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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 Cockroft-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 (CKDepi) equation [6] to calculate estimated glomerular filtration rate (eGFR) in mL/min/1.73 m^2 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.

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 Cockroft-Gault equation $CrCL = (140 - age) \times Weight/(72 \times SCr)$ 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 [$eGFR \times (1.73\ m^2/BSA)$]. 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 ^{125}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®
Abatacept/Orencia®
Abciximab/ReoPro®
Abiraterone/Zytiga™
AbobotulinumtoxinA/Dysport™
Acetylcysteine/Acetadote®
Adalimumab/Humira®
Adenosine/Adenocard®, Adenoscan®
Aflibercept (intravitreal)/Eylea™
Agalsidase beta/Fabrazyme®
Albendazole/Albenza®
Albumin/Albuminar®
Albuterol/Proventil®
Aldesleukin/Proleukin®
Alefacept/Amevive®
Alemtuzumab/Campath®
Alfentanil/Alfenta®
Alglucerase/Ceredase®
Alglucosidase alfa/Lumizyme™, Myozyme®
Alosetron/Lotronex®
$Alpha_1$-Proteinase Inhibitor ($Alpha_1$ Antitripsin)/Prolastin® C
Alpha galactosidase/Beano®
Alprazolam/Xanax®
Alprostadil/Caverject®
Alteplase/Activase®
Altretamine/Hexalen®
Aluminum hydroxide/Amphogel®, Alternagel®
Aluminum hydroxide and magnesium trisilicate or carbonate and alginic acid/Gaviscon®—Caution, contains small amounts of magnesium
Alvimopan/Entereg®
Ambenonium/Mytelase®
Ambrisentan/Letairis®
Amifostine/Ethyol®
Aminobenzoate potassium/Potaba®
Aminocaproic acid/Amicar®
Aminohippurate sodium
Aminolevulinic acid/Levulan®, Kerastick®
Aminophylline
Amiodarone/Cordarone®, Nexterone®
Amitriptyline/Elavil®
Amlodipine/Norvasc®
Amobarbital/Amytal®
Amoxapine/Asendin®
Amphotericin B/Fungizone®
Amphotericin B liposome/Ambisome®
Amyl nitrate
Anagrelide/Agrylin®
Anastrozole/Arimidex®
Anidulafungin/Eraxis™
Antihemophilic factor, human/Monoclate P®, Koate DVI®
Antihemophilic factor, recombinant/Recombinate®, Hexilate®
Antihemophilic factor/von Willebrand factor complex/Humate-P®
Anti-inhibitor coagulant complex/Feiba NF
Antithrombin III/Thrombate III®
Antithymocyte globulin, equine/Atgam®
Antithymocyte globulin, rabbit/Thymoglobulin®
Antivenin lactrodectus mactans
Aprepitant/Emend®
Argatroban
Arginine/R-gene®
Aripiprazole/Abilify®
Artemether and lumefantrine/Coartem®—Caution in severe renal impairment
Articaine 4 % and epinephrine/Orabloc™, Septocaine®
Ascorbic acid/Vitamin C
Asenapine/Saphris®
Asparaginase/Elspar®
Asparaginase *Erwinia chrysanthemi*/Erwinase™
Atomoxetine/Strattera®
Atorvastatin/Lipitor®
Atovaquone/Mepron®
Atracurium
Atropine
Avanafil/Stendra™
Axitinib/Inlyta®
Azficel-T/LaViv®
Azilsartan/Edarbi™
Azithromycin/Zithromax®—Caution in severe renal impairment (GFR < 10 mL/min)
Baclofen/Lioresal®—Caution in severe renal impairment
Balsalazide/Colazal®—Caution in severe renal impairment
Barium sulfate/Barobag™, Barosperse™, Cheetah™, Enhancer™, Entrobar™, HD 85™, HD™ 200 Plus, Intropaste™, Prepcat™, Scan C™, Tonojug™, Tonopaque™
Basiliximab/Simulect®
Beclomethasone/QVAR®, Beconase®
Belatacept/Nulojix®
Belimumab/Benlysta®
Belladonna and opium/B&O®
Benzphetamine/Didrex®
Benzonatate/Tessalon®
Benztropine/Cogentin®
Beta-carotene
Betamethasone/Celestone®
Betaxolol/Kerlone®—Caution, reduce dose in severe renal impairment
Bethanechol/Urecholine®
Bevacizumab/Avastin®
Bexarotene/Targretin®—Caution in severe renal impairment
Bicalutamide/Casodex®
Bisacodyl/Dulcolax®
Boceprevir/Victrelis™
Bortezomib/Velcade®
Bosentan/Tracleer®
Brentuximab/Adcetris™—Caution, the effects or risks imposed by renal impairment have not been determined
Bromocriptine/Cycloset®, Parlodel®
Brompheniramine/Brovex™
Budesonide/Entocort®
Bumetanide/Bumex®
Bupivacaine/Marcaine®
Buprenorphine/Buprenex®
Bupropion/Wellbutrin®—Caution in severe renal impairment
Busulfan/Myleran®
Butabarbital/Butisol®
C1 esterase inhibitor/Berinert®, Cinryze™
Cabazitaxel/Jevtana®—Caution in severe renal impairment
Cabergoline/Dostinex®
Caffeine sodium benzoate
Calcitonin/Miacalcin®
Calcitriol/Rocaltrol®
Calcium acetate/PhosLo®

Calcium carbonate/Tums®
Calcium citrate/Citracal®
Calcium polycarbophil/FiberCon®
Candesartan/Atacand®
Carbamazepine/Tegretol®
Carbidopa/Lodosyn®
Carbinoxamine/Palgic®
Carboprost/Hemabate®
Carisoprodol/Soma®
Carvedilol/Coreg®
Cascara sagrada
Caspofungin/Cancidas®
Castor oil
Cefaclor/Ceclor®
Ceftriaxone/Rocephin®
Certolizumab/Cimzia®—Caution, inadequate data to recommend dose in renal impairment
Cetrorelix/Cetrotide®
Cetuximab/Erbitux®
Cevimeline/Evoxac®
Chloramphenicol/Chloromycetin®—Caution in severe renal impairment
Chlordiazepoxide/Librium®
Chloroprocaine/Nesacaine®
Chloroquine/Aralen®
Chlorpheniramine/Chlor-trimeton®
Chlorpromazine/Thorazine®
Chlorzoxazone/Parafon®
Cholecalciferol/Vitamin D_3
Cholestyramine/Questran®
Choline magnesium trisalicylate/Trilisate®—Caution, monitor salicylate levels
Cilostazol/Pletal®—Caution in severe renal impairment (GFR < 25 mL/min)
Cinacalcet/Sensipar®
Cisatracurium/Nimbex®
Citalopram/Celexa®
Citric acid, sodium, and potassium citrate/Polycitra®—Caution with low urine output
Clemastine/Tavist®
Clevidipine/Cleviprex™
Clidinium and chlordiazepoxide/Librax®
Clindamycin/Cleocin®
Clobazam/Onfi™—Caution, no experience in severe renal impairment
Clomiphene/Clomid®, Serophene®
Clonazepam/Klonopin®
Clonidine/Catapres®
Clopidogrel/Plavix®
Clorazepate/Tranxene®
Cocaine
Collagenase *Clostridium histolyticum* injection/Xiaflex™
Colesevelam/Welchol®
Colestipol/Colestid®
Corticorelin/Acthrel®
Cortisone acetate
Cosyntropin/Cortrosyn®
Crizotinib/Xalkori®
Cromolyn/Gastrocrom®—Caution, consider dose reduction
Cyanocobalamin/Vitamin B_{12}
Cyclobenzaprine/Flexeril®
Cyclophosphamide/Cytoxan®—Caution, consider dose reduction in severe renal impairment (GFR < 10 mL/min) and/or chronic oral administration
Cyclosporine/Gengraf®, Neoral®, Sandimmune®
Cyproheptadine/Periactin®
Cytarabine/Cytosar®
Cytomegalovirus immune globulin/Cytogam®
Dacarbazine/DTIC®
Daclizumab/Zenapax®
Dactinomycin/Cosmegen®
Danazol/Cyclomen®
Dantrolene/Dantrium®
Dapsone
Darbepoetin alfa/Aranesp®
Darifenacin/Enablex®
Darunavir/Prezista®
Dasatinib/Sprycel®
Decitabine/Dacogen™
Deferiprone/Ferriprox®—Caution, not evaluated in patients with kidney disease
Degarelix/Firmagon®—Caution in severe renal impairment
Delavirdine/Rescriptor®
Denileukin/Ontak®
Denosumab/Prolia™, Xgeva™—Caution, patients with CrCL < 30 mL/min or on hemodialysis are at increased risk for hypocalcemia
Desflurane/Suprane®
Desipramine/Norpramin®
Desloratadine/Clarinex®—Caution in renal impairment, consider initiation with 5 mg every 48 h
Dexamethasone/Decadron®
Dexlansoprazole/Kapidex™
Dexmedetomidine/Precedex®
Dexmethylphenidate/Focalin®
Dextran 40/Gentran®—Caution in renal impairment
Dextroamphetamine/Dexedrine®
Dextroamphetamine and amphetamine/Adderall®
Dextromethorphan/Robitussin DM®
Diatrizoate/Gastrografin™, MD-Gastroview®
Diazepam/Valium®
Diazoxide/Proglycem®—Caution, consider reduced dosage in renal impairment
Dicloxacillin/Pathocil®
Dicyclomine/Bentyl®
Diethylpropion/Tenuate®
Diflunisal—Caution, no data in renal impairment
Digoxin immune Fab/Digibind®
Dihydrotachysterol/DHT™
Diltiazem/Cardizem®, Cartia®, Dilacor®, Taztia®, Tiazac®
Dimenhydrinate/Dramamine®
Dimercaprol/BAL®
Dinoprostone/Cervidil®, Prepidil®, Prostin E_2®
Diphenhydramine/Benadryl®
Diphenoxin and atropine/Motofen®
Diphenoxylate and atropine/Lomotil®
Diphtheria and tetanus toxoids and acellular pertussis vaccine/Adacel®, Boostrix®
Dipyridamole/Persantine®
Disulfiram/Antabuse®
Divalproex/Depakote®
Dobutamine/Dobutrex®
Docetaxel/Taxotere®
Docusate/Colace®
Dolasetron/Anzemet®
Donepezil/Aricept®
Dopamine/Intropin®
Doxapram/Dopram®
Doxazosin/Cardura®
Doxepin/Sinequan®
Doxercalciferol/Hectorol®
Doxorubicin/Adriamycin®
Doxylamine/Unisom®

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

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

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

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

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

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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*	

Acarbose - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Acarbose/Precose®	**{Antidiabetic; α-glucosidase inhibitor}**	
Usual initial dose:	25 mg orally one to three times daily with meals	
Usual maintenance dose:	50–100 mg orally three times daily with meals	
Typical maximum dose:	50 mg orally three times daily (weight ≤60 kg); 100 mg orally three times daily (weight >60 kg)	
Proportion eliminated unchanged:	35 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*SCr >2.0 mg/dL*	*Clinical trials in diabetic patients with significant renal dysfunction (SCr >2.0 mg/dL) have not been conducted; therefore, treatment of these patients with (acarbose) is not recommended.*
Alternative adjustment:	*GFR >50 mL/min*	*50 mg orally three times daily with meals*
	GFR 10–50 mL/min	*Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.*
	GFR <10 mL/min	*Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.*
	Hemodialysis	*Data not available. Avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.*
	CAPD	*Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.*
	CRRT	*Not applicable; preferably avoid unless no suitable alternative exists.*

Acebutolol - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Acebutolol/Sectral®	**{Antihypertensive; antianginal; β-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.*

Acetaminophen - Selected References

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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

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

Acetazolamide - Selected References

Acetazolamide injection USP [package insert]. Big Flats: X-GEN Pharmaceuticals Inc; 2009.

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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		
FDA-approved product labeling:	*Marked kidney disease or dysfunction*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*250 mg orally or IV every 6 h*
	GFR 10–50 mL/min	*125 mg orally or IV every 12 h*
	GFR <10 mL/min	*Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.*
	Hemodialysis	*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.**
	CAPD	*Data not available. Preferably avoid unless no suitable alternative exists; if indeed necessary, begin with low doses and monitor carefully.*
	CRRT	*250 mg orally or IV every 12 h*
Therapeutic Drug Monitoring		
Therapeutic Plasma Levels:	*Mid-interval to trough concentration: 4–10 mg/L*	

Acetohydroxamic Acid - Selected References

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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

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

Acitretin - Selected References

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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.

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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*

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

Alternative adjustment:

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

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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^2)*	*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:

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

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)[a]			
	≥50	*30–49*	*10–29*	*Hemodialysis*
Recommended dosage and dosing interval	*10 mg orally every 24 h*	*10 mg orally every 48 h*	*10 mg orally every 72 h*	*10 mg orally every 7 days following dialysis*

[a]*CrCL calculated by Cockroft-Gault method using lean or ideal body weight*

Alternative adjustment:

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

Alendronate - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Alendronate/Fosamax®	**{Anti-osteoporotic; bisphosphonate}**
Usual initial dose:	10 mg orally once daily or 35–70 mg orally once weekly
Usual maintenance dose:	10 mg orally once daily or 35–70 mg orally once weekly
Typical maximum dose:	70 mg/week
Proportion eliminated unchanged:	40–60 % of an assimilated dose; ~100 % of drug in plasma

Adjustment for Kidney Disease

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

Alfuzosin - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Alfuzosin/Uroxatral®	**{α_1-Adrenergic receptor blocker; ℞ 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		
FDA-approved product labeling:	*CrCL >30 mL/min*	*10 mg orally once daily after a meal*
	CrCL ≤30 mL/min	*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.*
Alternative adjustment:	*eCrCL ≥60 mL/min*	*10 mg orally once daily after a meal*
	eCrCL 30–59 mL/min	*10 mg orally once daily after a meal*
	eCrCL <30 mL/min	*5 mg orally once daily after a meal*

Aliskiren - Selected References

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Aliskiren/Tekturna® **{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

FDA-approved product labeling:	*Renal impairment (GFR <60 mL/min)*	*Avoid. Safety and effectiveness not established (patients with CrCL <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*
Alternative adjustment:	*eCrCL 31–59 mL/min*	*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.*
	eCrCL ≤30 mL/min	*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.*
	Hemodialysis	*Preferably avoid. Minimal data available; if indeed necessary, initiate therapy with 150 mg orally once daily with careful clinical and biochemical monitoring.*
	CRRT	*Preferably avoid. No published data available; if indeed necessary, initiate with 150 mg enterally once daily with careful monitoring.*

Allopurinol - Selected References

Aloprim® injection [package insert]; Lake Forest: Bioniche Pharma USA LLC; 2008.

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

Dosage Adjustment of Medications Eliminated by the Kidneys

Allopurinol/Zyloprim®, Aloprim®	**{Anti-gout; xanthine oxidase inhibitor}**	
Usual initial dose:	200 mg/m^2 orally or IV	
Usual maintenance dose:	200–400 mg/m^2/day orally or IV	
Typical maximum dose:	600 mg/day	
Proportion eliminated unchanged:	10 % (plus 80 % of each dose as pharmacologically active primary metabolite, oxypurinol)	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*CrCL 10–20 mL/min*	*200 mg orally or IV once daily*
	CrCL 3–10 mL/min	*100 mg orally or IV once daily*
	CrCL <3 mL/min	*100 mg/day orally or IV at extended intervals*
Alternative adjustment:	*GFR >50 mL/min*	*200 mg orally or IV once daily*
	GFR 10–50 mL/min	*150 mg orally or IV once daily*
	GFR <10 mL/min	*100 mg orally or IV once daily or 150 mg orally every 48 h*
	Hemodialysis	*100 mg orally or IV once daily or 150 mg orally every 48 h; administer supplemental half dose (50 %) after dialysis*
	CAPD	*Data not available*
	CRRT	*150 mg enterally or IV once daily*

Almotriptan - Selected References

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

Baldwin JR, Fleishaker JC, Azie NE, Carel BJ. A comparison of the pharmacokinetics and tolerability of the anti-migraine compound almotriptan in healthy adolescents and adults. Cephalgia. 2004;24:28–92.

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McEnroe JD, Fleishaker JC. Clinical pharmacokinetics of almotriptan, a serotonin 5-$HT_{1B/1D}$ receptor agonist for the treatment of migraine. Clin Pharmacokinet. 2005;44:237–46.

Almotriptan/Axert® **{Anti-migraine; serotonin 5-HT_3 receptor antagonist}**

Usual initial dose: 12.5 mg orally

Usual maintenance dose: 6.25–12.5 mg orally; may be repeated once in 2 h if necessary

Typical maximum dose: 25 mg/day

Proportion eliminated unchanged: 45 %

Adjustment for Kidney Disease

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

Amantadine - Selected References

Aoki FY, Sitar DS. Clinical pharmacokinetics of amantadine hydrochloride. Clin Pharmacokinet. 1988;14:35–51.

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Symmetrel® tablet and syrup [package insert]. Chadds Ford: Endo Pharmaceuticals Inc; 2009.

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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*

CrCL (mL/min)	*Dosage*
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*

Hemodialysis: 200 mg orally every 7 days

Alternative adjustment:

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

Amikacin - Selected References

Amikacin sulfate injection USP [package insert]. Lake Forest: Hospira Inc; 2004.

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Taccone FS, Laterre P-F, Spapen H, et al. Revisiting the loading dose of amikacin for patients with severe sepsis and septic shock. Crit Care. 2010;14:R53. Epub ahead of print. doi:10.1186/cc8945.

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Dosage Adjustment of Medications Eliminated by the Kidneys

Amikacin/Amikin®	**{Antibacterial; aminoglycoside}**	
Usual initial dose:	7.5 mg/kg	
Usual maintenance dose:	15 mg/kg/day IV once daily or divided into two or three equal doses (monitor[a], adjust)	
Typical maximum dose:	20 (to 30) mg/kg/day not to exceed 1.5 g/day	
Proportion eliminated unchanged:	95 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*7.5 mg/kg every (nine times SCr in mg/dL) h*	
Alternative adjustment:	*eCrCL >80 mL/min*	*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[a]*
	eCrCL 30–80 mL/min	*5–7.5 mg/kg every 24 h[a]*
	eCrCL 10–30 mL/min	*5–7.5 mg/kg every 48 h[a]*
	eCrCL <10 mL/min	*3.75 mg/kg every 48–72 h[a]*
	Hemodialysis	*3.75 mg/kg after dialysis[a]*
	CAPD	*7.5 mg/kg IV followed by amikacin instilled in peritoneal dialysate at a (peak) concentration desired in plasma, usually 15–20 mg/L[a]*
	CVVH	*15 mg/kg followed by 7.5 mg/kg every 24–48 h according to plasma concentrations[a]*
	CVVHD	*15–25 mg/kg followed by 7.5 mg/kg every 24–48 h according to plasma concentrations[a]*
	CVVHDF	*15–25 mg/kg followed by 7.5 mg/kg every 24–48 h according to plasma concentrations[a]*
[a]Therapeutic drug monitoring		
Therapeutic plasma levels:	*Peak*	*20–30 mg/L (conventional, multiple daily dosing)*
	Trough	*<10 mg/L; patients on extended-interval dosing generally should be re-dosed when levels fall below 5 mg/L.*

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.

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Midamor® tablet [package insert]. Minneapolis: Paddock Laboratories Inc; 2008.

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Vidt DG. Mechanism of action, pharmacokinetics, adverse effects, and therapeutics of amiloride hydrochloride, a new potassium-sparing diuretic. Pharmacotherapy. 1981;1:179–87.

Dosage Adjustment of Medications Eliminated by the Kidneys

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

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.

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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 an its N-acetylated metabolite: effectiveness in chelating brain manganese. Drug Metab Dispos. 2011;39:1904–9.

Hong L, Jiang W, Zheng W, Zeng S. HPLC analysis of para-aminosalicylic acid and its metabolite in plasma, cerebrospinal fluid and brain tissues. J Pharm Biomed Anal. 2011;54:1101–9.

Malone RS, Fish DN, Spiegel DM, Childs JM, Peloquin CA. The effect of hemodialysis on cycloserine, ethionamide, para-aminosalicylate, and clofazimine. Chest. 1999;116:984–90.

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.

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Dosage Adjustment of Medications Eliminated by the Kidneys

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

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.

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Brest AN, Moyer JH. Clinical pharmacology of diuretic drugs. Am J Cardiol. 1966;17:626–30.

Jarrell MA, Greer M, Maren TH. The effect of acidosis in hypokalemic periodic paralysis. Arch Neurol. 1976;33:791–3.

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Warren SE, Swerdlin ARH, Steinberg SM. Treatment of alkalosis with ammonium chloride: a case report. Clin Pharmacol Ther. 1979;25:624–7.

Ammonium Chloride — {Systemic acidifier; electrolyte replenisher}

Usual initial dose: 100–200 mEq IV in 500–1,000 mL 0.9 % sodium chloride IV over 3 h (not to exceed 5 mL/h)

Usual maintenance dose: As required by repeated sodium bicarbonate determinations

Typical maximum dose: 200 mEq/day

Proportion eliminated unchanged: Nil

Adjustment for Kidney Disease

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

Alternative adjustment: *Data not available*

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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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

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

Amoxicillin and Clavulanate - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Amoxicillin and Clavulanate/Augmentin®	**{Antibacterial; aminopenicillin/β-lactamase inhibitor}**	
Usual initial dose:	500 mg orally	
Usual maintenance dose:	250–500 mg orally or enterally every 8 h or 500–875 mg orally every 12 h	
Typical maximum dose:	1,750 mg/day	
Proportion eliminated unchanged:	60–80 %/25–40 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*CrCL >30 mL/min*	*250–500 mg orally or enterally every 8–12 h*
	CrCL 10–30 mL/min	*250–500 mg orally or enterally every 12 h*
	CrCL <10 mL/min	*250–500 mg orally or enterally every 24 h*
	Hemodialysis	*250–500 mg orally or enterally every 24 h; administer an additional dose both during and at the end of dialysis.*
	CAPD	*No data*
	CRRT	*No data*
Alternative adjustment:	*eCrCL >80 mL/min*	*250–500 mg orally or enterally every 8–12 h*
	eCrCL 51–80 mL/min	*250–500 mg orally or enterally every 8–12 h*
	eCrCL 10–50 mL/min	*250–500 mg orally or enterally every 12 h*
	eCrCL <10 mL/min	*250–500 mg orally or enterally every 24 h*
	Hemodialysis	*250–500 mg orally or enterally every 24 h; give 250–500 mg enterally after dialysis*
	CAPD	*250 mg orally or enterally every 12 h*
	CRRT	*Not applicable (consider IV ampicillin/sulbactam)*

Ampicillin (Enteral) - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Ampicillin (Enteral)/Polycillin® {Antibacterial; aminopenicillin}

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

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL >50 mL/min*	*250–500 mg orally or enterally every 6 h*
	CrCL 10–50 mL/min	*250–500 mg orally enterally every 6–12 h*
	CrCL <10 mL/min	*250–500 mg orally or enterally every 12–16 h*
	Hemodialysis	*250–500 mg orally or enterally every12–24 h; give supplemental dose after dialysis*
	CAPD	*250 mg orally or enterally every 12 h*
Alternative adjustment:	*GFR >50 mL/min*	*250–500 mg enterally every 6 h*
	GFR 10–50 mL/min	*250–500 mg enterally every 8 h*
	GFR <10 mL/min	*250–500 mg enterally every 12 h*
	Hemodialysis	*250–500 mg enterally every 12 h; administer after hemodialysis on dialysis days.*
	CRRT	*Not applicable (consider IV ampicillin)*

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.

