFR <30 mL/min), dosages should be reduced by half (i.e., 2 mg IV once yearly), infusion rates should be slowed (i.e., infuse each dose over 60 min), and duration of treatment should be limited to not more than 3 years.*

## Dosage Adjustment of Medications Eliminated by the Kidneys

### Zonisamide - Selected References

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## Dosage Adjustment of Medications Eliminated by the Kidneys

### Zonisamide/Zonegran®

{Antiepileptic; sodium channel and voltage-dependent T-type Ca<sup>2+</sup> channel blocker}

<b>Usual initial dose:</b>	100 mg orally once daily
<b>Usual maintenance dose:</b>	200–400 mg/day orally in one or two divided doses
<b>Typical maximum dose:</b>	600 mg/day
<b>Proportion eliminated unchanged:</b>	35 %

### *Adjustment for Kidney Disease*

**FDA-approved product labeling:**

*Marked renal impairment (CrCL <20 mL/min) is associated with an increase in zonisamide exposure (AUC) of 35 %. Zonisamide therapy has been associated with a mean 8 % increase SCr and BUN over from baseline. Zonisamide should be discontinued in patients who develop acute renal failure or a clinically significant sustained increase in the SCr/BUN concentration. Patients with renal disease should be treated with caution and might require slower titration and more frequent monitoring.*

**Alternative adjustment:**

<i>GFR &gt;50 mL/min</i>	<i>50–300 mg orally twice daily (0–25 % decrease)</i>
<i>GFR 10–50 mL/min</i>	<i>50–200 mg orally twice daily (25 % decrease)</i>
<i>GFR &lt;10 mL/min</i>	<i>25–150 mg orally twice daily (50 % decrease)</i>
<i>Hemodialysis</i>	<i>4–8 mg/kg/day orally once daily in the evening; administer after hemodialysis on dialysis days</i>
<i>CAPD</i>	<i>25–150 mg orally twice daily (50 % decrease)</i>
<i>CRRT</i>	<i>50–200 mg enterally twice daily (25 % decrease)</i>

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 Solu-Cortef®/Hydrocortisone (NR)  
 Solu-Medrol®/Methylprednisolone (NR)  
 Soma®/Carisoprodol (NR)  
 Somatuline® Depot/Lanreotide, 385  
 Somavert®/Pegvisomant (NR)  
 Somnote®/Chloral hydrate, 149  
 Sonata®/Zaleplon (NR)  
 Soriatane® Acitretin, 15  
 Sorine®/Sotalolol, 637  
 Sotradecol®/Sodium Tetradecyl Sulfate (NR)  
 Spectracef®/Cefditoren, 113  
 Sporanox®/Itraconazole, 369  
 Sprycel®/Dasatinib (NR)  
 SSKI®/Potassium iodide (NR)

Stadol®/Butorphanol, 93  
 Starlix®/Nateglinide (NR)  
 Stelara®/Ustekinumab (NR)  
 Stelazine®/Trifluoperazine (NR)  
 Stendra™/Avanafil (NR)  
 Stimat®/Desmopressin, 205  
 Strattera®/Atomoxetine (NR)  
 Stromectol®/Ivermectin (NR)  
 Sublimaze®/Fentanyl (NR)  
 Subsys™/Fentanyl (NR)  
 Sucraid®/Sacrosidase (NR)  
 Sudafed®/Pseudoephedrine (NR)  
 Sufenta®/Sufentanil (NR)  
 Sular®/Nisoldipine (NR)  
 Sulfatrim®/Sulfamethoxazole and Trimethoprim, 647  
 Sumycin®/Tetracycline, 671  
 Supartz™/Hyaluronate (NR)  
 Suprane®/Desflurane (NR)  
 Suprax®/Cefixime, 117  
 Surmontil®/Trimipramine (NR)  
 Sutent®/Sunitinib, 651  
 Symlin®/Pramlintide (NR)  
 Sympt-X®/Glutamine (NR)  
 Synagis®/Palivizumab (NR)  
 Synarel®/Nafarelin (NR)  
 Synercid®/Quinupristin and Dalfopristin (NR)  
 Synthroid®/Levothyroxine (NR)  
 Synvisc®/Hyaluronate (NR)  
 Syprine®/Trientine (NR)