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Dosage Adjustment of Medications Eliminated by the Kidneys

Ampicillin (IV)/Polycillin® **{Antibacterial; aminopenicillin}**

Usual initial dose: 2 g IV

Usual maintenance dose: 1–2 g IV every 6 h

Typical maximum dose: 50 mg/kg/dose (~3 g/dose) or 250 mg/kg/day (~12 g/day)

Proportion eliminated unchanged: 60 %

Adjustment for Kidney Disease

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

Ampicillin and Sulbactam - Selected References

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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.

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

Usual initial dose: 1.5–3 g IV

Usual maintenance dose: 1.5–3 g IV every 6 h

Typical maximum dose: 3 g IV

Proportion eliminated unchanged: 35 %

Adjustment for Kidney Disease

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

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

Alternative adjustment:

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

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.

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Dosage Adjustment of Medications Eliminated by the Kidneys

Anakinra/Kineret® **{Antirheumatic; human interleukin 1 receptor antagonist}**

Usual initial dose: 100 mg subcutaneously

Usual maintenance dose: 100 mg subcutaneously once daily

Typical maximum dose: 100 mg/day

Proportion eliminated unchanged: Unknown; plasma clearance decreased by 75 % in end-stage renal disease

Adjustment for Kidney Disease

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

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.

Apomorphine/Apokyn® **{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

FDA-approved product labeling:	*Mild to moderate renal impairment*	*1 mg subcutaneously three times daily (test dose and initial maintenance dose)*
	Severe renal impairment	*Studies in subjects with severe renal impairment have not been conducted.*
Alternative adjustment:	*Data not available*	

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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Arsenic Trioxide/Trisenox® **{Antineoplastic; fusion protein inhibitor; ℞ for acute promyelocytic leukemia}**

Usual initial dose: 0.15 mg/kg IV over 2 h

Usual maintenance dose: 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

Typical maximum dose: 0.15 mg/kg/day

Proportion eliminated unchanged: 20 % increasing to 60 % with repeated doses

Adjustment for Kidney Disease

FDA-approved product labeling:	*Severe renal impairment*	*Exposure of arsenic trioxide may be higher.*
	CrCL < 30 mL/min	*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).*
Alternative adjustment:	*CrCL > 80 mL/min*	*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.*
	CrCL 50–80 mL/min	*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.*
	CrCL 30–49 mL/min	*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.*
	CrCL < 30 mL/min	*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.*
	Hemodialysis	*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.*
	CAPD	*Presently, data not available for use of IV arsenic trioxide*
	CRRT	*Data not available*

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		
FDA-approved product labeling:	*CrCL ≥50 mL/min*	*81–325 mg orally once daily (antiplatelet) or 300–650 mg orally or rectally every 4 h as necessary (analgesic/antipyretic)*
	Kidney problems	*Ask a doctor before use.*
Alternative adjustment:	*GFR >50 mL/min*	*81–325 mg orally once daily (antiplatelet) or 650 mg orally or rectally every 4 h as necessary (analgesic/antipyretic)*
	GFR 10–50 mL/min	*81–162 mg orally once daily (antiplatelet) or 650 mg orally or rectally every 6 h as necessary (analgesic/antipyretic)*
	GFR <10 mL/min	*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.*
	Hemodialysis	*81–162 mg orally or rectally after hemodialysis on dialysis days*
	CAPD	*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.*
	CRRT	*81–162 mg orally once daily (antiplatelet) or 650 mg enterally or rectally every 6 h as necessary (analgesic/antipyretic)*

Atazanavir - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Atazanavir/Reyataz®	**{Antiretroviral; protease inhibitor}**	
Usual initial dose:	300 mg orally with ritonavir 100 mg or 400 mg orally (without ritonavir) with food once daily	
Usual maintenance dose:	300 mg orally with ritonavir 100 mg or 400 mg orally (without ritonavir) with food once daily	
Typical maximum dose:	400 mg/day	
Proportion eliminated unchanged:	7 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*Renal impairment, including patients with severe renal impairment not managed with hemodialysis*	*400 mg orally every 24 h (no dose adjustment necessary)*
	Treatment-naïve patients with ESRD managed with hemodialysis	*300 mg orally once daily with ritonavir 100 mg orally once daily*
	HIV-treatment-experienced patients with ESRD managed with hemodialysis	*Do not administer; avoid.*
Alternative adjustment:	*GFR >50 mL/min*	*400 mg orally every 24 h*
	GFR 10–50 mL/min	*Data not available*
	GFR <10 mL/min	*Data not available*
	Hemodialysis	*400 mg orally every 24 h (no dose adjustment necessary—only very limited data available)*
	CAPD	*Data not available*
	CRRT	*Data not available*

Atenolol - Selected References

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Tenormin® tablet [package insert]. Wilmington: AstraZeneca Pharmaceuticals LP; 2008.

Dosage Adjustment of Medications Eliminated by the Kidneys

Atenolol/Tenormin® **{Antihypertensive; antianginal; β-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*

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

Hemodialysis: 25–50 mg orally after each dialysis

Alternative adjustment:

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

Atovaquone and Proguanil - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

<u>Atovaquone and Proguanil</u>/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*	

Auranofin - Selected References

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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:

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

Azacitidine - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Azacitidine/Vidaza®	**{Antineoplastic; DNA demethylation agent, ℞ for myelodysplastic syndromes}**	
Usual initial dose:	75 mg/m^2 IV or subcutaneously	
Usual maintenance dose:	75 mg/m^2 subcutaneously daily for seven consecutive days every 4 weeks for a minimum of four cycles	
Typical maximum dose:	100 mg/m^2/day (if no beneficial effect is seen after. two lower-dose treatment cycles and if no toxicity other than nausea and vomiting has occurred)	
Proportion eliminated unchanged:	85 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*Impaired renal function*	*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.*
Alternative adjustment:	*Data not available*	

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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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:

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

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.

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Dosage Adjustment of Medications Eliminated by the Kidneys

Aztreonam/Azactam®	**{Antibacterial; monobactam}**	
Usual initial dose:	1–2 g IV	
Usual maintenance dose:	1–2 g IV every 6–12 h	
Typical maximum dose:	8 g/day	
Proportion eliminated unchanged:	75 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*CrCL 10–30 mL/min*	*500–1,000 mg IV every 6–12 h*
	CrCL <10 mL/min	*250–500 mg IV every 6–12 h*
	Hemodialysis	*250–500 mg IV every 6–12 h plus 125–250 mg after dialysis*
	CAPD	*250–500 mg IV every 6–12 h*
Alternative adjustment:	*GFR >50 mL/min*	*500–2,000 mg IV every 8–12 h*
	GFR 10–50 mL/min	*500–1,000 mg IV every 8–12 h*
	GFR <10 mL/min	*500 mg IV every 8 h*
	Hemodialysis	*1,000 mg IV every 12 h*
	CAPD	*500 mg IV every 8 h or add to dialysate qs 1,000 mg/L ×1 then 250 mg/L*
	CVVH	*1,000–2,000 mg IV every12 h*
	CVVHD or CVVHDF	*2,000 mg IV every 12 h*

B

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Bacitracin - Selected References

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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.*

Benazepril - Selected References

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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

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

Bendamustine - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Bendamustine/Treanda®	**{Antineoplastic; alkylating agent, mechlorethamine derivative}**	
Usual initial dose	100 mg/m^2 IV	
Usual maintenance dose	100 mg/m^2 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^2	
Proportion eliminated unchanged	~10 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*CrCL > 40 mL/min*	*100 mg/m^2 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*	

Bismuth Subsalicylate - Selected References

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

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

Adjustment for Kidney Disease

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

Bisoprolol - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Bisoprolol/Zebeta®	**{Antihypertensive; antianginal; β-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

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

Bivalirudin - Selected References

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Bivalirudin/Angiomax®	**{Antithrombotic; direct thrombin inhibitor}**
Usual initial dose	0.75 mg/kg IV
Usual maintenance dose	Continuous IV infusion of 1.75 mg/kg/h for the duration of the percutaneous coronary intervention procedure
Typical maximum dose	As required to attain aPTT 1.5–2.5 times baseline or control value
Proportion eliminated unchanged	20 %

Adjustment for Kidney Disease

FDA-approved product labeling: *For anticoagulation in patients undergoing percutaneous coronary intervention*

CrCL ≥ 60 mL/min	*0.75 mg/kg IV followed by infusion of 1.75 mg/kg/h*
CrCL 30–59 mL/min	*0.75 mg/kg IV followed by infusion of 1.75 mg/kg/h*
CrCL < 30 mL/min	*0.75 mg/kg IV followed by infusion of 1.00 mg/kg/h*
Hemodialysis	*0.75 mg/kg IV followed by infusion of 0.25 mg/kg/h*

Alternative adjustment: *For anticoagulation in patients with venous thromboembolism*

eCrCL ≥ 60 mL/min	*Continuous IV infusion of 0.15 mg/kg/h (no initial bolus)*
eCrCL 44–60 mL/min	*Continuous IV infusion of 0.075 mg/kg/h (no initial bolus)*
eCrCL 30–43 mL/min	*Continuous IV infusion of 0.05 mg/kg/h (no initial bolus)*
eCrCL < 30 mL/min	*Continuous IV infusion of 0.025 mg/kg/h (no initial bolus)*
CRRT	*Continuous IV (prefilter) infusion of 0.02 mg/kg/h (no initial bolus)* *Note: dosage usually should be based on total body weight in normal body weight and obese patients*

Bleomycin - Selected References

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

Usual initial dose 0.25–0.50 units/kg (10–20 units/m^2) 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^2) 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:

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

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.

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Dosage Adjustment of Medications Eliminated by the Kidneys

Buspirone/BuSpar®	**{Anxiolytic; serotonin 5-HT_{1A} and D_2 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^2) patients, steady state AUC of buspirone increased 4-fold compared with healthy (CrCL ≥ 80 mL/min/1.73 m^2) subjects.*
Alternative adjustment:	*GFR > 50 mL/min*	*10–15 mg orally twice daily*
	GFR 10–50 mL/min	*5–10 mg orally twice daily (~25 % decrease)*
	GFR < 10 mL/min	*2.5–7.5 mg orally twice daily (~50 % decrease)*
	Hemodialysis	*2.5–7.5 mg orally twice daily*
	CAPD	*2.5–7.5 mg orally twice daily*
	CRRT	*5–10 mg enterally twice daily*

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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Butorphanol/Stadol®	**{Analgesic; opioid μ-receptor partial agonist}**	
Usual initial dose	1 mg IV or IM or 1 mg (1 spray in 1 nostril) intranasally	
Usual maintenance dose	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	
Typical maximum dose	4 mg/dose	
Proportion eliminated unchanged	4 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*CrCL < 30 mL/min*	*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*
Alternative adjustment:	*GFR > 50 mL/min*	*0.5–1 mg IV or IM every 6 h PRN*
	GFR 10–50 mL/min	*0.375–0.75 mg IV or IM every 6 h PRN (25 % decrease)*
	GFR < 10 mL/min	*0.25–0.5 mg IV or IM every 6 h PRN (50 % decrease)*
	Hemodialysis	*Data not available*
	CAPD	*Data not available*
	CRRT	*0.375–0.75 mg IV or IM every 6 h PRN (25 % decrease)*

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Capecitabine - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

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

Usual initial dose: 1,250 mg/m^2 orally twice daily

Usual maintenance dose: 1,250 mg/m^2 orally twice daily for 2 weeks in 3-week cycles

Typical maximum dose: 2,500 mg/m^2/day

Proportion eliminated unchanged: 86 % (as parent drug and active metabolites)

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL >50 mL/min*	*1,250 mg/m^2 orally twice daily for 2 weeks in 3-week cycles*
	CrCL 30–50 mL/min	*950 mg/m^2 orally twice daily*
	CrCL <30 mL/min	*Contraindicated*
Alternative adjustment:	*Data not available*	
	Note: Hematological and other considerations may suggest further dosage adjustments.	

Capreomycin - Selected References

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

Usual initial dose: 1,000 mg IV or IM

Usual maintenance dose: 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

Typical maximum dose: 20 mg/kg/day

Proportion eliminated unchanged: 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)*

CrCL (mL/min)	*Capreomycin clearance (L/g/h × 10^{-2})*	*Half-life (h)*	*Dose (mg/kg) for the following dosing intervals*		
			24 h	*48 h*	*72 h*
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*	–	–

Alternative adjustment:

GFR >50 mL/min	*1 g IV every 24 h*
GFR 10–50 mL/min	*1 g IV every 24–48 h*
GFR <10 mL/min	*1 g IV every 48 h*
Hemodialysis	*1 g IV after hemodialysis on dialysis days only*
CAPD	*Data not available*
CRRT	*5 mg/kg IV every 24 h*

Captopril - Selected References

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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:

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

Carboplatin - Selected References

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Carboplatin/Paraplatin® {Antineoplastic; platinum coordination complex; DNA cross-link disruptor}

Usual initial dose: 300–360 mg/m^2 IV

Usual maintenance dose: 300–360 mg/m^2 IV every 4 weeks, or

Total dose (mg) = (target AUC [usually 4–6 mg/mL • min]) × (GFR [mL/min] + 25)

Typical maximum dose: 360 mg/m^2

Proportion eliminated unchanged: 50–75 %

Adjustment for Kidney Disease

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

Creatinine clearance (mL/min)	*Carboplatin dose*
41–59	*250 mg/m^2 IV*
16–40	*200 mg/m^2 IV*
≤15	*Not recommended*

Alternative adjustment:

GFR >50 mL/min	*300 mg/m^2 IV*
GFR 10–50 mL/min	*150 mg/m^2 IV (50 % decrease)*
GFR <10 mL/min	*75 mg/m^2 IV (75 % decrease)*
Hemodialysis	*150 mg/m^2 IV (50 % decrease)*
CAPD	*75 mg/m^2 IV (75 % decrease)*
CRRT	*200 mg/m^2 IV*

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

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.

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

Usual initial dose: 150 mg/m^2 IV

Usual maintenance dose: 150–200 mg/m^2 IV every 6 weeks

Typical maximum dose: 200 mg/m^2 (up to 1,200 mg/m^2 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.*

Alternative adjustment:

GFR 45–60 mL/min	*110–150 mg/m^2 IV every 2 weeks (25 % reduction)*
GFR 10–45 mL/min	*Preferably avoid due to increased risk for drug accumulation and resultant toxicity*
GFR <10 mL/min	*Preferably avoid due to increased risk for drug accumulation and resultant toxicity*
Hemodialysis	*Preferably avoid due to increased risk for drug accumulation and resultant toxicity*
CAPD	*Preferably avoid due to increased risk for drug accumulation and resultant toxicity*
CRRT	*Data not available*

Cefadroxil - Selected References

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Cefadroxil/Duricef® **{Antibacterial; first-generation cephalosporin}**

Usual initial dose: 1 g orally

Usual maintenance dose: 1–2 g/day orally in single or divided doses (twice daily) for 10 days

Typical maximum dose: 2 g/day in single or divided (twice daily) doses

Proportion eliminated unchanged: 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*

CrCL (mL/min)	*Dosage interval (h)*
0–10	*36*
10–25	*24*
25–50	*12*
>50	*12*

Alternative adjustment:

GFR >50 mL/min	*1,000 mg orally every 12 h*
GFR 10–50 mL/min	*500–1,000 mg orally every 12–24 h*
GFR <10 mL/min	*1,000 mg orally every 48 h*
Hemodialysis	*1,000 mg orally every 72 h, after hemodialysis on dialysis days*
CAPD	*500 mg orally every 24 h*
CRRT	*Not applicable (consider an IV cephalosporin)*

Cefazolin - Selected References

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Cefazolin/Ancef® **{Antibacterial; first-generation cephalosporin}**

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

Adjustment for Kidney Disease

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

Cefdinir - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Cefdinir/Omnicef® **{Antibacterial; third-generation cephalosporin}**

Usual initial dose: 600 mg orally

Usual maintenance dose: 300 mg orally every 12 h or 600 mg orally every 24 h

Typical maximum dose: 600 mg/day

Proportion eliminated unchanged: 15 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL <30 mL/min*	*300 mg orally once daily*
	Hemodialysis	*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.*
Alternative adjustment:	*GFR >50 mL/min*	*300 mg orally every 12 h*
	GFR 10–50 mL/min	*300 mg orally every 24 h*
	GFR <10 mL/min	*300 mg orally every 48 h*
	Hemodialysis	*300 mg orally every 48 h, after hemodialysis on dialysis days*
	CAPD	*300 mg orally every 48 h*
	CRRT	*Not applicable (consider an IV cephalosporin)*

Cefditoren - Selected References

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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

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

Cefepime - Selected References

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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*			
>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)*

Cefixime - Selected References

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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*

CrCL (mL/min)	*Dosage*
>60	*Standard (400 mg/day orally)*
21–60 or hemodialysis[a]	*75 % of standard (300 mg/day orally)*
<20 or continuous ambulatory peritoneal dialysis[a]	*50 % of standard (200 mg/day orally)*

[a]Neither hemodialysis nor peritoneal dialysis removes significant amounts of drug from the body

Alternative adjustment:

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

Cefotaxime - Selected References

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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

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

Cefotetan - Selected References

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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*

CrCL (mL/min)	*Dose*	*Frequency*
>30	*Usual recommended dosage*	*Every 12 h*
10–30	*Usual recommended dosage*	*Every 24 h*
<10	*Usual recommended dosage*	*Every 48 h*

Alternative adjustment:

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

Cefoxitin - Selected References

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Cefoxitin/Mefoxin® {Antibacterial; second-generation cephalosporin}

Usual initial dose: 1–2 g IV

Usual maintenance dose: 1–2 g IV every 6–8 h

Typical maximum dose: 2 g IV every 4 h or 3 g IV every 6 h

Proportion eliminated unchanged: 80 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Maintenance cefoxitin dosage in adults with renal impairment*

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

Alternative adjustment:

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

Cefpodoxime - Selected References

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Cefpodoxime/Vantin® **{Antibacterial; third-generation cephalosporin}**

Usual initial dose: 200 mg orally

Usual maintenance dose: 200 mg orally every 12 h

Typical maximum dose: 400 mg/day

Proportion eliminated unchanged: 50 %

Adjustment for Kidney Disease

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

Cefprozil - Selected References

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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*

CrCL (mL/min)	*Dosage*	*Dosing interval*
30–120	*250–500 mg orally*	*Every 12–24 h*
0–29	*125–250 mg orally*	*Every 12–24 h*
Hemodialysis: 250–500 mg orally after completion of hemodialysis		

Alternative adjustment:

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

Ceftaroline - Selected References

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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*

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

Alternative adjustment:

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

Ceftazidime - Selected References

Angus BJ, Smith MD, Suputtamongkol Y, et al. Pharmacokinetic-pharmacodynamic evaluation of ceftazidime continuous infusion vs intermittent bolus injection in septicaemic melioidosis. Br J Clin Pharmacol. 2000;49:184–91.

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Ceftazidime/Fortaz®, Tazicef® {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*

CrCL (mL/min)	*Dose (g)*	*Frequency of dosing*
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:

GFR >50 mL/min	*1–2 g IV every 8 h or 6g/24 h continuous IV infusion*
GFR 10–50 mL/min	*1–2 g IV every 12–24 h or 0.6–1.2 mg/kg/min continuous IV infusion*
GFR <10 mL/min	*0.5–1 g IV every 24 h or 0.3 mg/kg/min continuous IV infusion*
Hemodialysis	*0.5–1 g IV every 24 h; administer after hemodialysis on dialysis days or give supplemental 1 g IV after each dialysis.*
CAPD	*0.5 g IV every 24 h or 0.25 g/2 L dialysate*
Automated PD	*15 mg/kg IV every 24 h or 20 mg/kg intraperitoneally during long off-cycler dwell*
CVVH	*1–2 g IV every 12 h*
CVVHD	*2 g IV every 12 h*
CVVHDF	*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*

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.

Barr WH, Lin C-C, Radwanski E, Lim J, Symchowicz S, Affrime M. The pharmacokinetics of ceftibuten in humans. Diagn Microbiol Infect Dis. 1991;14:93–100.

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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*

CrCL (mL/min)	*Recommended dosing schedule*
>50	*9 mg/kg or 400 mg every 24 h*
30–49	*4.5 mg/kg or 200 mg every 24 h*
5–29	*2.25 mg/kg or 100 mg every 24 h*

Hemodialysis: 400 mg or 9 mg/kg (maximum 400 mg) orally after each hemodialysis

Alternative adjustment:

GFR >50 mL/min	*400 mg orally every 24 h*
GFR 10–50 mL/min	*200 mg orally every 24 h (50 % decrease)*
GFR <10 mL/min	*100 mg orally every 24 h (75 % decrease)*
Hemodialysis	*400 mg orally three times weekly or after each dialysis*
CAPD	*100 mg orally every 24 h*
CRRT	*Not applicable (consider an IV cephalosporin)*

Ceftizoxime - Selected References

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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:

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

Cefuroxime Axetil - Selected References

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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:

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

Cefuroxime Sodium - 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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Zinacef® injection [package insert]. Research Triangle Park: GlaxoSmithKline; 2009.

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*

CrCL (mL/min)	*Recommended dosing schedule*
>20	*750–1,500 mg every 8 h*
10–20	*750 mg every 24 h*
<10	*750 mg every 24 h*

Hemodialysis: 750 mg every 24 h; give after hemodialysis on dialysis days

Alternative adjustment:

GFR >50 mL/min	*750–1,500 mg IV every 8 h*
GFR 10–50 mL/min	*750–1,500 mg IV every 8–12 h*
GFR <10 mL/min	*750 mg IV every 24 h*
Hemodialysis	*750 mg IV every 24 h; administer after hemodialysis on dialysis days.*
CAPD	*750 mg IV every 24 h*
CRRT	*1,500 mg IV once followed by 750 mg IV every 12 h*

Celecoxib - Selected References

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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

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

Cephalexin - 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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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:

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

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.

Cetirizine/Zyrtec® **{Antihistamine; second-generation histamine H_1 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*

CrCL (mL/min)	*Recommended dosing schedule*
≥32	*10 mg every 24 h*
11–31	*5 mg every 24 h*
≤10	*Not recommended*

Alternative adjustment:

GFR >50 mL/min	*5–10 mg orally once daily*
GFR 10–50 mL/min	*5 mg orally once daily*
GFR <10 mL/min	*5 mg orally once daily*
Hemodialysis	*5 mg orally three times weekly to 5 mg orally daily; no supplemental dose after dialysis*
CAPD	*5 mg orally once daily*
CRRT	*Data not available*

Cetrorelix - Selected References

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

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Cetrorelix/Cetrotide® **{Gonadotropin-releasing hormone antagonist}**

Usual initial dose: 3 mg subcutaneously once or 0.25 mg subcutaneously daily

Usual maintenance dose: 3 mg subcutaneously once during early- to mid-follicular phase or 0.25 mg subcutaneously once daily until the day of hCG administration

Typical maximum dose: ~3.5 mg/cycle

Proportion eliminated unchanged: 7–14 %

Adjustment for Kidney Disease

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

Alternative adjustment: *Data not available*

Chloral Hydrate - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Chloral Hydrate/Somnote® **{Sedative hypnotic}**

Usual initial dose: 500–1,000 mg orally at bedtime or 30 min prior to procedure

Usual maintenance dose: 500–1,000 mg orally at bedtime

Typical maximum dose: 2 g/day

Proportion eliminated unchanged: 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*

Chlorambucil - Selected References

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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:

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

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

Chlorothiazide - Selected References

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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.*

Alternative adjustment:

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

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.

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Chlorpropamide/Diabinese® {Antidiabetic; sulfonylurea}

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

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

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.

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Chlorthalidone/Thalitone®, Hygroton® **{Diuretic; thiazide-like}**

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

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 n renal insufficiency and in continuous ambulatory peritoneal dialysis or high-flux dialysis. Clin Pharmacol Ther. 1999;65:21–8.

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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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Cidofovir/Vistide® **{Antiviral; ℞ 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

Alternative adjustment:

GFR >55 mL/min	*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)*
GFR 10–55 mL/min	*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).*
GFR <10 mL/min	*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).*
Hemodialysis	*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).*
CAPD	*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).*
CRRT	*Preferably avoid unless no suitable alternative exists; if indeed necessary, 2 mg/kg IV weekly (with probenecid).*

Cimetidine - 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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Tagamet® tablet, liquid, and injection [package insert]. Philadelphia: SmithKline Beecham Pharmaceuticals; 1991.

Vaziri KD, Ness RL, Barton CH. Hemodialysis clearance of cimetidine. Arch Intern Med. 1978;138:1685–6.

Webster J, Barber HE, Hawksworth GM, et al. Cimetidine: a clinical and pharmacokinetic study. Br J Clin Pharmacol. 1981;11:333–8.

Cimetidine/Tagamet® {Antacid; histamine H_2 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*

Ciprofloxacin - Selected References

Allon M, Lopez EJ, Min K-W. Acute renal failure due to ciprofloxacin. Arch Intern Med. 1990;150:2187–9.

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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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

Ciprofloxacin oral dosage	*Equivalent ciprofloxacin IV dosage*
250 mg tablet every 12 h	*200 mg IV every 12 h*
500 mg tablet every 12 h	*400 mg IV every 12 h*
750 mg tablet every 12 h	*400 mg IV every 8 h*

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*

CrCL (mL/min)	*Dose*
>50	*250–750 mg orally every 12 h*[a]
30–50	*250–500 mg orally every 12 h*[a]
5–29	*250–500 mg orally every 18 h*[a]
Hemodialysis or peritoneal dialysis	*250–500 mg orally every 24 h (after hemodialysis on dialysis days)*[a]

[a]*See table above for equivalent ciprofloxacin IV dosages*

Alternative adjustment:

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

Cisplatin - Selected References

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

Usual initial dose: 75–100 mg/m^2 IV

Usual maintenance dose: 75–100 mg/m^2 IV every 3–4 weeks

Typical maximum dose: 120 mg/m^2 IV

Proportion eliminated unchanged: 30–40 %

Adjustment for Kidney Disease

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

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

Cladribine - Selected References

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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.*

Alternative adjustment:

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

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

Clarithromycin - Selected References

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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:

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

Clomipramine - Selected References

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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:

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

Clozapine - Selected References

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Clozapine/Clozaril®, FazaClo® **{Atypical antipsychotic; dibenazepine 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:

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

Codeine - 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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Codeine {Analgesic; opioid μ-receptor agonist}

Usual initial dose: 15–60 mg orally, subcutaneously, IM, or IV

Usual maintenance dose: 15–60 mg (usually 30 mg) orally, subcutaneously, IM, or IV every 4 h as necessary

Typical maximum dose: 360 mg/24 h

Proportion eliminated unchanged: 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.*

Alternative adjustment:

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

Colchicine - Selected References

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

Usual initial dose: For acute gout flare: 1.2 mg orally followed by 0.6 mg orally 6 h later

Usual maintenance dose: 0.6 mg orally once or twice daily

Typical maximum dose: 1.2 mg/day orally

Proportion eliminated unchanged: 5–15 %

Adjustment for Kidney Disease

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

CrCL (mL/min)	*Dose*
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:

GFR >50 mL/min	*0.6 mg orally once or twice daily*
GFR 10–50 mL/min	*0.3–0.6 mg orally once or twice daily*
GFR <10 mL/min	*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.*
Hemodialysis	*0.3 mg once daily; monitor carefully.*
CAPD	*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.*
CRRT	*0.3–0.6 mg enterally once or twice daily*

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

Usual initial dose: 1.25–2.5 mg/kg IV or IM

Usual maintenance dose: 2.5–5 mg/kg/day IV or IM in two to four divided doses, depending on severity of infection

Typical maximum dose: 5 mg/kg/day IV or IM

Proportion eliminated unchanged: 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 creatinine (mg/dL)*	*Urea clearance (% of normal)*	*Dose (mg)*	*Frequency (times per day)*	*Total daily dose (mg)*	*Approx daily dose (mg/kg)*
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:

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

Conivaptan - Selected References

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Conivaptan/Vaprisol®	**{Vasopressin receptor antagonist; ℞ for hypovolemic/euvolemic hyponatremia}**	
Usual initial dose:	20 mg IV over 30 min	
Usual maintenance dose:	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	
Typical maximum dose:	40 mg/day	
Proportion eliminated unchanged:	1 % (plus 10 % as minimally active metabolites)	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*CrCL >60 mL/min*	*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.*
	CrCL 30–60 mg/min	*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.*
	CrCL <30 ml/min, anuria	*Contraindicated (no improvement can be expected.)*
Alternative adjustment:	*Data not available*	

Cycloserine - Selected References

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Cycloserine/Seromycin® **{Antitubercular; cell wall biosynthesis inhibitor}**

Usual initial dose: 250 mg orally twice daily

Usual maintenance dose: 250–500 mg orally twice daily

Typical maximum dose: 1,000 mg/day orally

Proportion eliminated unchanged: 65 %

Adjustment for Kidney Disease

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

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Dabigatran - Selected References

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Dabigatran/Pradaxa® **{Antithrombotic; direct thrombin inhibitor}**

Usual initial dose: 150 mg orally

Usual maintenance dose: 150 mg orally twice daily

Typical maximum dose: 300 mg/day orally

Proportion eliminated unchanged: 51–80 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL >30 mL/min*	*150 mg orally twice daily*
	CrCL15–30 mL/min	*75 mg orally twice daily*
	CrCL <15 mL/min	*Dosing recommendations cannot be provided.*
	Hemodialysis	*Dosing recommendations cannot be provided.*
	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.	
Alternative adjustment:	*eCrCL >30 mL/min*	*150 mg orally twice daily*
	eCrCL ≤30 mL/min	*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:* *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).* *CHADS = 2–3 (moderate risk) → Suggest therapeutic dose subcutaneous or IV UFH or prophylactic dose subcutaneous LMWH over no bridging.* *CHADS = 4–5 (high risk) → Recommend therapeutic dose subcutaneous or IV UFH over no bridging.*
	Hemodialysis	*Preferably avoid due to hemorrhagic risk*
	CRRT	*Data not available*

Dalfampridine - Selected References

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

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Dalfampridine/Ampyra™ **{Potassium channel blocker; ℞ 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*	

Dalteparin - Selected References

Clark NP. Low-molecular-weight heparin use in obese, elderly, and in renal insufficiency. Thromb Res. 2008;123:S58–61.

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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 ≤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.*

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.

Bahte SK, Bertram A, Burkhardt O, et al. Therapeutic serum concentrations of daptomycin after intraperitoneal administration in a patient with peritoneal dialysis-associated peritonitis [letter]. J Antimicrob Chemother. 2010;65:1312–4.

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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*

CrCL (mL/min)	*Complicated skin infections*	*Staphylococcus aureus bloodstream infections*
≥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:

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

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.

Greene W, Huffman D, Wienik PH, Schimpff S, Benjamin R, Bachur N. High-dose daunorubicin for acute nonlymphcytic leukemia: correlation of response and toxicity with pharmacokinetics and intracellular daunorubicin reductase activity. Cancer. 1972;30:1419–27.

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.

Daunorubicin/Cerubidine® **{Antineoplastic, anthracycline DNA topoisomerase II, and polymerase blocker}**

Usual initial dose: 25–45 mg/m^2 IV

Usual maintenance dose: 25–45 mg/m^2/day IV for two to three consecutive days of each cycle

Typical maximum dose: 60 mg/m^2 IV

Proportion eliminated unchanged: 20 % (as unchanged drug and active metabolites)

Adjustment for Kidney Disease

FDA-approved product labeling: *SCr >3.0 mg/dL* *Administer 50 % of the usual daily dose.*

Alternative adjustment: *Data not available*

Deferasirox - Selected References

Brosnahan G, Gokden N, Swaminathan S. Acute interstitial nephritis due to deferasirox: a case report. Nephrol Dial Transplant. 2008;23:3356–8.

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Quinn CT, Johnson VL, Kim H-Y, et al. Renal dysfunction in patients with thalassemia. Br J Haematol. 2011;153:111–7.

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Deferasirox/Exjade®	**{Fe^{3+} chelating agent; ℞ for chronic iron overload caused by blood transfusions (transfusional hemosiderosis)}**	
Usual initial dose:	20 mg/kg orally	
Usual maintenance dose:	20 mg/kg orally once daily 30 min before food	
Typical maximum dose:	40 mg/kg/day	
Proportion eliminated unchanged:	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*	

Deferoxamine - Selected References

Albalate M, Velasco L, Ortiz A, Monzú B, Casado S, Caramelo C. High risk of retinal damage by desferrioxamine in dialysis patients [letter]. Nephron. 1996;73:726–7.

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D'Haese PC, Couttenye M-M, De Broe ME. Diagnosis and treatment of aluminum bone disease. Nephrol Dial Transplant. 1996;11(Suppl 3):74–9.

Desferal® injection [package insert]. East Hanover: Novartis Pharmaceuticals Corp; 2010.

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Pengloan J, Dantal J, Rossazza C, Abazza M, Nivet H. Ocular toxicity after a single intravenous dose of desferrioxamine in 2 hemodialyzed patients. Nephron. 1987;46:211–2.

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Deferoxamine (Desferrioxamine)/Desferal®

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

Demeclocycline - Selected References

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

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

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Padfield PL, Hodsman GP, Morton JJ. Demeclocycline in the treatment of syndrome of inappropriate antidiuretic hormone release: with measurement of plasma ADH. Postgrad Med J. 1978;54:623–7.

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*

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.

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Gray E. Watton J, Cesmeli S, Barrowcliffe TW, Thomas DP. Experimental studies on a recombinant hirudin, CGP 39393. Thromb Haemost. 1991;65:355–9.

Iprivask® injection [package insert]. Hunt Valley: Canyon Pharmaceuticals; 2010.

Kaiser B, Simon A, Markwardt F. Antithrombotic effects of recombinant hirudin in experimental angioplasty and intravascular thrombolysis. Thromb Haemost. 1990;63:44–7.

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Marbet GA, Verstraete M, Kienast J, et al. Clinical pharmacology of intravenously administered recombinant desulfatohirudin (GGP 29393) in healthy volunteers. J Cardiovasc Pharmacol. 1993;22:364–72.

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Matheson AJ, Goa KL. Desirudin: a review of its use in the management of thrombotic disorders. Drugs. 2000;60: 679–700.

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Weitz JI, Hudoba M, Massel D, Maraganore J, Hirsch J. Clot-bound thrombin is protected from inhibition by heparin-antithrombin III but is susceptible to inactivation by antithrombin III-independent inhibitors. J Clin Invest. 1990;86:385–91.

Desirudin/Iprivask® **{Antithrombotic; direct thrombin inhibitor}**

Usual initial dose: 15 mg subcutaneously

Usual maintenance dose: 15 mg subcutaneously every 12 h

Typical maximum dose: 30 mg/day

Proportion eliminated unchanged: 40–50 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL ≥61 mL/min*	*15 mg subcutaneously every 12 h*
	CrCL ≥30–60 mL/min	*5 mg subcutaneously every 12 h*[a]
	CrCL <31 mL/min	*1.7 mg subcutaneously every 12 h*[a]
Alternative adjustment:	*GFR <10 mL/min*	*Minimal data available. Preferably avoid due to hemorrhagic risk*
	Hemodialysis	*Data not available*
	CRRT	*Data not available*

[a]*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*

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.

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Escolar G, Cases A, Monteagudo J, et al. Uremic plasma after infusion of desmopressin (DDAVP) improves the interaction of normal platelets with vessel endothelium. J Lab Clin Med. 1989;114:36–42.

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Desmopressin/DDAVP®, Stimate® **{Antidiuretic; hemostatic; arginine vasopressin analog; coagulation factor VIII stimulator; ℞ for central diabetes insipidus; ℞ for nocturnal enuresis; ℞ for hemorrhage}**

Usual initial dose: 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

Usual maintenance dose: 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

Typical maximum dose: 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

Proportion eliminated unchanged: 48 % (subcutaneously), 92 % (intranasal)

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL <50 mL/min*	*Contraindicated*
Alternative adjustment:	*CrCL <50 mL/min*	*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.*

Desvenlafaxine - Selected References

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

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

FDA-approved product labeling:	*CrCL >50 mL/min*	*50–400 mg orally once daily*
	CrCL 30–50 mL/min	*50 mg orally once daily*
	CrCL <30 mL/min	*50 mg orally every 48 h*
	Hemodialysis	*50 mg orally every 48 h (no supplemental dose after dialysis)*
	Note: Doses should not be escalated in patients with moderate or severe renal impairment or end-stage renal disease.	
Alternative adjustment:	*Data not available*	

Dexrazoxane - Selected References

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

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

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

Typical maximum dose: 1,000 mg/m^2 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^2 dexrazoxane to 50 mg/m^2 doxorubicin).*
Alternative adjustment:	*Data not available*	

Diatrizoate - Selected References

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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*

Diclofenac - Selected References

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Voltaren® tablet delayed release [package insert]. East Hanover: Novartis Pharmaceuticals Corp; 2011.

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

Usual initial dose: 50 mg orally

Usual maintenance dose: 50 mg orally two to three times daily

Typical maximum dose: 200 mg/day

Proportion eliminated unchanged: 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.*

Alternative adjustment:

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

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

Usual initial dose: 400 mg orally (250 mg if weight <60 kg)

Usual maintenance dose: 400 mg orally every 24 h (250 mg q12h if weight <60 kg)

Typical maximum dose: 400 mg orally

Proportion eliminated unchanged: 60 %

Adjustment for Kidney Disease

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

	Dosage (mg)	
CrCL (mL/min)	*≥60 kg*	*<60 kg*
≥60	*400 once daily*	*250 once daily*
30–59	*200 once daily*	*125 once daily*
10–29	*125 once daily*	*125 once daily*
<10	*125 once daily*	*Not suitable for use in patients <60 kg with CrCL <10 mL/min* *An alternate formulation of didanosine should be used*

Alternative adjustment:

GFR >50 mL/min	*200 mg orally every 12 h (125 mg q12h if <60 kg)*
GFR 10–50 mL/min	*200 mg orally every 24 h (125 mg q12h if <60 kg)*
GFR <10 mL/min	*125 mg orally every 24 h*
Hemodialysis	*125 mg orally every 24 h*
CAPD	*125 mg orally every 24 h*
CRRT	*200 mg enterally every 24 h (125 mg q12h if <60 kg)*

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.

Digoxin - Selected References

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Digoxin/Lanoxin®, Digitek® **{Inotropic agent; cardiac glycoside}**

Usual initial dose: 8–12 μg/kg IV or orally, e.g., 500 μg followed by 125 μg every 6 h ×2 doses

Usual maintenance dose: 125 μg IV or orally once daily

Typical maximum dose: 375 μg IV or orally once daily

Proportion eliminated unchanged: 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:

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

Therapeutic drug monitoring

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

Dihydroergotamine - Selected References

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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*	

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.

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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*

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

CrCL (mL/min)	*30–40*	*15–30*	*<15*
Approx maintenance–dosing interval	*q 8 h*	*q 12 h*	*q 24 h*

Alternative adjustment:

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

Dofetilide - Selected References

Coleman CI, Sood N, Chawla D, et al. Intravenous magnesium sulfate enhances the ability of dofetilide to successfully cardiovert atrial fibrillation or flutter: results of the Dofetilide and Intravenous Magnesium Evaluation. Europace. 2009;11:892–5.

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Dofetilide/Tikosyn® **{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*

Calculated CrCL (mL/min)	*Dofetilide dose*
>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.

Doripenem - Selected References

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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

Estimated CrCL (mL/min)	*Recommended dosage*
>50	*No dosage adjustment necessary*
≥30 to ≤50	*250 mg IV every 8 h*
>10 to <30	*250 mg IV every 12 h*

Alternative adjustment:

eCrCL >50 mL/min	*500 mg IV over 1–4 h every 8 h*
eCrCL 30–50 mL/min	*250 mg IV over 1–4 h every 8 h*
eCrCL 10–29 mL/min	*250 mg IV over 1–4 h every 12 h*
eCrCL <10 mL/min	*250 mg IV every 12 h*
Hemodialysis	*250 mg IV every 12 h or 500 mg IV every 24 h*
CVVHD	*250 mg IV every 12 h*
High flow CVVHDF	*500 mg IV every 12 h*

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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Ormseth MJ, Scholz BA, Boomershine CS. Duloxetine in the management of diabetic peripheral neuropathic pain. Patient Prefer Adherence. 2011;5:343–56.

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Duloxetine/Cymbalta® **{Antidepressant; anxiolytic; ℞ 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:

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

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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Dyphylline/Lufyllin® **{Bronchodilator; theophylline derivative; phosphodiesterase and prostaglandin inhibitor}**

Usual initial dose: 200 mg orally

Usual maintenance dose: 200–400 mg orally three or four times daily

Typical maximum dose: 15 mg/kg/day

Proportion eliminated unchanged: 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.*

Alternative adjustment:

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

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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 $CaNa_2EDTA$ and chelation of lead in renal failure. Clin Pharmacol Ther. 1986;40:686–93.

Edetate Calcium Disodium/ Calcium Disodium Versenate®

{Chelating agent; ℞ for lead poisoning}

Usual initial dose: 1,000 mg/m^2 IV or IM

Usual maintenance dose: If blood lead level is <70 mcg/dL but >20 mcg/dL (World Health Organization recommended upper allowable level), administer 1,000 mg/m^2/day IV or IM.

Typical maximum dose: 1,000 mg/m^2 IV or IM

Proportion eliminated unchanged: ~100 %

Adjustment for Kidney Disease

FDA-approved product labeling:

Normal renal function	*500 mg/m^2 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.*
Active renal disease/ anuria	*Contraindicated*

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.

Efavirenz and Emtricitabine and Tenofovir - Selected References

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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*

Emtricitabine - Selected References

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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*

	CrCL (mL/min)			
Formulation	*≥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:

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

Emtricitabine and Tenofovir - Selected References

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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*

CrCL (mL/min)[a]	*≥50*	*30–49*	*<30 (including patients requiring hemodialysis)*
Dosing interval	*Every 24 h*	*Every 48 h*	*Avoid*

[a]*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*

Enalapril - Selected References

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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*

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

Alternative adjustment:

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

Enalaprilat - Selected References

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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*

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

Alternative adjustment:

GFR >50 mL/min	*1.25 mg IV every 6 h over a 5-min period*
GFR 10–50 mL/min	*0.625–1.25 mg IV every 6 h*
GFR <10 mL/min	*0.312–0.625 mg IV every 6 h*
Hemodialysis	*0.312–0.625 mg IV every 6 h; dose after hemodialysis on dialysis days*
CAPD	*0.312–0.625 mg IV every 6 h*
CRRT	*0.625–1.25 mg IV every 6 h; titrate*

Enoxaparin - Selected References

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

Usual initial dose: 30–40 mg subcutaneously (prophylaxis); 1 mg/kg subcutaneously (treatment)

Usual maintenance dose: 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)

Typical maximum dose: 120 mg subcutaneously

Proportion eliminated unchanged: 40 %

Adjustment for Kidney Disease

FDA-approved product labeling:

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

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

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
[a]STEMI ST-elevation myocardial infarction, DVT deep vein thrombosis, PE pulmonary embolism

Alternative adjustment:	*GFR >50 mL/min*	*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)*
	GFR 10–50 mL/min	*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.*
	GFR <10 mL/min	*15 mg subcutaneously every 12 h (prophylaxis) or 0.5 mg/kg subcutaneously every 12 h (treatment) (50 % decrease); monitor anti-Xa levels.*
	Hemodialysis	*0.5 mg/kg subcutaneously every 12 h; monitor anti-Xa levels.*
	CAPD	*Data not available*
	CVVHD	*0.5–0.7 mg/kg IV every 12 h; monitor anti-Xa levels*

*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.*

Entecavir - Selected References

Baraclude® tablet and oral solution[package insert]. Princeton: Bristol-Myers Squibb Co; 2010.