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Tabloid®/Thioguanine (NR)  
 Tagamet®/Cimetidine, 161  
 Talwin™/Pentazocine, 533  
 Tambocor™/Flecainide, 285  
 Tamiflu®/Oseltamivir, 503  
 Tapazole®/Methimazole (NR)  
 Tarceva™/Erlotinib (NR)  
 Targretin®/Bexarotene (NR)  
 Tassigna®/Nilotinib (NR)  
 Tasmal®/Tolcapone (NR)  
 Tavist®/Clemastine (NR)  
 Taxol®/Paclitaxel (NR)  
 Taxotere®/Docetaxel (NR)  
 Tazicef®/Ceftazidime, 131  
 Taztia®/Diltiazem (NR)  
 3TC/Lamivudine, 383  
 TDF/Tenofovir, 239  
 Teflaro™/Ceftaroline, 129  
 Tegretol®/Carbamazepine (NR)  
 Tekturna®/Aliskiren, 27  
 Temodar®/Temozolamide (NR)  
 Tenex®/Guanfacine (NR)  
 Tenormin®/Atenolol, 63  
 Tenuate®/Diethylpropion (NR)  
 Tessalon®/Benzonatate (NR)  
 Teveten®/Eprosartan (NR)  
 Thalitone®/Chlorthalidone, 157  
 Thalomid®/Thalidomide (NR)  
 Thorazine®/Chlorpromazine (NR)  
 Thrombate III®/Antithrombin III (NR)  
 Thymoglobulin®/Antithymocyte Globulin, Rabbit (NR)  
 Thyrogen®/Thyrotropin Alfa (NR)  
 Thyrolar®/Liotrix (NR)  
 Tiazac®/Diltiazem (NR)

Ticlid®/Ticlopidine (NR)  
 Tigan®/Trimethobenzamide (NR)  
 Tikosyn®/Dofetilide, 223  
 Timentin®/Ticarcillin/Clavulanate, 675  
 Tindamax®/Tinidazole (NR)  
 TMP-SMX/Sulfamethoxazole and Trimethoprim, 647, 649  
 TNKase®/Tenecteplase (NR)  
 Tofranil®/Imipramine (NR)  
 Tolinase®/Tolazamide (NR)  
 Tonojug™/Barium Sulfate (NR)  
 Tonopaque™/Barium Sulfate (NR)  
 Topamax®/Topiramate, 693  
 Toposar™/Etoposide, 265  
 Toprol-XL®/Metoprolol (NR)  
 Toradol®/Ketorolac, 377  
 Torisel®/Temozolimus (NR)  
 Totect®/Dexrazoxane, 209  
 Toviaz™/Fesoterodine (NR)  
 Tracleer®/Bosentan (NR)  
 Tradjenta™/Linagliptin (NR)  
 Trandate®/Labetalol (NR)  
 Transderm Scop®/Scopolamine (NR)  
 Tranxene®/Clorazepate (NR)  
 Treanda® Bendamustine, 81  
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 Trental®/Pentoxifylline, 537  
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 Trilisate®/Choline Magnesium Trisalicylate (NR)  
 Trisenox®/Arsenic Trioxide, 57  
 Trizivir®/Lamivudine/Zidovudine/Abacavir,  
 Truvada®/Emtricitabine/Tenofovir, 239  
 Tums®/Calcium Carbonate (NR)  
 Tygacil®/Tigecycline (NR)  
 Tykerb®/Lapatinib (NR)  
 Tylenol®/Acetaminophen, 9  
 Tysabri®/Natalizumab (NR)

## U

Uloric®/Febuxostat (NR)  
 Ultane®/Sevoflurane (NR)  
 Ultiva®/Remifentanyl (NR)  
 Ultram®/Tramadol, 701  
 Unasyn®/Ampicillin/Sulbactam, 51  
 Unipen®/Nafcillin (NR)  
 Uniphyll®/Theophylline (NR)  
 Unisom®/Doxylamine (NR)  
 Univasc®/Moexipril, 467  
 Urecholine®/Bethanechol (NR)  
 Urispas®/Flavoxate (NR)  
 Uro-Mag®/Magnesium Gluconate, 415  
 Uroxatral®/Alfuzosin, 25  
 Urso®/Ursodiol (NR)

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 Valium®/Diazepam (NR)  
 Valtrex®/Valacyclovir, 719  
 Valturna®/Aliskiren/Valsartan,  
 Vancocin® (IV)/Vancomycin, 723  
 Vantas™/Histrelin (NR)