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

Usual initial dose: 0.5 mg orally

Usual maintenance dose: 0.5–1 mg orally once daily

Typical maximum dose: 1 mg

Proportion eliminated unchanged: 65 %

Adjustment for Kidney Disease

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

CrCL (mL/min)	*Usual dose (nucleoside naïve)*	*Lamivudine-refractory or decompensated liver disease*
≥50	*0.5 mg once daily*	*1 mg once daily*
30 to <50	*0.25 mg once daily[b] 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[b] or 0.5 mg every 72 h*	*0.3 mg once daily[b] or 1 mg every 72 h*
<10; hemodialysis[a] or CAPD	*0.05 mg once daily[b] or 0.5 mg every 7 days*	*0.1 mg once daily[b] or 1 mg every 7 days*

[a]Administer after hemodialysis on dialysis days
[b]Oral solution is recommended for doses <0.5 mg

Alternative adjustment: *Entecavir oral dosage adapted to renal function*

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

[a]Administer after hemodialysis on dialysis days
[b]Oral solution is recommended for doses <0.5 mg

Eplerenone - Selected References

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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*	

Eptifibatide - Selected References

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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*

Eribulin - Selected References

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Eribulin/Halaven™ **{Antineoplastic; tubulin-based antimitotic; ℞ for refractory metastatic breast cancer}**

Usual initial dose: 1.4 mg/m^2 IV over 2–5 min

Usual maintenance dose: 1.4 mg/m^2 IV over 2–5 min on days 1 and 8 of a 21-day cycle for a minimum of four cycles

Typical maximum dose: 1.4 mg/m^2/dose

Proportion eliminated unchanged: 7 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Cr CL >50 mL/min*	*1.4 mg/m^2 IV over 2–5 min on days 1 and 8 of a 21-day cycle*
	CrCL 30–50 mL/min	*1.1 mg/m^2 IV over 2–5 min on days 1 and 8 of a 21-day cycle*
	CrCL <30 mL/min	*Not recommended (no data)*
Alternative adjustment:	*Data not available*	

Ertapenem - Selected References

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Ertapenem/Invanz® {Antibacterial; carbapenem}

Usual initial dose: 1 g IM or IV

Usual maintenance dose: 1 g IM or IV once daily

Typical maximum dose: 1 g/day

Proportion eliminated unchanged: 40 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL >30 mL/min*	*1 g IV daily*
	CrCL ≤30 mL/min	*500 mg IV daily*
	Hemodialysis	*500 mg IV daily; no supplemental dose is necessary if the daily doses are given within 6 h before dialysis; if given >6 h prior to dialysis, give supplemental dose of 150 mg IV.*
Alternative adjustment:	*GFR >50 mL/min*	*1 g IM or IV every 24 h or 1 g IV followed by continuous IV infusion of 1 g/24 h*
	GFR 10–50 mL/min	*1 g IM or IV every 24 h*
	GFR <10 mL/min	*500 mg IV every 24 h*
	Extended daily dialysis	*1 g IV every 24 h*
	Hemodialysis	*500 mg IV every 24 h; administer supplemental 150 mg IV after hemodialysis on dialysis days.*
	CAPD	*500 mg IM or IV every 24 h*
	CRRT	*1 g IV every 24 h*

Ethacrynic Acid - Selected References

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Ethacrynic Acid; Ethacrynate Sodium / Edecrin®

{Diuretic, loop/high ceiling}

Usual initial dose:	25–50 mg orally or 50 mg (0.5–1 mg/kg) IV
Usual maintenance dose:	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.
Typical maximum dose:	400 mg/day orally or 200 mg/day IV
Proportion eliminated unchanged:	20 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Anuria or severe progressive renal disease*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*50–200 mg/day*
	GFR 10–50 mL/min	*50–200 mg/day*
	GFR <10 mL/min	*Preferably avoid due to risk for gastrointestinal toxicity and ototoxicity*
	Hemodialysis	*Data not available*
	CAPD	*Data not available*
	CRRT	*Data not available*

Ethambutol - Selected References

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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:

GFR >50 mL/min	*15–25 mg/kg orally every 24 h*
GFR 10–50 mL/min	*15 mg/kg orally every 24–36 h or 10 mg/kg orally every 24 h*
GFR <10 mL/min	*15 mg/kg orally every 48 h or 7 mg/kg orally every 24 h*
Hemodialysis	*15–25 mg/kg orally every 48 h; after hemodialysis on dialysis days*
CAPD	*15 mg/kg orally every 48 h*
CRRT	*15–25 mg/kg enterally every 24–36 h*

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Ethionamide/Trecator® {Antitubercular; peptide synthesis inhibitor}

Usual initial dose: 250 mg orally

Usual maintenance dose: 500–1,000 mg/day (15–20 mg/kg/day) orally in three to four divided doses

Typical maximum dose: 1,000 mg/day

Proportion eliminated unchanged: 1 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Data not available*

Alternative adjustment:

GFR >50 mL/min	*500–1,000 mg/day (15–20 mg/kg/day) orally with or without food in two to four divided doses*
GFR 10–50 mL/min	*500–1,000 mg/day (15–20 mg/kg/day) orally with or without food in two to four divided doses*
GFR <10 mL/min	*250–500 mg/day (5–10 mg/kg/day) orally with or without food in two to three divided doses*
Hemodialysis	*250–500 mg orally twice daily with or without food, after hemodialysis on dialysis days*
CAPD	*250–500 mg/day (5–10 mg/kg/day) orally with or without food in two to three divided doses*
CRRT	*500–1,000 mg/day (15–20 mg/kg/day) orally with or without food in two to four divided doses*

Etodolac - Selected References

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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*

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Etoposide (VP-16)/Toposar™ **{Antineoplastic; podophyllotoxin derivative; antimitotic}**

Usual initial dose: 35–100 mg/m^2 IV

Usual maintenance dose: 50–100 mg/m^2/day IV on days 1–5 to 100 mg/m^2/day IV on days 1, 3, and 5 (testicular cancer); 35 mg/m^2/day for 4 days to 50 mg/m^2/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^2

Proportion eliminated unchanged: 45 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL >50 mL/min*	*35–100 mg/m^2 IV according to cancer type or protocol schedule*
	CrCL 15–50 mL/min	*26.25–75 mg/m^2 IV according to cancer type or protocol (75 % of usual dose)*
	CrCL <15 mL/min	*No data; further dose reduction should be considered.*
Alternative adjustment:	*GFR >50 mL/min*	*35–100 mg/m^2 IV according to cancer type or protocol schedule*
	GFR 30–50 mL/min	*26.25–75 mg/m^2 IV according to cancer type or protocol (75 % of usual dose)*
	GFR 10–29 mL/min	*26.25–75 mg/m^2 IV according to cancer type or protocol (75 % of usual dose)*
	GFR <10 mL/min	*17.5–50 mg/m^2 IV according to cancer type or protocol (50 % of usual dose)*
	Hemodialysis	*17.5–50 mg/m^2 IV according to cancer type or protocol (50 % of usual dose)*
	CAPD	*17.5–50 mg/m^2 IV according to cancer type or protocol (50 % of usual dose)*
	CRRT	*26.25–75 mg/m^2 IV according to cancer type or protocol (75 % of usual dose)*

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.

Exenatide - Selected References

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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

FDA-approved product labeling:	*CrCL 30–50 mL/min*	*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.*
	CrCL <30 mL/min	*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.*
	Renal transplantation	*Use with caution; exenatide may induce nausea and vomiting with transient hypovolemia, and treatment may worsen renal function.*
Alternative adjustment:	*eCrCL <30 mL/min*	*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 <30 mL/min, although in patients with moderate renal impairment, exenatide exposure was increased by 62 %.*

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Famciclovir/Famvir® **{Antiviral; penciclovir prodrug; nucleoside analog; viral DNA polymerase inhibr}**

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*
Single-day dosing regimens			
Recurrent genital herpes 1,000 mg every 12 h for 1 day	*≥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*
Recurrent herpes labialis 1,500 mg single dose	*≥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*
Multiple-day dosing regimens			
Herpes zoster 500 mg every 8 h	*≥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*
Suppression of recurrent genital herpes 250 mg every 12 h	*≥40*	*250*	*Every 12 h*
	20–39	*125*	*Every 12 h*
	<20	*125*	*Every 24 h*
	Hemodialysis	*125*	*Following each dialysis*
Recurrent orolabial or genital herpes in HIV-infected patients 500 mg every 12 h	*≥40*	*500*	*Every 12 h*
	20–39	*500*	*Every 24 h*
	<20	*250*	*Every 24 h*
	Hemodialysis	*250*	*Following each dialysis*
Alternative adjustment:	*CRRT*	*Not applicable (consider IV ganciclovir)*	

Famotidine (Oral) - Selected References

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Famotidine (Oral)/Pepcid® {Antacid; histamine H_2 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

FDA-approved product labeling:	*CrCL <50 mL/min*	*20 mg orally daily at bedtime or 40 mg orally every 36–48 h*
Alternative adjustment:	*GFR >50 mL/min*	*20 mg orally at bedtime or 10 mg orally twice daily*
	GFR 10–50 mL/min	*10–20 mg orally at bedtime*
	GFR <10 mL/min	*5–10 mg orally at bedtime*
	Hemodialysis	*10 mg orally at bedtime (after dialysis) or 20 mg orally three times weekly immediately after dialysis*
	CAPD	*5–10 mg orally at bedtime*
	CRRT	*10–20 mg enterally once daily in the evening*

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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Famotidine (IV)/Pepcid® IV {Antacid; histamine H_2 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

FDA-approved product labeling:	*CrCL <50 mL/min*	*10 mg IV every 12 h or 20 mg every 36–48 h*
Alternative adjustment:	*GFR >50 mL/min*	*20 mg IV every 12 h or 20 mg IV followed by continuous IV infusion of 1.66 mg/h (40 mg/24 h)*
	GFR 10–50 mL/min	*10 mg IV every 12 h*
	GFR <10 mL/min	*10 mg IV every 24 h*
	Hemodialysis	*10 mg IV every 24 h (after dialysis)*
	CAPD	*10 mg IV every 24 h*
	CRRT	*10 mg IV every 12 h*

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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Felbamate/Felbatol® {Antiepileptic; N-methyl-D-aspartate (NMDA) antagonist}

Usual initial dose: 1,200 mg/day orally in three or four divided doses

Usual maintenance dose: 1,200–3,600 mg/day orally in three or four divided doses

Typical maximum dose: 3,600 mg/day

Proportion eliminated unchanged: 25 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal dysfunction*	*Starting and maintenance doses should be reduced by one-half.*
Alternative adjustment:	*GFR >50 mL/min*	*1,200–3,600 mg/day orally in three or four divided doses*
	GFR 10–50 mL/min	*800–2,400 mg/day orally in three or four divided doses (25–50 % dose reduction)*
	GFR <10 mL/min	*600–1,800 mg/day orally in three or four divided doses (50 % dose reduction)*
	Hemodialysis	*600–1,800 mg/day orally in three or four divided doses (50 % dose reduction, dose after dialysis)*
	CAPD	*600–1,800 mg/day orally in three or four divided doses (50 % dose reduction)*
	CRRT	*600–1,800 mg/day enterally in three or four divided doses (50 % dose reduction)*

Fenofibrate - Selected References

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Fenofibrate/TriCor® **{Antihypercholesterolemic; fibric acid derivative; peroxisome proliferator-activated receptor-α 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

FDA-approved product labeling:	*Mild to moderate renal impairment (CrCL 30–80 mL/min)*	*48 mg orally once daily; increase only after evaluation of the effects on renal function and lipid levels at this dose.*
	Severe renal dysfunction (CrCL ≤30 mL/min)	*Contraindicated*
Alternative adjustment:	*Data not available*	

Fenoprofen - Selected References

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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

FDA-approved product labeling:	*Significantly impaired renal function*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*300–600 mg three to four times daily*
	GFR 10–50 mL/min	*300–600 mg three to four times daily*
	GFR <10 mL/min	*Preferably avoid due to risk for gastrointestinal and renal toxicity.*
	Hemodialysis	*Preferably avoid due to risk for gastrointestinal and renal toxicity.*
	CAPD	*Preferably avoid due to risk for gastrointestinal and renal toxicity.*
	CRRT	*Not applicable; preferably avoid.*

Fexofenadine - Selected References

Allegra® [package insert]. Bridgewater: Sanofi-Aventis US LLC; 2008.

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Fexofenadine/Allegra® **{Antihistamine; second-generation histamine H_1 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

FDA-approved product labeling:	*Decreased renal function*	*Starting dose is 60 mg once daily.*
Alternative adjustment:	*GFR >50 mL/min*	*60 mg orally every 12 h*
	GFR 10–50 mL/min	*60 mg orally every 12–24 h*
	GFR <10 mL/min	*60 mg orally every 24 h*
	Hemodialysis	*60 mg orally every 24 h (after dialysis)*
	CAPD	*60 mg orally every 24 h*
	CRRT	*60 mg enterally every 12 h*

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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Williams AJ, McQuinn RL, Walls J. Pharmacokinetics of flecainide acetate in patients with severe renal impairment. Clin Pharmacol Ther. 1988;43:449–55.

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:	*GFR >50 mL/min*	*50–100 mg orally every 12 h*
	GFR 10–50 mL/min	*50–75 mg orally every 12 h*[a]
	GFR <10 mL/min	*25–50 mg orally every 12 h*[a]
	Hemodialysis	*25–50 mg orally every 12 h*[a]
	CAPD	*25–50 mg orally every 12 h*[a]
	CVVH	*25–50 mg orally every 12 h*[a]

[a]*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.*

Fluconazole (IV) - Selected References

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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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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*

CrCL (mL/min)	*Percent of recommended dose*
>50	*100 %*
≤50 (no dialysis)	*50 %*
Regular dialysis	*100 % after each dialysis*

Alternative adjustment:

GFR >50 mL/min	*400–800 mg IV every 24 h*
GFR 10–50 mL/min	*200–400 mg IV every 24 h*
GFR <10 mL/min	*200 mg every IV 24 h*
Hemodialysis	*400 mg IV after dialysis*
CAPD	*200 mg IV every 24 h*
CVVH	*200–800 mg IV every 24 h*
CVVHD	*400–800 mg IV every 24 h*
CVVHDF	*400–800 mg IV every 24 h (consider 800 mg q24h if dialysate flow rate >2 L/h or treating Candida glabrata or other relatively azole-resistant species.)*

Fluconazole (Enteral) - Selected References

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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*

Single-dose treatment of vaginal candidiasis	*No adjustment needed*
Other fungal infections	
CrCL (mL/min)	*Percent of recommended dose*
>50	*100 %*
≤50 (no dialysis)	*50 %*
Regular dialysis	*100 % after each dialysis*

Alternative adjustment:

eCrCL >50 mL/min	*50–400 mg enterally every 24 h*
eCrCL 10–50 mL/min	*25–200 mg enterally every 24 h (50 % decrease)*
eCrCL <10 mL/min	*25–100 mg enterally every 24 h (75 % decrease)*
Hemodialysis	*50–400 mg enterally after each dialysis*
CAPD	*100 mg enterally every 24 h or 200 mg intraperitoneally during a 12-h dwell every 48 h*
CRRT	*Not applicable (consider parenteral antifungal)*

Flucytosine - Selected References

Ancobon® capsule [package insert]. Costa Mesa: Valeant Pharmaceuticals International; 2007.

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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:

GFR >50 mL/min	*37.5 mg/kg orally every 6 h*
GFR 10–50 mL/min	*25–37.5 mg/kg orally every 12–24 h*
GFR <10 mL/min	*15–25 mg/kg orally every 24 h*
Hemodialysis	*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*
CAPD	*500–1,000 mg orally every 24 h or 50 mg/L of peritoneal dialysis fluid (limited data)*
CVVH	*25–37.5 mg/kg orally every 24–48 h*

Fludarabine - Selected References

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Fludarabine/Fludara® {Antineoplastic; DNA polymerase-α and ribonucleotide reductase inhibitor}

Usual initial dose: 25 mg/m^2 IV

Usual maintenance dose: 25 mg/m^2 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^2 IV daily

Proportion eliminated unchanged: 60 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Fludarabine starting dose for renal impairment*

CrCL (mL/min)	*Starting dose*
≥80	*25 mg/m^2 (full dose)*
50–79	*20 mg/m^2*
30–49	*15 mg/m^2*
<30	*Do not administer/avoid*

Alternative adjustment:

GFR >50 mL/min	*30–50 mg/m^2 IV daily ×3 to 5 prior to hematopoietic stem cell transplantation*
GFR 10–50 mL/min	*25 mg/m^2 IV daily ×5 prior to hematopoietic stem cell transplantation*
GFR <10 mL/min	*12.5 mg/m^2 IV daily ×5*
Hemodialysis	*6–12.5 mg/m^2 IV daily ×5 (after dialysis)*
Extended daily dialysis	*40 mg/m^2 IV daily ×3 (limited data)*
CAPD	*12.5 mg/m^2 IV daily ×5*
CRRT	*18.75 mg/m^2 IV daily ×5*

Fomepizole - Selected References

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Fomepizole/Antizol® **{Antidote; ℞ 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*

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*

Fondaparinux - Selected References

Arixtra® injection [package insert]. Research Triangle Park: GlaxoSmithKline; 2011.

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Fondaparinux/Arixtra® **{Antithrombotic; selective antithrombin III-mediated coagulation factor Xa inhibitor}**

Usual initial dose:	2.5 mg subcutaneously (prophylaxis), 5–10 mg subcutaneously (treatment)
Usual maintenance dose:	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)
Typical maximum dose:	10 mg/day
Proportion eliminated unchanged:	77 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL 30–50 mL/min*	*Use with caution*
	CrCL <30 mL/min	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*2.5–10 mg subcutaneously once daily*
	GFR 30–50 mL/min	*1.5 mg subcutaneously once daily (prophylaxis)*
	GFR <30 mL/min	*Preferably avoid due to increased hemorrhagic risk.*
	Hemodialysis	*Data not available; preferably avoid due to increased hemorrhagic risk.*
	CAPD	*Data not available; preferably avoid due to increased hemorrhagic risk.*
	CRRT	*Data not available; preferably avoid due to increased hemorrhagic risk.*

Foscarnet - Selected References

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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

	Herpes simplex: equivalent to		*Cytomegalovirus: equivalent to*	
			180 mg/kg/day total	
CrCL (mL/min/kg)	*80 mg/kg/day total (40 mg/kg q12h)*	*120 mg/kg/day total (40 mg/kg q8h)*	*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

	Cytomegalovirus: equivalent to	
CrCL (mL/min/kg)	*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*

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Fosfomycin/Monurol® **{Antibacterial; phosphonic acid derivative}**

Usual initial dose: 3 g (one sachet) orally dissolved in cool or tepid (not hot) water

Usual maintenance dose: None (usual Rx for uncomplicated cystitis is single-dose treatment)

Typical maximum dose: 400 mg/kg/day (for serious systemic infections)

Proportion eliminated unchanged: 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.
Alternative adjustment:	*GFR <60 mL/min*	*3 g orally ×1 (no dose adjustment is necessary for single-dose treatment of uncomplicated cystitis with any level of kidney disease)*
	CrCL >80 mL/min	*2–8 g IV every 6–8 h*
	CrCL 40–79 mL/min	*2–4 IV every 12 h*
	CrCL 20–39 mL/min	*2–4 g IV followed by 2–4 g IV every 8 h*
	CrCL 5–19 mL/min	*2–4 g IV followed by 1–2 g IV every 12 h*
	CrCL <5 mL/min	*2–4 g IV followed by 1–2 g IV every 24 h*
	Hemodialysis	*2–4 g IV followed by 1–2 g IV after hemodialysis on dialysis days*
	CAPD	*4 g instilled intraperitoneally with a prolonged dwell ×1 followed by 1 g intraperitoneally every 48 h*
	CVVH	*8 g IV every 12 h*

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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Gabapentin/Neurontin® {Antiepileptic; adjunctive analgesic}

Usual initial dose: 100 mg orally

Usual maintenance dose: 300–600 mg orally three times daily

Typical maximum dose: 3,600 mg/day

Proportion eliminated unchanged: 80 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL ≥60 mL/min*	*600 mg sustained-release orally every evening*
	CrCL 30–59 mL/min	*600 mg sustained-release orally every 48 h*
	CrCL <30 mL/min	*Sustained-release tablets (600 mg) not recommended (℞ for restless legs)*

Gabapentin dosage based on renal function

CrCL (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*
		Post-hemodialysis supplemental dose (mg)				
Hemodialysis[a]		*125*	*150*	*200*	*250*	*350*

[a]*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*

Alternative adjustment:	*GFR ≥60 mL/min*	*300–1,200 mg enterally every 8 h*
	GFR 30–59 mL/min	*600 mg enterally every 12 h*
	GFR 10–29 mL/min	*200–600 mg enterally every 24 h*
	GFR <10 mL/min	*100 mg enterally every 24 h*
	Hemodialysis	*100 mg enterally every 24 h or 200–300 mg enterally after hemodialysis on dialysis days only*
	CAPD	*300 mg enterally every 48 h*
	CRRT	*300 mg enterally every 12–24 h*

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Gadobenate/MultiHance™ **{Gadolinium-based contrast agent}**

Usual initial dose: 0.2 mL/kg (0.1 mmol/kg) administered as a rapid bolus IV injection

Usual maintenance dose: N/A

Typical maximum dose: 0.2 mL/kg (0.1 mmol/kg)

Proportion eliminated unchanged: 78–96 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*GFR ≥30 mL/min/1.73 m²*	*0.2 mL/kg (0.1 mmol/kg) IV*
	GFR <30 mL/min/1.73 m²	*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.*
Alternative adjustment:	*GFR ≥30 mL/min*	*0.2 mL/kg (0.1 mmol/kg) IV*
	GFR <30 mL/min	*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 **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.*

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Gadodiamide/Omniscan™ **{Gadolinium-based contrast agent}**

Usual initial dose: 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

Usual maintenance dose: N/A

Typical maximum dose: 0.2 mL/kg (0.1 mmol/kg)

Proportion eliminated unchanged: 95 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*GFR ≥30 mL/min*	*0.1–0.2 mL/kg IV*
	GFR <30 mL/min	*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.*
Alternative adjustment:	*GFR ≥30 mL/min*	*0.1–0.2 mL/kg IV*
	GFR <30 mL/min	*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.*

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Gadopentetate/Magnevist® **{Gadolinium-based contrast agent}**

Usual initial dose:	0.2 mL/kg (0.1 mmol/kg) IV at a rate not to exceed 10 mL/15 s
Usual maintenance dose:	N/A
Typical maximum dose:	0.1 mmol/kg
Proportion eliminated unchanged:	92 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*GFR ≥30 mL/min/1.73 m²*	*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 m²	*Contraindicated*
Alternative adjustment:	*GFR ≥30 mL/min/1.73 m²*	*0.1 mmol/kg (0.2 mL/kg) IV*
	GFR <30 mL/min/1.73 m² 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.*

Gadoteridol - Selected References

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Thomsen HS. How to avoid nephrogenic systemic fibrosis: current guidelines in Europe and the United States. Radiol Clin North Am. 2009;47:871–5.

Gadoteridol/ProHance®	**{Gadolinium-based contrast agent}**
Usual initial dose:	0.2 mL/kg (0.1 mmol/kg) IV as a rapid bolus (>60 mL/min) or infusion (10–60 mL/min)
Usual maintenance dose:	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
Typical maximum dose:	0.4 mL/kg (0.2 mmol/kg)
Proportion eliminated unchanged:	98 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*GFR ≥30 mL/min*	*0.2 mL/kg (0.1 mmol/kg) IV as a rapid bolus (>60 mL/min) or infusion (10–60 mL/min)*
	GFR <30 mL/min	*0.2 mL/kg (0.1 mmol/kg) IV as a rapid bolus (>60 mL/min) or infusion (10–60 mL/min)*
Alternative adjustment:	*GFR ≥30 mL/min*	*0.2 mL/kg (0.1 mmol/kg) IV as a rapid bolus (>60 mL/min) or infusion (10–60 mL/min)*
	GFR <30 mL/min/1.73 m² and patients with acute kidney injury of any severity due to hepatorenal syndrome or in the perioperative liver transplant period	*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.*

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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Thomsen HS. How to avoid nephrogenic systemic fibrosis: current guidelines in Europe and the United States. Radiol Clin North Am. 2009;47:871–5.

Gadoversetamide/OptiMARK™ {Gadolinium-based contrast agent}

Usual initial dose: 0.2 mL/kg (0.1 mmol/kg) IV at a rate of 1–2 mL/s

Usual maintenance dose: N/A

Typical maximum dose: 0.2 mL/kg (0.1 mmol/kg)

Proportion eliminated unchanged: 96 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*GFR ≥30 mL/min/1.73 m²*	*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 m²	*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.*

Gadoxetate - Selected References

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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 m²*	*0.1 mL/kg IV*
	GFR <30 mL/min/1.73 m²	*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 m²) 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*	*0.1 mL/kg IV*
	GFR <30 mL/min and/or acute kidney injury of any severity due to hepatorenal syndrome or in the perioperative liver transplant period	*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.*

Galantamine - Selected References

Bickel U, Thomsen T, Weber W, et al. Pharmacokinetics of galanthamine in humans and corresponding cholinesterase inhibition. Clin Pharmacol Ther. 1991;50:420–8.

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Galantamine/Razadyne® **{Reversible competitive acetylcholinesterase inhibitor; ℞ 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*	

Gallium Nitrate - Selected References

Bockman R. The effects of gallium nitrate on bone resorption. Semin Oncol. 2003;30(Suppl 5):5–12.

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Zojer N, Keck AV, Pecherstorfer M. Comparative tolerability of drug therapies for hypercalcemia of malignancy. Drug Saf. 1999;21:389–406.

Gallium Nitrate/Ganite™ **{Hypocalcemic agent; bone resorption inhibitor}**

Usual initial dose: 200 mg/m^2 IV daily

Usual maintenance dose: 200 mg/m^2 continuous IV infusion over 24 h daily for 5 consecutive days or until normalization of serum calcium levels

Typical maximum dose: 200 mg/m^2 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*	

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.

Bastien O, Boulieu R, Bleyzac N, Estanove S. Clinical use of ganciclovir during renal failure and continuous hemodialysis. Intensive Care Med. 1994;20:47–8.

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De Keyser K, Van Laecke S, Peeters P, Vanholder R. Human cytomegalovirus and kidney transplantation: a clinician's update. Am J Kidney Dis. 2011;58:118–26.

Erice A, Jordan C, Chac BA, Fletcher C, Chinnock BJ, Balfour JJ Jr. Ganciclovir treatment of cytomegalovirus disease in transplant recipients and other immunocompromised hosts. JAMA. 1987;257:3082–7.

Fletcher C, Sawchuck R, Chinnock B, de Miranda P, Balfour HH Jr. Human pharmacokinetics of the antiviral drug DHPG. Clin Pharmacol Ther. 1986;40:281–6.

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Jassal SV, Roscoe JM, Zaltzman JS, et al. Clinical practice guidelines: prevention of cytomegalovirus disease after renal transplantation. J Am Soc Nephrol. 1998;9:1697–708.

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Lake KD, Fletcher CV, Love KR, Brown DC, Joyce LD, Pritzker MR. Ganciclovir pharmacokinetics during renal impairment. Antimicrob Agents Chemother. 1988;32:1899–900.

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Ganciclovir (IV)/Cytovene® IV **{Antiviral; nucleoside analog; ℞ 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*

	Induction		*Maintenance*	
CrCL (mL/min)	*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*

Ganciclovir (Oral) - Selected References

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Ganciclovir (Oral)/Cytovene® **{Antiviral; nucleoside analog; ℞ 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*

CrCL (mL/min)	*Ganciclovir capsule doses*
≥ 70	*1,000 mg 3 times daily or 500 mg every 3 hours, 6 times daily*
50 to 69	*1,500 mg once daily or 500 mg 3 times daily*
25 to 49	*1,000 mg once daily or 500 mg twice daily*
10 to 24	*500 mg once daily*
< 10	*500 mg 3 times per week following hemodialysis*

Alternative adjustment:

GFR >50 mL/min	*1,000 mg orally three times daily*
GFR 10–50 mL/min	*1,000 mg orally twice daily*
GFR <10 mL/min	*500 mg orally every 48 h*
Hemodialysis	*500 mg orally three times/week after dialysis*
CAPD	*500 mg orally every 48 h*
CRRT	*Not applicable (consider IV ganciclovir)*

*Note: Oral ganciclovir should be used only for prophylaxis (*not *treatment) of cytomegalovirus disease.*

Gemfibrozil - Selected References

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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

FDA-approved product labeling:	*Mild to moderate renal impairment*	*Use with caution.*
	Severe renal impairment	*Contraindicated.*
Alternative adjustment:	*GFR >50 mL/min*	*600 mg orally twice daily.*
	GFR 10–50 mL/min	*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.*
	GFR <10 mL/min	*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.*
	Hemodialysis	*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.*
	CAPD	*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.*
	CRRT	*Not applicable; preferably avoid.*

Gemifloxacin - Selected References

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Gemifloxacin/Factive® {Antibacterial; fluoroquinolone}

Usual initial dose:	320 mg orally
Usual maintenance dose:	320 mg orally once daily
Typical maximum dose:	320 mg/day
Proportion eliminated unchanged:	25–40 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL >40 mL/min*	*320 mg orally once daily*
	CrCL ≤40 mL/min	*160 mg orally every 24 h*
	Hemodialysis	*160 mg orally every 24 h*
	Peritoneal dialysis (CAPD)	*160 mg orally every 24 h*
Alternative adjustment:	*GFR >50 mL/min*	*320 mg orally every 24 h*
	GFR 10–50 mL/min	*160–320 mg orally every 24 h*
	GFR <10 mL/min	*160 mg every 24 h*
	Hemodialysis	*160 mg every 24 h; administer after hemodialysis on dialysis days*
	CAPD	*160 mg every 24 h*
	CRRT	*160–320 mg every 24 h*

Gentamicin - Selected References

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Gentamicin/Garamycin® {Antibacterial; aminoglycoside}

Usual initial dose: 2–7 mg/kg IV (actual body weight [ABW] or ideal [IBW] + 0.4(ABW – IBW) if ABW > IBW)

Usual maintenance dose: 3–5 mg/kg/day in two to three divided doses or 4–7 mg/kg IV every 24 h

Typical maximum dose: 10 mg/kg/day

Proportion eliminated unchanged: 95 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Dosage adjustment guide for patients with renal impairment*[a] *(dosage at 8-h intervals after the usual initial dose)*

Serum creatinine (mg/dL)	*CrCL (mL/min)*	*Percent of usual dose*
≤1.0	*>100*	*100*
1.1–1.3	*70–100*	*80*
1.4–1.6	*55–70*	*65*
1.7–1.9	*45–55*	*55*
2.0–2.2	*40–45*	*50*
2.3–2.5	*35–40*	*40*
2.6–3.0	*30–35*	*35*
3.1–3.5	*25–30*	*30*
3.6–4.0	*20–25*	*25*
4.1–5.1	*15–20*	*20*
5.2–6.6	*10–15*	*15*
6.7–8.0	*< 10*	*10*

Hemodialysis: 1–1.7 mg/kg at the end of each dialysis

Alternative adjustment:

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*[a]
GFR 10–50 mL/min	*2–2.5 mg/kg IV once followed by 1.7 mg/kg IV every 24–48 h*[a] *(if pre-dose plasma level is within desired range, usually ≤1 mg/L)*[a]
GFR <10 mL/min	*1.7 mg/kg IV every 72 h (if pre-dose plasma level is within desired range, usually ≤1 mg/L)*[a]
Hemodialysis	*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)*[a]
CAPD	*Add to dialysate qs 4–8 mg/L*[a]
CVVHD or CVVHDF	*1.5–2.5 mg/kg IV every 24–48 h (if pre-dose plasma level is within desired range, usually ≤1 mg/L)*[a]

[a]*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.

Glipizide - Selected References

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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:

GFR >50 mL/min	*2.5–15 mg once or twice daily according to blood glucose levels.*
GFR 10–50 mL/min	*2.5–7.5 mg once or twice daily according to blood glucose levels.*
GFR <10 mL/min	*Preferably avoid due to risk of severe hypoglycemia.*
Hemodialysis	*Preferably avoid due to risk of severe hypoglycemia.*
CAPD	*Preferably avoid due to risk of severe hypoglycemia.*
CRRT	*Not applicable; preferably avoid due to risk of severe hypoglycemia.*

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Glyburide/Micronase®, Diaβeta® **{Antidiabetic; sulfonylurea}**

Usual initial dose:	2.5–5 mg orally once daily before breakfast
Usual maintenance dose:	1.25–20 mg/day orally in single or divided doses
Typical maximum dose:	20 mg/day
Proportion eliminated unchanged:	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.*

Alternative adjustment:	*GFR >50 mL/min*	*1.25–10 mg once or twice daily according to blood glucose levels*
	GFR 30–50 mL/min	*1.25–5 mg once or twice daily according to blood glucose levels*
	GFR <30 mL/min	*Preferably avoid due to risk of severe hypoglycemia.*
	Hemodialysis	*Preferably avoid due to risk of severe hypoglycemia.*
	CAPD	*Preferably avoid due to risk of severe hypoglycemia.*
	CRRT	*Not applicable; preferably avoid due to risk of severe hypoglycemia.*

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6% Hetastarch in 0.9% Sodium Chloride/ Hespan® 6% Hetastarch in Lactated Electrolyte Injection/Hextend®

{Plasma volume expander; colloid}

Usual initial dose: 500 mL IV

Usual maintenance dose: 500–1,000 mL/day IV

Typical maximum dose: 20 mL/kg (≈1,500 mL) per day

Proportion eliminated unchanged: 33 %

Adjustment for Kidney Disease

FDA-approved product labeling:

Renal disease with oliguria or anuria not related to hypovolemia	*Contraindicated*

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.

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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*

Hydroxyethyl Starch 130/0.4 in 0.9 % Sodium Chloride - Selected References

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6 % Hydroxyethyl Starch 130/0.4 in 0.9 % Sodium Chloride /Voluven®

{Plasma volume expander; colloid}

Usual initial dose:	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
Usual maintenance dose:	≤50 mL/kg (3 g/kg) per day (equivalent to 3,500 mL in a 70-kg patient)
Typical maximum dose:	50 mL/kg/day (~3,500 mL/day)
Proportion eliminated unchanged:	59–70 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal dysfunction*	*Adjust dosage, avoid fluid overload*
	Renal failure with oliguria or anuria not associated with hypovolemia	*Contraindicated*
Alternative adjustment:	*eCrCL 30–50 mL/min*	*≤500 mL/24 h IV*
	eCrCL 15–30 mL/min	*≤500 mL/24 h IV*
	Hemodialysis	*Data not available; preferably avoid due to risk for accumulation and possible nephrotoxicity*
	CAPD	*Data not available; preferably avoid due to risk for accumulation and possible nephrotoxicity*
	CRRT	*Data not available; preferably avoid due to risk for accumulation and possible nephrotoxicity*

Hydroxyurea - Selected References

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Hydroxyurea (Hydroxycarbamide)/ Hydrea®, Droxia®

{Antineoplastic; ribonucleotide reductase inhibitor}

Usual initial dose: Malignancy, 20–30 mg/kg orally; sickle cell disease, 15 mg/kg orally

Usual maintenance dose: 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

Typical maximum dose: 35 mg/kg/day

Proportion eliminated unchanged: 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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Ibandronate/Boniva® **{Anti-osteoporotic; bisphosphonate}**

Usual initial dose: 2.5 mg or 150 mg orally or 3 mg IV

Usual maintenance dose: 2.5 mg orally once daily or 150 mg orally once monthly or 3 mg IV over 15–30 s every 3 months

Typical maximum dose: 150 mg/month orally or 6 mg IV over 15–60 min every 3 months

Proportion eliminated unchanged: 50–60 % of an IV dose within 24 h

Adjustment for Kidney Disease

FDA-approved product labeling:	*Mild or moderate renal impairment*	*No dose adjustment needed*
	Severe renal impairment (SCr >2.3 mg/dL or CrCL <30 mL/min)	*Use not recommended*
Alternative adjustment:	*GFR ≥30 mL/min*	*150 mg orally once monthly or 3–6 mg IV every 3 months*
	GFR <30 mL/min	*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*

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Idarubicin/Idamycin® **{Antineoplastic; anthracycline}**

Usual initial dose: 12 mg/m^2 IV

Usual maintenance dose: 12 mg/m^2 IV daily for 3 days

Typical maximum dose: 12 mg/m^2/day

Proportion eliminated unchanged: 3–5 % in 24 h, 16 % in 4 days (8 % of active hydroxylated metabolite, idarubicinol)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal impairment*	*Dose reduction should be considered.*
Alternative adjustment:	*GFR >50 mL/min*	*12 mg/kg IV daily for 3 days*
	GFR 10–50 mL/min	*8 mg/kg IV daily for 3 days (~25 % decrease)*
	GFR <10 mL/min	*6 mg/kg IV daily for 3 days (50 % decrease)*
	Hemodialysis	*Data not available*
	CAPD	*Data not available*
	CRRT	*Data not available*

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

Ifosfamide - Selected References

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Ifosfamide/Ifex® **{Antineoplastic; alkylating agent}**

Usual initial dose: 1.2 g/m^2

Usual maintenance dose: 1.2 g/m^2 IV over 1–2 h daily for 5 consecutive days every 3 weeks or after hematological recovery (with mesna)

Typical maximum dose: May be limited by hematological toxicity

Proportion eliminated unchanged: 14 % (Stereoselective renal metabolism may contribute to production of nephrotoxic metabolites such as chloroacetaldehyde.)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Compromised renal function*	*Studies to establish optimal dose schedules in such patients have not been conducted.*
Alternative adjustment:	*GFR >50 mL/min*	*1.2 g/m^2 IV daily for 5 days every 3 weeks or after hematological recovery*
	GFR 10–50 mL/min	*0.9 g/m^2 IV daily for 5 days every 3 weeks or after hematological recovery (25 % decrease)*
	GFR <10 mL/min	*0.6 g/m^2 IV daily for 5 days every 3 weeks or after hematological recovery (50 % decrease)*
	Hemodialysis	*0.0.4–0.6 g/m^2 IV daily for 5 days every 3 weeks or after hematological recovery (~50 % decrease)*
	CAPD	*0.6 g/m^2 IV daily for 5 days every 3 weeks or after hematological recovery (50 % decrease)*
	CRRT	*0.9 g/m^2 IV daily for 5 days*

Note: Urological, hematological, and/or other considerations may suggest further dosage adjustments.

Imatinib - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Imatinib/Gleevec®	**{Antineoplastic; protein-tyrosine kinase inhibitor}**	
Usual initial dose:	400–600 mg orally with a meal	
Usual maintenance dose:	400–600 mg orally once daily or 400 mg orally twice daily with meals	
Typical maximum dose:	1,200 mg/day	
Proportion eliminated unchanged:	5 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*CrCL ≥60 mL/min*	*400–600 mg orally once daily with a meal or 400 mg orally twice daily with meals*
	CrCL 40–59 mL/min	*400–600 mg orally once daily with a meal*
	CrCL 20–39 mL/min	*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)*
	CrCL <20 mL/min	*100 mg orally once daily with a meal*
Alternative adjustment:	*eCrCL ≥60 mL/min*	*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.*
	eCrCL 40–59 mL/min	*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.*
	eCrCL 20–39 mL/min	*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.*
	eCrCL <20 mL/min	*100 mg orally once daily was generally well tolerated in two patients.*
	Hemodialysis	*400 mg orally once daily with a meal was effective and well tolerated in at least two patients.*

Imipenem/Cilastatin - Selected References

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Imipenem/Cilastatin/Primaxin® **{Antibacterial; carbapenem}**

Usual initial dose: 500 mg IV

Usual maintenance dose: 500 mg IV every 6 h

Typical maximum dose: 4,000 mg/day

Proportion eliminated unchanged: 70 %

Adjustment for Kidney Disease

FDA-approved product labeling:

Imipenen-cilastatin reduced IV dosage in adult patients with impaired renal function

	Body weight (kg)				
CrCL (mL/min)	*≥70*	*60*	*50*	*40*	*30*
	If total daily dose for normal renal function is 1 g/day, use:				
≥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*
	If total daily dose for normal renal function is 1.5 g/day, use:				
≥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*
	If total daily dose for normal renal function is 2 g/day, use:				
≥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*
	If total daily dose for normal renal function is 3 g/day, use:				
≥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*
	If total daily dose for normal renal function is 4 g/day, use:				
≥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

Alternative adjustment:

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	

Indapamide - Selected References

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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

FDA-approved product labeling:	*Severe renal disease*	*Use with caution.*
	Anuria	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*2.5 mg orally once daily*
	GFR 10–50 mL/min	*1.25–2.5 mg orally once daily*
	GFR <10 mL/min	*1.25–2.5 mg orally once daily (limited data available)*
	Hemodialysis	*1.25–2.5 mg orally once daily (limited data available)*
	CAPD	*Data not available; preferably avoid due to potentially limited effectiveness*
	CRRT	*Not applicable; preferably avoid*

Indomethacin - Selected References

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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

FDA-approved product labeling:	*Advanced renal disease*	*Not recommended, avoid*
Alternative adjustment:	*Hemodialysis*	*25 mg orally three times daily*

Insulins - Selected References

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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}**

Usual initial dose: 0.2–0.4 units/kg/day subcutaneously in divided amounts; 0.1–14 units/h IV

Usual maintenance dose: 0.5–2 units/kg/day subcutaneously in divided amounts, often 40–60 % as basal insulin with the remainder as prandial rapid-acting insulin

Typical maximum dose: Widely variable

Proportion eliminated unchanged: None

Adjustment for Kidney Disease

FDA-approved product labeling: *The requirements for insulin may be reduced in patients with renal impairment.*

Alternative adjustment:

GFR >50 mL/min	*100 % of usual dose; monitor and titrate.*
GFR 10–50 mL/min	*75 % of usual dose; monitor and titrate.*
GFR <10 mL/min	*50 % of usual dose; monitor and titrate.*
Hemodialysis	*50 % of usual dose; no supplemental dose after dialysis; monitor and titrate.*
CAPD	*50 % of usual dose; monitor and titrate.*
CRRT	*75 % of usual dose; monitor and titrate.*

Interferon Alfa-2b and Ribavirin - Selected References

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Interferon Alfa-2b and Ribavirin/Rebetron™ {Antiviral; ℞ for hepatitis C}

Usual initial dose:	Interferon alfa-2b three million units intramuscularly or subcutaneously three times weekly plus ribavirin 1,000–1,200 mg/day in two divided doses
Usual maintenance dose:	Interferon alfa-2b three million units intramuscularly or subcutaneously three times weekly plus ribavirin 1,000–1,200 mg/day in two divided doses
Typical maximum dose:	Interferon alfa-2b three million units intramuscularly or subcutaneously three times weekly plus ribavirin 1,200 mg/day in two divided doses
Proportion eliminated unchanged:	Interferon alfa-2b = nil; ribavirin 5–15 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL <50 mL/min*	*Contraindicated (ribavirin)*
Alternative adjustment:	*Hemodialysis*	*Three million units subcutaneously three times weekly with ribavirin 200 mg orally once daily*

Isocarboxazid - Selected References

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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*	

Itraconazole - Selected References

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Itraconazole/Sporanox® **{Antifungal; triazole ergosterol biosynthesis inhibitor}**

Usual initial dose: 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

Usual maintenance dose: Capsules, 200 mg orally once or twice daily with food; oral solution, 100 mg orally twice daily without food

Typical maximum dose: 600 mg/day

Proportion eliminated unchanged: <1 % (35 % as inactive metabolites)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal impairment*	*Caution should be exercised when this drug is administered in this patient population.*
Alternative adjustment:	*GFR >50 mL/min*	*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*
	GFR 10–50 mL/min	*Oral solution: 100 mg enterally every 12 h given without food*
	GFR <10 mL/min	*Oral solution: 50–100 mg enterally every 12 h given without food (50 % decrease)*
	Hemodialysis	*Oral solution: 100 mg enterally every 12 h given without food*
	CAPD	*Oral solution: 50–100 mg enterally every 12 h given as an oral solution without food*
	CVVH	*Oral solution: 100 mg enterally every 12 h given without food*
	CVVHD or CVVHDF	*Oral solution: 100–200 mg enterally every 12 h given without food*

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Kanamycin - Selected References

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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 × SCr [mg/dL]) h[a]*	
Alternative adjustment:	*GFR >50 mL/min*	*7.5 mg/kg IM or IV every 12–24 h[a]*
	GFR 10–50 mL/min	*7.5 mg/kg IM or IV every 24–72 h[a]*
	GFR <10 mL/min	*7.5 mg/kg IM or IV every 48–72 h[a]*
	Hemodialysis	*3.75 mg/kg IM or IV after hemodialysis on dialysis days only[a]*
	CAPD	*Add to dialysate qs 15–20 mg/L[a]*
	CRRT	*7.5 mg/kg IM or IV every 24–72 h[a]*

[a]Therapeutic Drug Monitoring

Therapeutic plasma levels:	*Peak: 25–35 mg/L*
	Trough: 4–8 mg/L

Ketoprofen - Selected References

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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

FDA-approved product labeling:	*Mildly impaired renal function*	*Max 150 mg/day*
	Severe/end-stage renal impairment (GFR <25 mL/min/1.73 m^2)	*Max 100 mg/day*
Alternative adjustment:	*GFR >50 mL/min*	*25–75 mg orally three times daily*
	GFR 10–50 mL/min	*25–50 mg orally three times daily (~25 % decrease)*
	GFR <10 mL/min	*12.5–25 mg orally two to three times daily (~50 % decrease)*
	Hemodialysis	*12.5–25 mg orally two to three times daily (~50 % decrease)*
	CAPD	*12.5–25 mg orally two to three times daily (~50 % decrease)*
	CRRT	*Not applicable; preferably avoid*

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Ketorolac/Toradol®	**{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

FDA-approved product labeling:	*Renally impaired patients*	*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 >40 mg/day*
	Advanced renal impairment or patients at risk for renal failure due to volume depletion	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*15–30 mg IM or IV every 6 h, not to exceed 5 days duration*
	GFR 10–50 mL/min	*Preferably avoid or 7.5–15 mg IM or IV every 6 h, not to exceed 5 days duration (50 % decrease)*
	GFR <10 mL/min	*Preferably avoid due to risk for gastrointestinal and renal toxicity*
	Hemodialysis	*Preferably avoid due to risk for gastrointestinal and renal toxicity*
	CAPD	*Preferably avoid due to risk for gastrointestinal and renal toxicity*
	CRRT	*7.5–15 mg IM or IV every 6 h, not to exceed 5 days duration*

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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

FDA-approved product labeling:	*Mild to moderate renal impairment (CrCL >30 mL/min)*	*100–200 mg enterally or IV twice daily (no dose adjustment necessary)*
	Severe renal impairment (CrCL ≤30 mL/min)	*100–150 mg enterally or IV twice daily (max 300 mg/day)*
	Hemodialysis	*Give supplemental dose (50 % of single maintenance dose amount) after each dialysis.*
Alternative adjustment:	*GFR ≤30 mL/min*	*100–150 mg enterally or IV twice daily (max 300 mg/day; cardiac monitoring is recommended during dose titration and intercurrent acute illness)*