Vantin®/Cefpodoxime, 125  
 Vaprisol®/Conivaptan, 181  
 Varivax®/Varicella Virus Vaccine (NR)  
 VariZIG™/Varicella-Zoster Immune Globulin (NR)  
 Vasotec®/Enalapril, 241  
 Vasotec® IV/Enalaprilat, 243  
 Vectibix®/Panitumumab (NR)  
 Velban®/Vinblastine (NR)  
 Velcade®/Bortezomib (NR)  
 Venofer®/Iron Sucrose (NR)  
 Ventavis®/Iloprost (NR)  
 Vermox®/Mebendazole (NR)  
 Versed®/Midazolam (NR)  
 Versenate®/Calcium Disodium/Edetate Calcium Disodium, 233  
 Vesanoïd®/Tretinoin (NR)  
 Vesicare®/Solifenacin, 633  
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 Viagra®/Sildenafil (NR)  
 Vibativ™/Telavancin, 661  
 Vibramycin®/Doxycycline (NR)  
 Vicodin®/Hydrocodone and Acetaminophen (NR)  
 Victoza®/Liraglutide (NR)  
 Victrelis™/Boceprevir (NR)  
 Videx® EC/Didanosine EC, 215  
 Viibryd™/Vilazodone (NR)  
 Vimpat®/Lacosamide, 381  
 Viracept®/Nelfinavir (NR)  
 Viramune®/Nevirapine (NR)  
 Virazole®/Ribavirin (Inhaled) (NR)  
 Viread®/Tenofovir, 665  
 Visipaque®/Iodixanol (NR)  
 Visken®/Pindolol (NR)  
 Vistaril®/Hydroxyzine (NR)  
 Vistide®/Cidofovir, 159  
 Visudyne®/Verteporfin (NR)  
 Vitamin B12/Cyanocobalamin (NR)  
 Vitamin B1/Thiamine (NR)  
 Vitamin C/Ascorbic acid (NR)  
 Vitamin D3/Cholecalciferol (NR)  
 Vivactil®/Protriptyline (NR)  
 Vivaglobin®/Immune Globulin (NR)  
 Vivotif®/Typhoid Vaccine (NR)  
 Voltaren®/Diclofenac, 213  
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 Voraxaze®/Glucarpidase (NR)  
 Votrient™/Pazopanib (NR)  
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 Vumon®/Teniposide (NR)  
 Vyvanse™/Lisdexamphetamine (NR)

**W**

WelChol®/Colesevelam (NR)  
 Wellbutrin®/Bupropion (NR)  
 Wycillin®/Penicillin G Procaine (NR)  
 Wytensin®/Guanabenz (NR)

**X**

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 Xenazine®/Tetrabenazine (NR)  
 Xgeva™/Denosumab (NR)  
 Xiaflex™/Collagenase Clostridium histolyticum injection (NR)  
 Xifaxan™/Rifaximin (NR)  
 Xigris®/Drotrecogin alfa (NR)  
 Xolair®/Omalizumab (NR)  
 Xylocaine®/Lidocaine (NR)  
 Xyrem®/Sodium Oxybate (NR)  
 Xyzal®/Levocetirizine, 393

**Y**

Yervoy™/Ipilimumab (NR)  
 Yocon®/Yohimbine (NR)  
 Yodoxin®/Iodoquinol (NR)

**Z**

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 Zantac® IV/Ranitidine (IV), 593  
 Zantac®/Ranitidine (Enteral), 591  
 Zarontin®/Ethosuximide (NR)  
 Zarontin®/Ethosuximide (NR)  
 Zaroxolyn®/Metolazone (NR)  
 Zavesca®/Miglustat, 461  
 Zebeta®/Bisoprolol, 85  
 Zegerid®/Omeprazole and Sodium Bicarbonate (NR)  
 Zelboraf™/Vemurafenib (NR)  
 Zemplar®/Paricalcitol (NR)  
 Zemuron®/Rocuronium (NR)  
 Zenapax®/Daclizumab (NR)  
 Zenpep®/Pancrelipase (NR)  
 Zerit®/Stavudine, 461  
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 Ziagen®/Abacavir (NR)  
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 Zithromax®/Azithromycin (NR)  
 Zocor®/Simvastatin (NR)  
 Zofran®/Ondansetron (NR)  
 Zoladex®/Goserelin (NR)  
 Zolinza®/Vorinostat (NR)  
 Zoloft®/Sertraline (NR)  
 Zometa®/Zoledronic Acid, 741  
 Zomig®/Zolmitriptan (NR)  
 Zonegran®/Zonisamide, 743  
 Zortress®/Everolimus (NR)  
 Zostavax®/Zoster Vaccine (NR)  
 Zosyn®/Piperacillin/Tazobactam, 551  
 Zovirax® (Enteral)/Acyclovir (Enteral), 19  
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 Zovirax® (Oral)/Acyclovir (Oral),  
 Zyflo®/Zileuton (NR)  
 Zyloprim®/Allopurinol, 29  
 Zyprexa®/Olanzapine (NR)  
 Zyrtec®/Cetirizine, 145  
 Zytiga™/Abiraterone (NR)  
 Zyvox®/Linezolid (NR)