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Lamivudine (3TC)/Epivir® {Antiretroviral; nucleoside analog; ℞ 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)*

CrCL (mL/min)	*Recommended dosage of lamivudine*
Human immunodeficiency virus (HIV-1) infection	
≥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*
Hepatitis B virus HBV infection	
≥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:	*GFR >50 mL/min*	*150 mg orally every 12 h or 300 mg orally once daily*
	GFR 10–50 mL/min	*150 mg orally every 24 h*
	GFR <10 mL/min	*20 mg orally every 24 h*
	Hemodialysis	*25 mg orally once daily or 75 mg orally every other day; administer after hemodialysis on dialysis days.*
	CAPD	*10 mg orally once daily*
	CRRT	*150 mg orally every 24 h*

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Lanreotide/Somatuline® Depot **{Somatostatin analog; ℞ 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*

Patient response	*Dose*
GH >1 to ≤2.5 ng/mL; normalized IGF-1; and/or controlled clinical symptoms	*90 mg every 28 days*
GH >2.5 ng/ml; IGF-1 elevated; and/or clinical symptoms uncontrolled	*120 mg every 28 days*
GH ≤1 ng/mL; IGF-1 normal clinical symptoms controlled	*60 mg every 28 days*

Alternative adjustment: *Data not available*

Lenalidomide - Selected References

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Lenalidomide/Revlimid® **{Immunomodulator; ℞ 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*

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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*

		Adjusted infusion rate	
CrCL [mL/min]	*SCr [mg/dL]*	*% 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)*

Levetiracetam - Selected References

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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*

Renal function status	*CrCL (mL/min)*	*Oral or IV dose (mg)*	*Frequency*
Healthy	*>80*	*500–1,500*	*Every 12 h*
Mild	*50–80*	*500–1,000*	*Every 12 h*
Moderate	*30–50*	*250–750*	*Every 12 h*
Severe	*<30*	*250–500*	*Every 12 h*
ESRD patients on dialysis	*–*	*500–1,000*	*Every 24 h*

Alternative adjustment:

GFR >50 mL/min	*500–1,000 mg orally or IV every 12 h*
GFR 10–50 mL/min	*250–750 mg orally or IV every 12 h*
GFR <10 mL/min	*500–1,000 mg orally or IV every 24 h*
Hemodialysis	*500–1,000 mg orally or IV every 24 h plus 250–500 mg after hemodialysis on dialysis days*
CAPD	*500–1,000 mg orally or IV every 24 h*
CRRT	*250–750 mg orally or IV every 12 h*

Levocetirizine - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Levocetirizine/Xyzal®	**{Antihistamine; second-generation histamine H_1 blocker}**	
Usual initial dose:	5 mg orally	
Usual maintenance dose:	2.5–5 mg orally once daily	
Typical maximum dose:	10 mg	
Proportion eliminated unchanged:	77 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*Mild renal impairment (CrCL 50–80 mL/min)*	*2.5 mg orally once daily in the evening*
	Moderate renal impairment (CrCL 30–50 mL/min)	*2.5 mg orally every other day in the evening*
	Severe renal impairment (CrCL 10–30 mL/min)	*2.5 mg orally twice weekly in the evening*
	End-stage renal disease (CrCL <10 mL/min)	*Contraindicated*
	Hemodialysis	*Contraindicated*
Alternative adjustment:	*CRRT*	*Not applicable*

Levofloxacin - Selected References

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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)

Dosage in normal renal function	*CrCL 20–49 mL/min*	*CrCL 10–19 mL/min*	*Hemodialysis or chronic ambulatory peritoneal dialysis (CAPD)*
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

Alternative adjustment:	*GFR >50 mL/min*	*500–750 mg orally or IV once followed by 250–750 mg orally or IV every 24 h*
	GFR 10–50 mL/min	*500–750 mg orally or IV once followed by 250–750 mg orally or IV every 24–48 h*
	GFR <10 mL/min	*500–750 mg orally or IV once followed by 250–500 mg orally or IV every 48 h*
	Hemodialysis	*500–750 mg orally or IV once followed by 250–500 mg orally or IV every 48 h; administer after hemodialysis on dialysis days.*
	CAPD	*500–750 mg orally or IV once followed by 250–500 mg orally or IV every 48 h*
	CVVH	*500–750 mg IV once followed by 250 mg IV every 24 h*
	CVVHD	*500–750 mg IV once followed by 250–500 mg IV every 24 h*
	CVVHDF	*500–750 mg IV once followed by 250–750 mg IV every 24 h*

Lisinopril - Selected References

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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*

Renal status	*CrCL (mL/min)*	*SCr (mg/dL)*	*Initial dose (mg/day)*
Healthy renal function to mild impairment	*>30*	*<3*	*10*
Moderate to severe renal function impairment	*≥10* *≤30*	*≥3.0*	*5*
Dialysis patients	*<10*	–	*2.5*

No adjustment is necessary for patients with CrCL ≥30 mL/min

Alternative adjustment:

GFR >50 mL/min	*5–10 mg initially followed by 5–40 mg/day*
GFR 10–50 mL/min	*2.5–5 mg initially followed by 5–20 mg/day (25–50 % decrease)*
GFR <10 mL/min	*2.5 mg initially followed by 2.50–20 mg/day (50–75 % decrease)*
Hemodialysis	*2.5 mg initially followed by 2.50–20 mg/day (50–75 % decrease)*
CAPD	*Data not available*
CRRT	*2.5–5 mg initially followed by 5–20 mg/day*

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.

Alternative adjustment:

GFR >50 mL/min	*900–1,200 mg/day orally in divided doses*
GFR 10–50 mL/min	*300–600 mg/day orally in divided doses (25–50 % decrease)*
GFR <10 mL/min	*150–450 mg/day orally in divided doses (50–75 % decrease)*
Hemodialysis	*150–450 mg/day orally in divided doses; dose after dialysis*
CAPD	*150–450 mg/day orally in divided doses*
CRRT	*300–600 mg/day enterally in divided doses*

Therapeutic Drug Monitoring

Therapeutic plasma levels: *0.6–1.2 mEq/L; draw sample 8–12 h after previous dose (just before next dose).*

Lomustine - Selected References

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Lomustine/CeeNU® **{Antineoplastic; alkylating agent; nitrosourea}**

Usual initial dose: 130 mg/m^2 orally

Usual maintenance dose: 130 mg/m^2 as a single oral dose every 6 weeks

Typical maximum dose: 130 mg/m^2

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:

GFR >50 mL/min	*130 mg/m^2 as a single oral dose every 6 weeks*
GFR 10–50 mL/min	*65–100 mg/m^2 as a single oral dose every 6 weeks (25–50 % decrease)*
GFR <10 mL/min	*30–65 mg/m^2 as a single oral dose every 6 weeks (50–75 % decrease)*
Hemodialysis	*30–65 mg/m^2 as a single oral dose every 6 weeks; supplemental dose after dialysis not necessary*
CAPD	*30–65 mg/m^2 as a single oral dose every 6 weeks (50–75 % decrease)*
CRRT	*Data not available*

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

Loracarbef - Selected References

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Loracarbef/Lorabid® **{Antibacterial; second-generation cephalosporin}**

Usual initial dose:	400 mg orally
Usual maintenance dose:	200–400 mg orally every 12 h for 7–14 days
Typical maximum dose:	800 mg/day
Proportion eliminated unchanged:	85 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL ≥50 mL/min*	*200–400 mg orally every 12 h*
	CrCL 10–49 mL/min	*200–400 mg every 24 h*
	CrCL <10 mL/min	*200–400 mg orally every 3–5 days*
	Hemodialysis	*200–400 mg orally every 3–5 days; administer supplemental dose following hemodialysis on dialysis days.*
Alternative adjustment:	*GFR >50 mL/min*	*200–400 mg orally every 12 h*
	GFR 10–50 mL/min	*200–400 mg orally every 24 h*
	GFR <10 mL/min	*200–400 mg orally every 3–5 days*
	Hemodialysis	*200–400 mg orally every 3–5 days; administer supplemental dose following hemodialysis on dialysis days.*
	CAPD	*200–400 mg orally every 3–5 days*
	CRRT	*Not applicable (consider an IV cephalosporin)*

Lurasidone - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Lurasidone/Latuda®	**{Atypical antipsychotic}**	
Usual initial dose:	40 mg orally once daily	
Usual maintenance dose:	40–80 mg orally once daily	
Typical maximum dose:	80 mg/day	
Proportion eliminated unchanged:	5 %	
Adjustment for Kidney Disease		
FDA-approved product labeling:	*CrCL ≥50 mL/min*	*40–80 mg orally once daily*
	CrCL ≥10 to <50 mL/min	*Do not exceed 40 mg orally once daily.*
Alternative adjustment:	*GFR <10 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*

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Magnesium Citrate - Selected References

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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.

van Staden PD, Müller FO, van Heerden MA. Influence of long-term citro-soda ingestion on acid-base balance and blood gases. S Afr Med J. 1979;55:887–90.

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.*

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.

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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.

Magnesium Hydroxide (Milk of Magnesia) {Laxative; antacid}

Usual initial dose:	30 mL (2,400 mg) orally
Usual maintenance dose:	30–60 mL (2,400–4,800 mg) orally once daily at bedtime or in divided doses
Typical maximum dose:	60 mL (4,800 mg)
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*	*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.*

Magnesium/Aluminum Hydroxide and Simethicone - Selected References

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Magnesium/Aluminum Hydroxide and Simethicone/Maalox®, Mylanta® **{Antacid; antiflatulent}**

Usual initial dose:	15–60 mL orally
Usual maintenance dose:	10–20 mL between meals and at bedtime as needed or 60 mL 2 and 4 h after meals and at bedtime
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*	*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 >3.5; or 30 mL orally PRN abdominal discomfort*
	GFR 30–49 mL/min	*30 mL orally every 4 h PRN abdominal discomfort; monitor serum magnesium levels.*
	GFR <30 mL/min	*Preferably avoid due to potential toxicity from magnesium accumulation. Consider use of proton pump inhibitor, dose-adjusted histamine H_2 antagonist, or sucralfate.*

Magnesium Sulfate - Selected References

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Magnesium Sulfate (IV), Magnesium Gluconate/Uro-Mag® {Electrolyte supplement; antispasmodic}

Usual initial dose: 1–4 g IV; 500–1,000 mg orally

Usual maintenance dose: 1–40 g daily IV; 500–1,000 mg orally twice daily

Typical maximum dose: 3 g/h IV; 4,000 mg/day orally

Proportion eliminated unchanged: ~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*
(a) *ICU patients*			
1.3–1.7 mEq/L	*Magnesium gluconate 1,000 mg via enteral route every 6 h × 4*	*Magnesium gluconate 1,000 mg via enteral route every 12 h × 2*	*Magnesium gluconate 1,000 mg via enteral route every 12 h × 2*
	If enteral route NOT available, magnesium sulfate 2 g IV × 2	*If enteral route NOT available, magnesium sulfate 2 g IV × 1*	*If enteral route NOT available, magnesium sulfate 1 g IV × 1*
0.6–1.2 mEq/L	*Magnesium sulfate 2 g IV × 4*	*Magnesium sulfate 2 g IV × 2*	*Magnesium sulfate 2 g IV × 1*
≤0.5 mEq/L	*Notify MD*	*Notify MD*	*Notify MD*
(b) Non-ICU patients			
1.3–1.7 mEq/L	*Magnesium gluconate 1,000 mg via enteral route every 6 h × 4*	*Magnesium gluconate 1,000 mg via enteral route every 12 h × 2*	*Magnesium gluconate 1,000 mg via enteral route every 12 h × 2*
	If enteral route NOT available, magnesium sulfate 2 g IV × 2	*If enteral route NOT available, magnesium sulfate 2 g IV × 1*	*If enteral route NOT available, magnesium sulfate 1 g IV × 1*
1.0–1.2 mEq/L	*Magnesium sulfate 2 g IV × 3*	*Magnesium sulfate 2 g IV × 2*	*Magnesium sulfate 2 g IV × 1*
<1.0 mEq/L or symptomatic patient	*Notify MD*	*Notify MD*	*Notify MD*

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

Mannitol - Selected References

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Mannitol/Osmitrol® **{Osmotic diuretic; genitourinary irrigant}**

Usual initial dose:	12.5 g (200 mg/kg) IV over 5 min (test dose to assess renal function)
	0.5–1.5 g/kg IV
Usual maintenance dose:	0.25–0.5 g/kg IV every 4–6 h
Typical maximum dose:	3 g/kg
Proportion eliminated unchanged:	90 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Well-established (not acute or impending) anuria due to severe renal disease*	*Contraindicated*
	Progressive renal damage or dysfunction after institution of mannitol, including increasing oliguria and azotemia	*Contraindicated*
Alternative adjustment:	*Data not available*	

Maraviroc - Selected References

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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*

Concomitant medications	*Normal* *CrCL >80 mL/min*	*Mild* *CrCL 51–80 mL/min*	*Moderate* *CrCL 30–50 mL/min*	*Severe* *CrCL <30 mL/min*	*End-stage renal disease (ESRD)* *On regular hemodialysis*
Potent CYP3A inhibitors (with or without a CYP3A inducer)[a]	*150 mg twice daily*	*150 mg twice daily*	*150 mg twice daily*	*Not recommended*	*Not recommended*
Other concomitant medications[b]	*300 mg twice daily*	*300 mg twice daily*	*300 mg twice daily*	*300 mg twice daily*	*300 mg twice daily*
Potent CYP3A inducers (without a potent CYP3A inhibitor)[c]	*600 mg twice daily*	*600 mg twice daily*	*600 mg twice daily*	*Not recommended*	*Not recommended*

Concomitant medications	*Maraviroc dose for normal renal function*
[a]Potent CYP3A inhibitors (with or without a potent CYP3A inducer) including: Protease inhibitors (except tipranavir/ritonavir)	*150 mg twice daily*
Delavirdine	
Ketoconazole, itraconazole, clarithromycin	
Other potent CYP3A inhibitors (e.g., nefazodone, telithromycin)	
[b]Other concomitant medications, including tipranavir/ritonavir, nevirapine, raltegravir, all nucleoside reverse-transcriptase inhibitors, and enfuvirtide	*300 mg twice daily*
[c]Potent CYP3A inducers (without a potent CYP3A inhibitor) including:	*600 mg twice daily*
Efavirenz	
Rifampin	
Etravirine	
Carbamazepine, phenobarbital, and phenytoin	

Alternative adjustment: *Data not available*

Mefenamic Acid - Selected References

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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

FDA-approved product labeling:	*Preexisting renal disease*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*250 mg orally every 6 h*
	GFR 10–50 mL/min	*Preferably avoid due to risk of gastrointestinal and renal toxicity.*
	GFR <10 mL/min	*Preferably avoid due to risk of gastrointestinal and renal toxicity.*
	Hemodialysis	*Preferably avoid due to risk of gastrointestinal and renal toxicity.*
	CRRT	*Not applicable; preferably avoid.*

Meloxicam - Selected References

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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		
FDA-approved product labeling:	*Preexisting mild to moderate kidney disease*	*Use with caution; no dose adjustment is necessary*
	Severe renal impairment (CrCL <15 mL/min)	*Not recommended; avoid*
Alternative adjustment:	*Hemodialysis*	*7.5 mg orally once daily*

Melphalan (IV) - Selected References

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Melphalan (IV)/Alkeran® IV {Antineoplastic; alkylating agent; nitrogen mustard}

Usual initial dose: 16 mg/m^2 IV

Usual maintenance dose: 16 mg/m^2 IV every 2 weeks times four doses then 16 mg/m^2 IV every 4 weeks

Typical maximum dose: 16 mg/m^2 IV

Proportion eliminated unchanged: 40 % (range 5–90 %)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal insufficiency (BUN ≥30 mg/dL)*	*8 mg/m^2/dose IV (50 % decrease)*
Alternative adjustment:	*GFR >50 mL/mi:*	*16 mg/m^2 IV every 2 weeks times four doses then 16 mg/m^2 IV every 4 weeks*
	GFR 10–50 mL/min	*12 mg/m^2 IV every 2 weeks times four doses then 12 mg/m^2 IV every 4 weeks (25 % decrease)*
	GFR <10 mL/min	*8 mg/m^2 IV every 2 weeks times four doses then 8 mg/m^2 IV every 4 weeks (50 % decrease)*
	Hemodialysis	*8 mg/m^2 IV every 2 weeks times four doses then 8 mg/m^2 IV every 4 weeks (50 % decrease)*
	CAPD	*8 mg/m^2 IV every 2 weeks times four doses then 8 mg/m^2 IV every 4 weeks (50 % decrease)*
	CRRT	*12 mg/m^2 IV every 2 weeks times four doses then 12 mg/m^2 IV every 4 weeks (50 % decrease)*

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^2 in patients with GFR <30 mL/min.

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

Melphalan (Oral) - Selected References

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Melphalan (Oral)/Alkeran® **{Antineoplastic; alkylating agent; nitrogen mustard}**

Usual initial dose: 6 mg (3 tablets) orally once daily times 2–3 weeks

Usual maintenance dose: 6 mg (3 tablets) once daily times 2–3 weeks then discontinue times 4 weeks then 2 mg orally once daily

Typical maximum dose: 0.25 mg/kg/day

Proportion eliminated unchanged: 10–30 %

Adjustment for Kidney Disease

FDA-approved product labeling: *It may be prudent to use a reduced dose initially.*

Alternative adjustment:

GFR >50 mL/min	*6 mg (3 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 2 mg orally once daily*
GFR 10–50 mL/min	*4 mg (2 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 2 mg orally once daily (~25 % decrease)*
GFR <10 mL/min	*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)*
Hemodialysis	*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*
CAPD	*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)*
CRRT	*4 mg (2 tablets) orally once daily times 2–3 weeks then discontinue times 4 weeks then 2 mg orally once daily (~25 % decrease)*

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

Memantine - Selected References

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Memantine/Namenda™ **{N-Methyl-D-aspartate (NMDA) antagonist; R for Alzheimer's disease}**

Usual initial dose: 5 mg orally once daily

Usual maintenance dose: 10 mg orally twice daily

Typical maximum dose: 20 mg/day

Proportion eliminated unchanged: 50 %

Adjustment for Kidney Disease

FDA-approved product labeling: *CrCL ≥30 mL/min* *10 mg orally twice daily*

CrCL 5–29 mL/min *5 mg orally twice daily*

Alternative adjustment: *Data not available*

Meperidine - Selected References

Burgess KR, Burgess EE, Whitelaw WA. Impaired ventilatory response to carbon dioxide in patients with chronic renal failure: implications for the intensive care unit. Crit Care Med. 1994;22:413–9.

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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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Verbeeck RK, Branch RA, Wilkinson GR. Drug metabolites in renal failure: pharmacokinetic and clinical implications. Clin Pharmacokinet. 1981;6:329–45.

Meperidine/Demerol® {Analgesic, opioid μ-receptor agonist}

Usual initial dose:	50–150 mg PO, IM, or subcutaneously or 10–25 mg IV
Usual maintenance dose:	50–150 mg PO, IM, or subcutaneously or 10–25 mg IV every 3–4 h as necessary
Typical maximum dose:	600 mg/day
Proportion eliminated unchanged:	5 % (active metabolite normeperidine predominantly eliminated in urine)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Severe renal impairment*	*Give with caution.*
Alternative adjustment:	*GFR >50 mL/min*	*50–150 mg PO, IM, or subcutaneously or 10–25 mg IV every 3 h as necessary*
	GFR 10–50 mL/min	*Avoid due to risk for neurotoxicity/seizures.*
	GFR <10 mL/mi	*Avoid due to risk for neurotoxicity/seizures.*
	Hemodialysis	*Avoid due to risk for neurotoxicity/seizures.*
	CAPD	*Avoid due to risk for neurotoxicity/seizures.*
	CRRT	*Avoid due to risk for neurotoxicity/seizures.*

Meprobamate - 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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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

FDA-approved product labeling:	*Compromised kidney function*	*Caution should be exercised.*
Alternative adjustment:	*GFR >50 mL/min*	*200–400 mg orally every 6 h*
	GFR 10–50 mL/min	*200–400 mg orally every 8–12 h*
	GFR <10 mL/min	*200–400 mg orally every 12–18 h*
	Hemodialysis	*Data not available*
	CAPD	*Data not available*
	CRRT	*Not applicable, preferably avoid*

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.

Balis FM, Adamson PC. Application of pharmacogenetics to optimization of mercaptopurine dosing [editorial]. J Natl Cancer Inst. 1999;91:1983–5.

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Zimm S, Johnson GE, Chabner BA, Poplack DG. Cellular pharmacokinetics of mercaptopurine in human neoplastic cells and cell lines. Cancer Res. 1985;45:4156–61.

Mercaptopurine/Purinethol® **{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.

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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Meropenem/Merrem® **{Carbapenem/thienamycin antibiotic}**

Usual initial dose: 500–2,000 mg IV

Usual maintenance dose: 1–2 g IV every 8 h

Typical maximum dose: 2,000 mg IV every 8 h

Proportion eliminated unchanged: 66–79 %

Adjustment for Kidney Disease

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

CrCL (mL/min)	*Dose (mg IV)*	*Dosing interval*
≥51	*500–1,000*	*Every 8 h*
26–50	*500–1,000*	*Every 12 h*
10–25	*250–500*	*Every 12 h*
<10	*500–1,000*	*Every 24 h*

Alternative adjustment:

GFR >50 mL/min	*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*
GFR 10–50 mL/min	*1 g IV every 12 h*
GFR <10 mL/min	*500–1,000 mg IV every 24 h*
Hemodialysis	*500–1,000 mg IV every 24 h; dose after hemodialysis on dialysis days*
Extended daily dialysis	*500–1,000 mg IV every 8 h*
CAPD	*500–1,000 mg IV every 24 h*
CVVH	*500–1,000 mg IV every 12 h*
CVVHD or CVVHDF	*750–1,000 mg IV every 8 h or 1,500 mg IV every 12 h or 2 g/24 h continuous IV infusion*

Metaxalone - Selected References

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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*	

Metformin - Selected References

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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*	*Contraindicated*
Alternative adjustment:	*GFR >60 mL/min*	*500–1,000 mg orally twice daily with meals*
	GFR 41–60 mL/min	*250–750 mg orally twice daily with meals*
	GFR 10–40 mL/min	*Avoid due to risk for metabolic complications such as lactic acidosis.*
	GFR <10 mL/min	*Avoid due to risk for metabolic complications such as lactic acidosis.*
	Hemodialysis	*Avoid due to risk for metabolic complications such as lactic acidosis.*
	CAPD	*Avoid due to risk for metabolic complications such as lactic acidosis.*
	CVVH	*Not applicable; avoid due to risk for metabolic complications such as lactic acidosis.*
	CVVHD or CVVHDF	*Not applicable; avoid due to risk for metabolic complications such as lactic acidosis.*

Methadone - Selected References

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Methadone/Dolophine® **{Analgesic, opioid μ-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:

GFR >50 mL/min	*2.5–10 mg orally or IV every 8–12 h*
GFR 10–50 mL/min	*2.5–10 mg orally or IV every 8–12 h*
GFR <10 mL/min	*1.25–5 mg orally or IV every 8–12 h (25–50 % decrease)*
Hemodialysis	*1.25–5 mg orally or IV every 8–12 h (25–50 % decrease)*
CAPD	*1.25–5 mg orally or IV every 8–12 h (25–50 % decrease)*
CRRT	*2.5–10 mg orally or IV every 8–12 h*

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.

Methenamine - Selected References

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Methenamine/Hiprex®, Mandelamine® {Antibacterial; urinary antiseptic}

Usual initial dose: 1 g orally

Usual maintenance dose: 1 g orally twice daily after meals

Typical maximum dose: 4 g/day

Proportion eliminated unchanged: 80 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal insufficiency*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*1 g orally every twice daily after meals*
	GFR 10–50 mL/min	*Avoid due to risk for drug and/or formaldehyde accumulation.*
	GFR <10 mL/min	*Avoid due to risk for drug and/or formaldehyde accumulation.*
	Hemodialysis	*Avoid due to risk for drug and/or formaldehyde accumulation.*
	CAPD	*Avoid due to risk for drug and/or formaldehyde accumulation.*
	CRRT	*Not applicable; avoid.*

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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Methocarbamol (IV)/Robaxin® IV **{Centrally acting skeletal muscle relaxant}**

Usual initial dose: 1,000 mg IV

Usual maintenance dose: 1,000 mg IV, repeated if necessary up to twice within 24 h

Typical maximum dose: 3,000 mg/day

Proportion eliminated unchanged: <10 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal impairment*	*Contraindicated (due to excipient content [polyethylene glycol 300])*
Alternative adjustment:	*Data not available*	

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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Methotrexate/Rheumatrex®, Trexall™ {Antineoplastic; antimetabolite; disease-modifying antirheumatic drug}

Usual initial dose: 7.5 mg orally

Usual maintenance dose: 5–15 mg orally once weekly

Typical maximum dose: 30 mg/week

Proportion eliminated unchanged: 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:

GFR >50 mL/min	*5–15 mg orally once weekly*
GFR 10–50 mL/min	*2.5–5 mg orally once weekly (50 % decrease; avoid high-dose therapy)*
GFR <10 mL/min	*Avoid unless no suitable alternative exists; if indeed necessary, 2.5–5 mg orally once weekly*
Hemodialysis	*2.5–5 mg orally once weekly (50 % decrease); avoid high-dose therapy.*
CAPD	*Minimal data available. Avoid unless no suitable alternative exists; if indeed necessary, 2.5–5 mg orally once weekly*
CRRT	*2.5–5 mg orally once weekly (50 % decrease); avoid high-dose therapy.*

Methyldopa (IV) - Selected References

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Methyldopate/Aldomet® IV **{Antihypertensive; α_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:

GFR >50 mL/min	*250–500 mg IV every 8 h*
GFR 10–50 mL/min	*250–500 mg IV every 8–12 h*
GFR <10 mL/min	*250–500 mg IV every 12–24 h*
Hemodialysis	*250–500 mg IV every 12–24 h; administer after hemodialysis on dialysis days.*
CAPD	*250–500 mg IV every 12–24 h*
CRRT	*250–500 mg IV every 8–12 h; titrate.*

Methylnaltrexone - Selected References

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Methylnaltrexone/Relistor®	**{Peripherally acting opioid antagonist; ℞ 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*	

Metoclopramide - Selected References

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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

FDA-approved product labeling:	*CrCL <40 mL/min*	*Initiate therapy at approximately one-half the recommended dosage.*
Alternative adjustment:	*GFR >50 mL/min*	*10 mg orally or IV four times daily or 2–10 mg/kg IV prior to administration of moderately or highly emetogenic chemotherapy agents*
	GFR 10–50 mL/min	*7.5 mg orally or IV four times daily (25 % decrease)*
	GFR <10 mL/min	*5 mg orally or IV four times daily (50 % decrease)*
	Hemodialysis	*5 mg orally or IV four times daily (no supplement after dialysis; 50 % decrease)*
	CAPD	*5 mg orally or IV four times daily (50 % decrease)*
	CRRT	*7.5 mg orally or IV four times daily (25 % decrease)*

Midodrine - Selected References

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Midodrine/ProAmatine® **{Vasopressor; α_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

FDA-approved product labeling:	*Abnormal renal function*	*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).*
Alternative adjustment:	*GFR >50 mL/min*	*5–10 mg orally every 8 h*
	GFR 10–50 mL/min	*5–10 mg orally every 8 h*
	GFR <10 mL/min	*Data not available*
	Hemodialysis	*2.5 mg orally twice daily on dialysis days; 1.25 mg twice daily on non-dialysis days; titrate.*
	CAPD	*Data not available*
	CRRT	*5–10 mg orally every 8 h; titrate.*

Miglitol - Selected References

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Dosage Adjustment of Medications Eliminated by the Kidneys

Miglitol/Glyset® **{Antidiabetic; α-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*

Miglustat - Selected References

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Miglustat/Zavesca® **{Enzyme (glucosylceramide synthetase) inhibitor; ℞ for type 1 Gaucher disease}**

Usual initial dose: 100 mg orally

Usual maintenance dose: 100 mg orally three times daily

Typical maximum dose: 300 mg/day

Proportion eliminated unchanged: ~95 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL >70 mL/min*	*100 mg orally three times daily*
	CrCL 50–70 mL/min	*100 mg orally twice daily*
	CrCL 30–50 mL/min	*100 mg orally once daily*
	CrCL <30 mL/min	*Use not recommended; avoid.*
Alternative adjustment:	*Data not available*	

Milnacipran - Selected References

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Milnacipran/Savella™ **{Antidepressant; serotonin and norepinephrine reuptake inhibitor (SNRI)}**

Usual initial dose:	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
Usual maintenance dose:	50 mg orally twice daily
Typical maximum dose:	200 mg/day
Proportion eliminated unchanged:	55 % (renally eliminated metabolites are pharmacologically inactive)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Moderate renal impairment (CrCL ≥30 mL/min)*	*50 mg orally twice daily; use with caution.*
	Severe renal impairment (CrCL 5–29 mL/min)	*25 mg orally twice daily (50 % decrease)*
	End-stage renal disease. (CrCL <5 mL/min)	*Not recommended; avoid.*
Alternative adjustment:	*Data not available*	

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Milrinone/Primacor® **{Inotropic agent; phosphodiesterase inhibitor}**

Usual initial dose: 50 mcg/kg; administer IV slowly over 10 min.

Usual maintenance dose: 0.375–0.75 mcg/kg/min IV

Typical maximum dose: 1.13 mg/kg/day

Proportion eliminated unchanged: 80 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Milrinone dosage adjustment in renally impaired patients*

CrCL (mL/min)	*Infusion rate (mcg/kg/min)*
5	*0.20*
10	*0.23*
20	*0.28*
30	*0.33*
40	*0.38*
50	*0.43*

Alternative adjustment:

GFR >50 mL/min	*50 mcg/kg IV followed by 0.375 mcg/kg/min IV; titrate (max 0.75 mcg/kg/min).*
GFR 31–50 mL/min	*0.375 mcg/kg/min IV*
GFR 10–30 mL/min	*0.25 mcg/kg/min IV*
Hemodialysis	*Data not available*
CAPD	*Data not available*
CVVH	*0.2–0.25 mcg/kg/min IV*

Moexipril - Selected References

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

Usual initial dose: 7.5 mg orally once daily taken 1 h before food

Usual maintenance dose: 7.5–30 mg orally in one or two divided doses taken 1 h before meals

Typical maximum dose: 60 mg/day

Proportion eliminated unchanged: 40 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL ≤40 mL/min*	*3.75 mg once daily initially, titrated if necessary to a maximum daily dose of 15 mg*
Alternative adjustment:	*GFR >50 mL/min*	*7.5–30 mg orally in one or two divided doses taken 1 h before meals*
	GFR 10–50 mL/min	*3.75–15 mg orally in one or two divided doses taken 1 h before meals (50 % decrease)*
	GFR <10 mL/min	*3.75–15 mg orally in one or two divided doses taken 1 h before meals (50 % decrease)*
	Hemodialysis	*3.75–15 mg orally in one or two divided doses taken 1 h before meals*
	CAPD	*3.75–15 mg orally in one or two divided doses taken 1 h before meals*
	CRRT	*3.75–15 mg orally in one or two divided doses taken 1 h before meals (50 % decrease)*

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Morphine/Embeda™, Kadian®, MS Contin® {Analgesic, opioid μ-receptor agonist}

Usual initial dose: 2–4 mg IV or 10 mg orally

Usual maintenance dose: 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)

Typical maximum dose: 80 mg/h (chronic pain in opioid-tolerant patient)

Proportion eliminated unchanged: 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.*

Alternative adjustment:

GFR >50 mL/min	*100 % of usual dose*
GFR 10–50 mL/min	*75 % of usual dose*
GFR <10 mL/min	*Preferably avoid or 50 % of usual dose*
Hemodialysis	*Preferably avoid or 50 % of usual dose*
CAPD	*Preferably avoid or 50 % of usual dose*
CRRT	*75 % of usual dose; titrate.*

Mycophenolate Mofetil – Selected References

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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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Nabumetone/Relafen® {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

FDA-approved product labeling:	*CrCL ≥50 mL/min*	*1,000 mg orally once daily*
	CrCL 30–49 mL/min	*750 mg orally once daily; max 1,500 mg/day*
	CrCL <30 mL/min	*500 mg orally once daily; max 1,000 mg/day*
Alternative adjustment:	*GFR >50 mL/min*	*1,000 mg orally once daily*
	GFR 10–50 mL/min	*500–1,000 mg once daily (0–50 % decrease)*
	GFR <10 mL/min	*500–1,000 mg once daily (0–50 % decrease)*
	Hemodialysis	*1,000 mg orally once daily*
	CAPD	*Data not available*
	CRRT	*Not applicable; preferably avoid*

Nadolol - Selected References

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Nadolol/Corgard® **{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*

CrCL (mL/min)	*Dosage interval (h)*
>50	*24*
31–50	*24–36*
10–30	*24–48*
<10	*40–60*

Alternative adjustment:

GFR >50 mL/min	*40–240 mg orally once daily*
GFR 10–50 mL/min	*20–80 mg orally every 24 h (50 % decrease)*
GFR <10 mL/min	*10–40 mg orally every 24 h (~75 % decrease)*
Hemodialysis	*10–40 mg orally three times weekly after dialysis*
CAPD	*Data not available*
CRRT	*20–120 mg orally every 24 h (50 % decrease)*

Nalidixic Acid - Selected References

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Nalidixic Acid/NegGram® {Antibacterial; urinary antiseptic}

Usual initial dose: 1 g orally

Usual maintenance dose: 1 g orally four times daily

Typical maximum dose: 4 g/day

Proportion eliminated unchanged: 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*

Alternative adjustment:

GFR >50 mL/min	*1 g orally four times daily*
GFR 10–50 mL/min	*Avoid due to risk of acute neurological and/or metabolic complications*
GFR <10 mL/min	*Avoid due to risk of acute neurological and/or metabolic complications*
Hemodialysis	*Avoid due to risk of acute neurological and/or metabolic complications*
CAPD	*Avoid due to risk of acute neurological and/or metabolic complications*
CRRT	*Not applicable; avoid*

Naproxen - Selected References

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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*

Naratriptan - Selected References

Amerge® tablet film coated. Research Triangle Park: GlaxoSmithKline LLC; 2010.

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Naratriptan/Amerge® **{Anti-migraine; serotonin 5-HT_3 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*	

Nebivolol - Selected References

Ambrosio G, Flather MD, Böhm M, et al. β-Blockade with nebivolol for prevention of acute ischaemic events in elderly patients with heart failure. Heart. 2011;97:209–14.

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Nebivolol/Bystolic™ **{Antihypertensive; antianginal; β-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*

Neomycin - Selected References

Aguilera A, Gonzalez-Espinoza L, Codoceo R, et al. Bowel bacterial overgrowth as another cause of malnutrition, inflammation, and atherosclerosis syndrome in peritoneal dialysis patients. Adv Perit Dial. 2010;26:130–6.

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Neomycin/Mycifradin®, Neo-Fradin® **{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*

Neostigmine - Selected References

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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

FDA-approved product labeling:	*Mechanical obstruction of the urinary tract*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*0.5–2 mg slow IV injection*
	GFR 10–50 mL/min	*0.25–1 mg slow IV injection (50 % decrease)*
	GFR <10 mL/min	*0.125–0.5 mg slow IV injection (75 % decrease)*
	Hemodialysis	*0.125–0.5 mg slow IV injection (75 % decrease)*
	CAPD	*0.125–0.5 mg slow IV injection (75 % decrease)*
	CRRT	*0.25–1 mg slow IV injection (50 % decrease)*

Nitrofurantoin - Selected References

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Nitrofurantoin/Macrodantin®, 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*

Nizatidine - Selected References

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Nizatidine/Axid® **{Antacid; histamine H_2 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*

	Dosage	
CrCL (mL/min)	*Active duodenal ulcer, GERD, benign gastric ulcer*	*Maintenance therapy*
20–50	*150 mg daily*	*150 mg every other day*
<20	*150 mg every other day*	*150 mg every 3 days*

Alternative adjustment:

GFR >50 mL/min	*150–300 mg orally at bedtime*
GFR 10–50 mL/min	*150 mg orally every 24–48 h*
GFR <10 mL/min	*150 mg orally every 48–72 h*
Hemodialysis	*150 mg orally every 48–72 h*
CAPD	*150 mg orally every 48–72 h*
CRRT	*Not applicable (consider IV histamine H_2 blocker)*

Norfloxacin - Selected References

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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

FDA-approved product labeling:	*CrCL ≤30 mL/min*	*400 mg orally once daily*
Alternative adjustment:	*GFR >50 mL/min*	*400 mg orally every 12 h*
	GFR 10–50 mL/min	*400 mg orally every 12–24 h*
	GFR <10 mL/min	*400 mg orally every 24 h*
	Hemodialysis	*400 mg orally every 24 h*
	CAPD	*400 mg orally every 24 h*
	CRRT	*Not applicable (consider IV fluoroquinolone)*

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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

FDA-approved product labeling:	*CrCL 20–50 mL/min*	*200–400 mg orally every 24 h*
	CrCL <20 mL/min	*100–200 mg orally every 24 h (half the usual recommended unit dose)*
Alternative adjustment:	*GFR >50 mL/min*	*200–400 mg orally every 12 h*
	GFR 10–50 mL/min	*200–400 mg orally every 12–24 h*
	GFR <10 mL/min	*200 mg orally every 24 h*
	Hemodialysis	*400 mg orally followed by 200–400 mg orally every 24 h; administer after hemodialysis on dialysis days.*
	CAPD	*400 mg orally followed by 200 mg orally once daily*
	CVVH	*400 mg orally every 8 h*

Oprelvekin - Selected References

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Oprelvekin/Neumega® **{Thrombopoiesis stimulator; recombinant human interleukin 11; ℞ 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 [CrCL ≤30 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*

Oseltamivir - Selected References

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Oseltamivir/Tamiflu® **{Antiviral; neuraminidase inhibitor; ℞ for influenza}**

Usual initial dose: *75 mg orally*

Usual maintenance dose:

Influenza treatment	75 mg orally every 12 h for 5 days
Influenza prophylaxis	75 mg orally once daily for ≥10 days

Typical maximum dose: *150 mg/day*

Proportion eliminated unchanged: 10 % (as parent prodrug; 70 % of active de-esterified metabolite is excreted in urine)

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL 10–30 mL/min*	*Influenza treatment*	*75 mg orally once daily for 5 days*
	CrCL 10–30 mL/min	*Influenza prophylaxis*	*75 mg orally every other day or 30 mg every day*
	End-stage renal disease, hemodialysis, or peritoneal dialysis		*No recommended dosing recommendations available*
Alternative adjustment:	*GFR >50 mL/min*	*Influenza treatment*	*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)*
		Influenza prophylaxis	*75 mg orally once daily*
	GFR 10–50 mL/min	*Influenza treatment*	*75 mg orally once daily*
		Influenza prophylaxis	*75 mg orally every other day*
	GFR <10 mL/min	*Data not available*	
	Hemodialysis	*Influenza treatment*	*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)*
		Influenza prophylaxis	*75 mg orally every 5 days or 30 mg orally after each alternate dialysis session (limited data)*
	CAPD	*Influenza treatment*	*30 mg orally once or twice weekly*
		Influenza prophylaxis	*75 mg orally every 5 days (limited data)*
	CRRT	*Influenza treatment*	*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)*
		Influenza prophylaxis	*75 mg enterally once daily*

Oxacillin - Selected References

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Oxacillin/Prostaphlin® **{Antibacterial; isoxazolyl 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:	*GFR 5 to >50 mL/min*	*500–2,000 mg IV every 4 h (no change)*
	Hemodialysis	*500–2,000 mg IV every 4 h (no change)*
	CAPD	*500–2,000 mg IV every 4 h (no change)*
	CVVHD or CVVHDF	*2 g IV every 4–6 h*

Oxaprozin - Selected References

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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:	*Renal function impairment*	*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.*
	Hemodialysis	*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.*
Alternative adjustment:	*GFR >50 mL/min*	*1,200 mg orally every 24 h*
	GFR 10–50 mL/min	*1,200 mg orally every 24 h*
	GFR <10 mL/min	*600 mg orally every 24 h (50 % decrease)*
	Hemodialysis	*600 mg orally every 24 h (50 % decrease)*
	CAPD	*Data not available*
	CRRT	*600 mg orally every 24 h*

Oxcarbazepine - Selected References

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Oxcarbazepine/Trileptal® **{Antiepileptic; adjunctive analgesic; ℞ 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 with150 mg orally twice daily (300 mg/day, half the usual dose) and increase slowly to achieve the desired clinical response.*
Alternative adjustment:	*GFR >50 mL/min*	*600 mg orally every 12 h*
	GFR 10–50 mL/min	*300–600 mg orally every 12 h (0–25 % decrease); monitor drug levels.*[a]
	GFR <10 mL/min	*300 mg orally every 12 h (50 % decrease); monitor drug levels.*[a]
	Hemodialysis	*300 mg orally every 12 h (50 % decrease); monitor drug levels.*[a]
	CAPD	*300 mg orally every 12 h (50 % decrease); monitor drug levels.*[a]
	CRRT	*300 mg orally every 12 h (50 % decrease); monitor drug levels.*[a]

[a]***Therapeutic Drug Monitoring***

Therapeutic plasma levels: *Trough: 12–30 mg/L*

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Paliperidone - Selected References

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Paliperidone/Invega® **{Atypical antipsychotic; benzisoxazole derivative}**

Usual initial dose: 3 mg orally or 234 mg intramuscularly (extended-release intramuscular suspension) followed by 156 mg intramuscularly 1 week later

Usual maintenance dose: 6 mg orally once daily or 117 mg intramuscularly (extended-release intramuscular suspension) once monthly

Typical maximum dose: 12 mg/day orally

Proportion eliminated unchanged: 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.*

Pamidronate - Selected References

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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*

Pancuronium - Selected References

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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 overdosage, the monitoring of muscle twitch response to a peripheral nerve stimulator is advised*

Alternative adjustment:

GFR >50 mL/min	*0.04–0.1 mg/kg IV every 25–60 min*
GFR 10–50 mL/min	*0.02–0.05 mg/kg IV every 25–60 min (50 % decrease)*
GFR <10 mL/min	*Preferably avoid due to risk for excessively prolonged neuromuscular blockade and paralysis*
Hemodialysis	*Preferably avoid due to risk for excessively prolonged neuromuscular blockade and paralysis*
CAPD	*Preferably avoid due to risk for excessively prolonged neuromuscular blockade and paralysis*
CRRT	*0.02–0.05 mg/kg IV every 25–60 min (50 % decrease)*

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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Paroxetine/Paxil® **{Antidepressant; selective serotonin reuptake inhibitor (SSRI)}**

Usual initial dose: 20 mg orally

Usual maintenance dose: 20–40 mg orally once daily

Typical maximum dose: 60 mg/day

Proportion eliminated unchanged: 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

FDA-approved product labeling: *Severe renal impairment—initial dose is 10 mg/day; increases may be made if indicated; dosage should not exceed 40 mg/day*

Alternative adjustment:

GFR >50 mL/min	*20–40 mg orally once daily*
GFR 10–50 mL/min	*10–30 mg/day orally (25–50 % decrease)*
GFR <10 mL/min	*10–20 mg/day orally (50 % decrease)*
Hemodialysis	*10–20 mg/day orally (50 % decrease)*
CAPD	*10–20 mg/day orally (50 % decrease)*
CRRT	*10–30 mg/day orally (25–50 % decrease)*

Peginterferon Alfa-2a - Selected References

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Peginterferon Alfa-2a/Pegasys® {Antiviral; interferon; ℞ 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

FDA-approved product labeling:	*CrCL <50 mL/min*	*Use with caution; monitor for toxicity.*
	End-stage renal disease requiring hemodialysis	*Dose reduction to 135 μg subcutaneously once weekly is recommended; monitor for toxicity.*
	Note: Do not administer ribavirin to patients with CrCL <50 mL/min.	
Alternative adjustment:	*Hemodialysis*	*135 μg subcutaneously once weekly (with reduced dose ribavirin 200 mg orally once daily)*

Peginterferon Alfa-2b - Selected References

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Peginterferon Alfa-2b/ PEG-Intron®, Sylatron™

{Antiviral; interferon}

Usual initial dose: Melanoma, 6 mcg/kg subcutaneously; Hepatitis C, 1 mcg/kg subcutaneously

Usual maintenance dose: 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

Typical maximum dose: 1.5 mcg/kg/week

Proportion eliminated unchanged: Nil

Adjustment for Kidney Disease

FDA-approved product labeling:

Melanoma

CrCL 30–50 mL/min	*4.5 mcg/kg subcutaneously once weekly (25 % decrease)*
CrCL 10–29 mL/min	*3 mcg/kg subcutaneously once weekly (50 % decrease)*

Hepatitis C

CrCL 30–50 mL/min	*1.125 mcg/kg subcutaneously once weekly (25 % decrease)*
CrCL 10–29 mL/min	*0.75 mcg/kg subcutaneously once weekly (50 % decrease)*

Note: Do not administer ribavirin to patients with CrCL <50 mL/min.

Alternative adjustment:

Hepatitis C

Hemodialysis	*1 mcg/kg subcutaneously once weekly (with ribavirin 200 mg orally once daily)*

Pemetrexed - Selected References

Alimta® injection [package insert]. Indianapolis: Eli Lilly and Co; 2004.

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Pemetrexed/Alimta® **{Antineoplastic; antimetabolite; antifolate}**

Usual initial dose: 500 mg/m^2 IV over 10 min

Usual maintenance dose: 500 mg/m^2 IV over 10 min on day 1 of each 21-day cycle

Typical maximum dose: 500 mg/m^2 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.

Penicillamine - Selected References

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Penicillamine/Cuprimine®, Depen® **{Chelating agent; antirheumatic; ℞ 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

FDA-approved product labeling:	*Renal insufficiency*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*500–1,000 mg orally every 24 h 1 h before or 2 h after meals*
		125 mg orally every other day (early diffuse systemic sclerosis)
	GFR 10–50 mL/min	*Avoid due to risk of nephrotoxicity.*
	GFR <10 mL/min	*Avoid due to risk of nephrotoxicity.*
	Hemodialysis	*250–500 mg orally every 24 h (50 % decrease)*
	CAPD	*Data not available; avoid due to risk of nephrotoxicity.*
	CRRT	*Data not available*

Penicillin G - Selected References

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Penicillin G Potassium (Benzylpenicillin)/Pfizerpen®

{Antibacterial; prototypical β-lactam}

Usual initial dose: 2–5 million units IV

Usual maintenance dose: 5–30 million units/day in 4–12 divided doses or continuous IV infusion of 20–30 million units/day

Typical maximum dose: 30 million units/day

Proportion eliminated unchanged: 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 ≥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.

Pentamidine (IV) - Selected References

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Pentamidine (IV)/Pentam® 300 {Antiprotozoal; antiparasitic}

Usual initial dose: 4 mg/kg IV

Usual maintenance dose: 4 mg/kg IV once daily for 14–21 days

Typical maximum dose: 4 mg/kg/day

Proportion eliminated unchanged: 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.*

Alternative adjustment:

GFR >35 mL/min	*3–4 mg/kg IV every 24 h*
GFR 10–35 mL/min	*4 mg/kg IV every 24–48 h*
GFR <10 mL/min	*4 mg/kg IV every 48 h*
Hemodialysis	*4 mg/kg IV every 24–36 h; supplement 0.75 mg/kg IV after hemodialysis on dialysis days.*
CAPD	*4 mg/kg IV every 48 h*
CRRT	*4 mg/kg IV every 24 h*

Pentazocine - 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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Yamashiro H. Effect of pentazocine on renal blood flow. Br J Anaesth. 1978;50:1337.

Pentazocine/Talwin™ **{Analgesic; opioid μ-receptor partial agonist}**

Usual initial dose: 30 mg IV, IM, or subcutaneously

Usual maintenance dose: 30 mg IV, IM, or subcutaneously every 3–4 h

Typical maximum dose: 30 mg/dose IV, 60 mg/dose IM or subcutaneously, or 360 mg/day

Proportion eliminated unchanged: <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.*

Alternative adjustment:

GFR >50 mL/min	*30 mg IV every 4 h as necessary*
GFR 10–50 mL/min	*20 mg IV every 4 h as necessary (25 % decrease)*
GFR <10 mL/min	*15 mg IV every 4 h as necessary (50 % decrease)*
Hemodialysis	*15 mg IV every 4 h as necessary (50 % decrease)*
CAPD	*Data not available; preferably avoid.*
CRRT	*Data not available; preferably avoid.*

Pentostatin - 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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Pentostatin/Nipent® **{Antineoplastic; antimetabolite; purine analog}**

Usual initial dose: 4 mg/m^2 IV

Usual maintenance dose: 4 mg/m^2 IV every other week

Typical maximum dose: 4 mg/m^2

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^2.*

CrCL >60 mL/min	*4 mg/m^2 IV every other week*
CrCL 50–60 mL/min	*2 mg/m^2 IV every other week*
CrCL <50 mL/min	*Minimal data; avoid*

Alternative adjustment:

eCrCL >60 mL/min	*4 mg/m^2 IV every other week*
eCrCL 41–40 mL/min	*3 mg/m^2 IV every other week*
eCrCL 21–40 mL/min	*2 mg/m^2 IV every other week*
eCrCL ≤20 mL/min	*Data not available*

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

Pentoxifylline - Selected References

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Pentoxifylline/Trental® **{Rheologic agent; blood viscosity reducer agent}**

Usual initial dose: 400 mg orally

Usual maintenance dose: 400 mg orally three times daily with meals

Typical maximum dose: 1,200 mg/day

Proportion eliminated unchanged: 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.*

Alternative adjustment:

GFR >50 mL/min	*400 mg orally every 8–12 h*
GFR 10–50 mL/min	*400 mg orally every 12–24 h*
GFR <10 mL/min	*400 mg orally every 24 h*
Hemodialysis	*400 mg orally every 24 h (no supplemental post-dialysis dose)*
CAPD	*400 mg orally every 24 h*
CRRT	*Data not available*

Peramivir - Selected References

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Peramivir {Antiviral}

Usual initial dose: 600 mg IV over 30 min

Usual maintenance dose: 600 mg IV over 30 min once daily for 5–10 days

Typical maximum dose: 600 mg IV

Proportion eliminated unchanged: 90 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Peramivir adult renal function impairment dosage recommendations*

Creatinine clearance	*Dose (IV)*
Mild renal impairment (CrCL 50–80 mL/min)	*600 mg daily*
Moderate renal impairment (CrCL 31–49 mL/min)	*150 mg daily*
Severe renal impairment (CrCL 10–30 mL/min)	*100 mg daily*
End-stage renal impairment (CrCL <10 mL/min not on dialysis or renal replacement therapy)	*100 mg on day, then 15 mg daily thereafter*
End-stage renal disease on intermittent hemodialysis	*100 mg on day 1, then 100 mg over 2 h after each hemodialysis session on dialysis days only*

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): $Cl_{CRRT} = Q_f + Q_d$

Alternative adjustment:

CRRT	*600 mg IV daily*
Slow low-efficiency hemodialysis	*600 mg IV daily*

Perindopril - Selected References

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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:	*CrCL ≥30 mL/min*	*4 mg orally once daily; usual max 8 mg/day*
	CrCL <30 mL/min	*Safety not established; use not recommended*
	Hemodialysis	*2 mg orally once daily; max 8 mg/day*
		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:	*GFR >50 mL/min*	*4 mg orally every 24 h 1 h before or at least 2 h after meals*
	GFR 10–50 mL/min	*2 mg orally every 24–48 h 1 h before or at least 2 h after meals*
	GFR <10 mL/min	*2 mg orally every 48 h 1 h before or at least 2 h after meals*
	Hemodialysis	*2 mg orally every 48 h 1 h before or at least 2 h after meals (no supplemental post-dialysis dose)*
	CAPD	*2 mg orally every 48 h 1 h before or at least 2 h after meals*
	CRRT	*2 mg orally every 24–48 h*

Phenazopyridine - Selected References

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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

FDA-approved product labeling:	*Impaired renal function, uremia*	*Contraindicated*
Alternative adjustment:	*eCrCL ≥50 mL/min*	*100–200 mg orally every 8–12 h*
	eCrCL <50 mL/min	*Avoid due to risk for nephrotoxicity and possible methemoglobinemia and hemolytic anemia.*

Phenobarbital - Selected References

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Phenobarbital/Luminal® **{Antiepileptic; sedative}**

Usual initial dose: 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_d, volume of distribution in L/kg}] with good supportive care) PO, IV, or IM

Usual maintenance dose: 60–100 mg orally two to three times daily PO, IM, or IV (1–3 mg/kg/day)[a]

Typical maximum dose: 2,000 mg

Proportion eliminated unchanged: 16 % (plus 21 % of each dose as hydroxylated metabolite; urine pH dependent)

Adjustment for Kidney Disease

FDA-approved product labeling: *Not available*

Alternative adjustment:		
	GFR >50 mL/min	*30–100 mg orally every 8–12 h*[a]
	GFR 10–50 mL/min	*30–100 mg orally every 8–12 h*[a]
	GFR <10 mL/min	*30–100 mg orally every 12–16 h*[a]
	Hemodialysis	*30–100 mg orally every 12–16 h (administer supplemental dose before hemodialysis plus one-half usual dose amount after hemodialysis on dialysis days)*[a]
	CAPD	*15–60 mg orally every 12–16 h (approx 50 % decrease)*[a]
	CRRT	*30–100 mg orally every 8–12 h*[a]

[a]Therapeutic Drug Monitoring

Therapeutic plasma levels: *Trough: 15–40 mg/L*

Phenytoin - Selected References

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Phenytoin/Dilantin® **{Antiepileptic}**

Usual initial dose: 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_d, volume of distribution in L/kg}] with good supportive care)

Usual maintenance dose: 100 mg IV or orally three times daily

Typical maximum dose: 1,000 mg/day

Proportion eliminated unchanged: 5 % (protein binding markedly decreased in uremia)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Data not available*	
Alternative adjustment:	*GFR >50 mL/min*	*100 mg IV or orally every 8 h*[a]
	GFR 10–50 mL/min	*100 mg IV or orally every 8 h*[a]
	GFR <10 mL/min	*50–100 mg IV or orally every 8–12 h*[a]
	Hemodialysis	*50–100 mg IV or orally every 8–12 h (no supplemental post-dialysis dose)*[a]
	CAPD	*50–100 mg IV or orally every 8–12 h*[a]
	CRRT	*50–100 mg IV or orally every 8–12 h*[a]

[a]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:

$$C_{\text{corrected}} = \frac{C_{\text{observed}}}{0.2 \times \text{albumin}\left(\text{g / dL}\right) + 0.1}$$

where

C_{observed} = measured total serum phenytoin concentration

$C_{\text{corrected}}$ = serum phenytoin concentration corrected for altered protein binding in uremic patients

Phosphate - Selected References

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Phosphate, Sodium or Potassium (IV); Sodium-Potassium Phosphate/KPhos Neutral® {Electrolyte}

Usual initial dose: 0.08 mmol/kg IV

Usual maintenance dose: –

Typical maximum dose: 1 mmol/kg/day IV or potassium phosphate 1,000 mg orally four times daily

Proportion eliminated unchanged: 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)*

(a) ICU patients

	Glomerular filtration rate (GFR in mL/min)		
Serum/plasma [PO_4]	*>50*	*25–50*	*<25*
2.1–3.0 mg/dL	*Sodium-potassium phosphate (KPhos Neutral®) 1,000 mg via enteral route every 6 h × 4.* *If enteral route NOT available, sodium phosphate 45 mmol IV × 1*	*Sodium-potassium phosphate (KPhos Neutral®) 1,000 mg via enteral route every 12 h × 2.* *If enteral route NOT available, sodium phosphate 22.5 mmol IV × 1*	*Sodium-potassium phosphate (KPhos Neutral®) 500 mg via enteral route every 12 h × 2.* *If enteral route NOT available, sodium phosphate 15 mmol IV × 1*
1.1–2.0 mg/dL	*Sodium phosphate 60 mmol IV × 1*	*Sodium phosphate 45 mmol IV × 1*	*Sodium phosphate 22.5 mmol IV × 1*
≤1.0 mg/dL	*Notify MD*	*Notify MD*	*Notify MD*

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

(b) Non-ICU patients

	Mild depletion [PO_4] 2.1–2.4 mg/dL	*Moderate depletion [PO_4] 1.0–2.0 mg/dL*	*Severe depletion [PO_4] <1.0 mg/dL*
Initial treatment	*No treatment or sodium-potassium phosphate (KPhos Neutral®) 500 mg orally TID*	*Sodium phosphate 5–10 mmol (0.1 mmol/kg) IV over 2 h*	*Sodium phosphate 10–20 mmol (0.2 mmol/kg) IV over 4 h*

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

Piperacillin and Tazobactam - Selected References

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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*
>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[a]	*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*

[a]*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.

Piroxicam - Selected References

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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

FDA-approved product labeling:	*Mild to moderate renal insufficiency*	*No adjustment necessary*
	Advanced renal disease	*No data, not recommended*
	Severe renal failure	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*20 mg orally once daily*
	GFR 10–50 mL/min	*20 mg orally once daily*
	GFR <10 mL/min	*Preferably avoid due to risk for gastrointestinal and renal toxicity.*
	Hemodialysis	*Data not available; preferably avoid.*
	CAPD	*Data not available; preferably avoid.*
	CRRT	*Not applicable; preferably avoid.*

Pitavastatin - Selected References

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Pitavastatin/Livalo® **{Antihypercholesterolemic agent; hydroxymethylglutaryl-coenzyme A (HMG-CoA) reductase inhibitor}**

Usual initial dose: 2 mg orally once daily

Usual maintenance dose: 1–4 mg orally once daily

Typical maximum dose: 4 mg/day

Proportion eliminated unchanged: 15 %

Adjustment for Kidney Disease

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

Renal function	*Initial dose*	*Maximum dose*
eGFR ≥60 mL/min/1.73 m²	*2 mg once daily*	*4 mg once daily*
eGFR 30–59 mL/min/1.73 m²	*1 mg once daily*	*2 mg once daily*
eGFR <30 mL/min/1.73 m² (not on dialysis)	*Avoid*	*Avoid*
Hemodialysis	*1 mg once daily*	*2 mg once daily*

Alternative adjustment: *Data not available*

Plerixafor - Selected References

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Plerixafor/Mobozil® **{Hematopoietic stem cell mobilizer}**

Usual initial dose: 0.24 mg/kg subcutaneously

Usual maintenance dose: 0.24 mg/kg subcutaneously once daily for 4 days (on day 5 following 4 consecutive days of granulocyte colony stimulating factor G-CSF)

Typical maximum dose: 40 mg/day

Proportion eliminated unchanged: 70 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Recommended subcutaneous dosage of plerixafor in patients with renal function impairment*

eCrCL (mL/min)	*Plerixafor dosage*
>50	*0.24 mg/kg once daily (not to exceed 40 mg/day)*
≤50	*0.16 mg/kg once daily (not to exceed 27 mg/day)*
Hemodialysis	*Insufficient information to make dosage recommendation*

Alternative adjustment: *Hemodialysis:* *0.16 mg/kg subcutaneously X1 after 4 days of G-CSF (very limited clinical data)*

Polymyxin B - Selected References

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Polymyxin B/Poly-Rx® **{Antibacterial}**

Usual initial dose: 12,500 units/kg IV

Usual maintenance dose: 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.

Typical maximum dose: 25,000 units/kg/day

Proportion eliminated unchanged: 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.

eCrCL >80 mL/min	*7,500–12,500 units/kg IV every 12 h*
eCrCL 50–80 mL/min	*7,500–12,500 units/kg IV every 12 h*
eCrCL 20–49 mL/min	*5,625–9,375 units/kg IV every 12 h (25 % decrease)*
eCrCL 10–19 mL/min	*2,475–4,125 units/kg IV every 12 h (67 % decrease)*
eCrCL <10 mL/min	*1,125–1,875 units/kg IV every 12 h (85 % decrease)*
Hemodialysis	*Data not available*
CAPD	*150,000 units IV every 12 h (very limited data)*
CRRT	*25,000 units/kg IV once followed by 8,000 units/kg IV daily (very limited data)*

Note: 10,000 units of polymyxin B sulfate = 1 mg of polymyxin B base

Polythiazide - Selected References

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Polythiazide/Renese® **{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

FDA-approved product labeling:	*Renal disease*	*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.*
	Anuria	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*1–4 mg orally every 24 h*
	GFR 10–50 mL/min	*1–4 mg orally every 24 h*
	GFR <10 mL/min	*Ineffective; preferably avoid.*
	Hemodialysis	*Ineffective; preferably avoid.*
	CAPD	*Ineffective; preferably avoid.*
	CRRT	*Not applicable; avoid.*

Potassium Chloride - Selected References

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Potassium Chloride {Electrolyte supplement}

Usual initial dose: Dosage is dependent upon the age, weight, and clinical condition of the patient as well as laboratory determinations.

Usual maintenance dose: Dosage is dependent upon the age, weight, and clinical condition of the patient as well as laboratory determinations.

Typical maximum dose: 240 mEq/day

Proportion eliminated unchanged: 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

	Glomerular filtration rate (GFR in mL/min)		
Serum/plasma potassium level	*>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

	Glomerular filtration rate (GFR in mL/min)		
Serum/plasma potassium level	*>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

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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Sidell FR, Groff WA, Kaminskis A. Pralidoxime methanesulfonate: plasma levels and pharmacokinetics after oral administration to man. J Pharm Sci. 1972;61:1136–42.

Willems JL, Langenberg JP, Verstraete AG, et al. Plasma concentrations of pralidoxime methylsulphate in organophosphorus poisoned patients. Arch Toxicol. 1992;66:260–6.

Pralidoxime (2-PAM)/Protopam™ **{Antidote; cholinesterase reactivator; ℞ 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*

Pramipexole - Selected References

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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*

Renal status	*Starting dose (mg)*	*Maximum dose (mg)*
Normal to mild impairment (CrCL > 60 mL/min)	*0.125 orally three times dally*	*1.5 mg orally three times dally*
Moderate impairment (CrCL 35–59 mL/min)	*0.125 orally twice*	*1.5 mg orally twice daily*
Severe impairment (CrCL 15–34 mL/min)	*0.125 orally once daily*	*1.5 orally once daily*
Very severe impairment (CrCL <15 mL/min and hemodialysis patients)	*Use has not been adequately studied in this group of patients*	

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.*

Pregabalin - Selected References

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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*

CrCL (mL/min)	*Total pregabalin daily dose (mg/day)**				*Dose regimen*
60	*150*	*300*	*450*	*600*	*BID or TID*
30–60	*75*	*150*	*225*	*300*	*BID or TID*
15–30	*25–50*	*75*	*100–150*	*150*	*Once daily or BID*
<15	*25*	*25–50*	*50–75*	*75*	*Once daily*

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*

Primidone - Selected References

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Primidone/Mysoline® {Antiepileptic}

Usual initial dose: 100 mg orally

Usual maintenance dose: 250 mg orally three times daily

Typical maximum dose: 2,000 mg/day

Proportion eliminated unchanged: 30 % (plus 30 % of each dose excreted in urine as pharmacologically active phenethylmalonamide)

Adjustment for Kidney Disease

FDA-approved product labeling: *Data not available*

Alternative adjustment:

GFR >50 mL/min	*250 mg orally every12 h; may titrate to maximum 1,500 mg/day*[a]
GFR 10–50 mL/min	*250 mg orally every 12 h*[a]
GFR <10 mL/min	*250 mg orally every 24 h*[a]
Hemodialysis	*250 mg orally every 24 h; administer supplemental dose after hemodialysis on dialysis days.*[a]
CAPD	*Data not available*
CRRT	*Data not available*

[a]***Therapeutic Drug Monitoring***

Therapeutic plasma levels:

Primidone trough: *5–12 mg/L*

Phenobarbital trough: *15–40 mg/L*

Note that primidone clearance often increases during 4–12 weeks of continuous therapy.

Probenecid - Selected References

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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

FDA-approved product labeling:	*GFR >30 mL/min*	*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*
	GFR ≤30 mL/min	*May be ineffective; not recommended*
Alternative adjustment:	*GFR >50 mL/min*	*500 mg orally twice daily*
	GFR 10–50 mL/min	*Preferably avoid due to risk for nephrotoxicity.*
	GFR <10 mL/min	*Preferably avoid due to risk for nephrotoxicity.*
	Hemodialysis	*Preferably avoid due to risk for nephrotoxicity.*
	CAPD	*Preferably avoid due to risk for nephrotoxicity.*
	CRRT	*Not applicable; avoid.*

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Procainamide/Pronestyl®, Procan® SR {Antiarrhythmic, class IA}

Usual initial dose:	17 mg/kg (approx 1,000 mg) IV at a rate not to exceed 50 mg/min or 500 mg orally
Usual maintenance dose:	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)
Typical maximum dose:	5,000 mg/day
Proportion eliminated unchanged:	50 % (depending on acetylator phenotype, an additional 20–30 % of each dose is excreted in urine as active *N*-acetylprocainamide)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal insufficiency*	*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 N-acetylprocainamide independently of reductions in CrCL—compared to normal young adults, there is approximately 25 % reduction at age 50 and 50 % at age 75.*
Alternative adjustment:	*GFR >50 mL/min*	*500 mg orally every 4 h or 1,000–1,500 mg extended release every 12 h*
	GFR 10–50 mL/min	*500 mg orally every 6–12 h*
	GFR <10 mL/min	*Data not available; preferably avoid.*
	Hemodialysis	*Clearance and elimination are prolonged unpredictably; preferably avoid.*
	CAPD	*250 mg every 12 h; monitor carefully (very limited data).*
	CRRT	*Data not available; preferably avoid.*

Therapeutic Drug Monitoring

Therapeutic plasma levels:	Procainamide trough:	4–10 mg/L
	N-Acetylprocainamide (NAPA) trough:	15–25 mg/L

Pyridostigmine - Selected References

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Pyridostigmine/Mestinon®, Regonol® **{Acetylcholinesterase inhibitor; ℞ 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

FDA-approved product labeling:	*Renal disease*	*Lower doses may be required; treatment should be based on titration of drug dosage to effect.*
Alternative adjustment:	*GFR >50 mL/min*	*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)*
	GFR 10–50 mL/min	*15–30 mg orally every 4–6 h or 90–180 mg extended release once or twice daily (~65 % decrease)*
	GFR <10 mL/min	*10–30 mg orally every 4–6 h or 45–90 mg extended release once or twice daily (~80 % decrease)*
	Hemodialysis	*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*
	CAPD	*10–30 mg orally every 4–6 h or 45–90 mg extended release once or twice daily (~80 % decrease)*
	CRRT	*15–30 mg orally every 4–6 h or 90–180 mg extended release once or twice daily (~65 % decrease)*

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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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*

CrCL (mL/min)	*Maximum recommended initial daily dose*
>60	*10 mg*
30–60	*5 mg*
10–30	*2.5 mg*
<10	*Insufficient data for dosage recommendation*

Alternative adjustment:

GFR >50 mL/min	*20–40 mg orally every 12–24 h*
GFR 10–50 mL/min	*2.5–5 mg orally every 24 h, titrate*
GFR <10 mL/min	*2.5 mg orally every 24 h, titrate*
Hemodialysis	*2.5 mg orally every 24 h, titrate; no supplemental dose after dialysis required*
CAPD	*2.5 mg orally every 24 h, titrate*
CRRT	*2.5–5 mg orally every 24 h, titrate*

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Quinidine/Quinidex®, Quinaglute® **{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)[a]*
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)[a]*
GFR <10 mL/min	*100 mg orally every 4 h (sulfate) or 162 mg orally every 8 h (gluconate) (~75 % of usual dose)[a]*
Hemodialysis	*100 mg orally every 4 h (sulfate) or 162 mg orally every 8 h (gluconate) (~75 % of usual dose); dose after dialysis[a]*
CAPD	*100 mg orally every 4 h (sulfate) or 162 mg orally every 8 h (gluconate) (~75 % of usual dose)[a]*
CRRT	*200 mg orally every 6 h (sulfate) or 324 mg orally every 8–12 h (gluconate) (100 % of usual dose)[a]*

[a]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

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Quinine/Qualaquin® **{Antimalarial}**

Usual initial dose:	648 mg orally
Usual maintenance dose:	648 mg orally every 8 h with food for 7 days
Typical maximum dose:	1,944 mg/day
Proportion eliminated unchanged:	20 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Severe chronic renal impairment*	*648 mg orally followed 12 h later by 324 mg orally every 12 h*
Alternative adjustment:	*GFR >50 mL/min*	*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* *Uncomplicated malaria:10 mg/kg (≈648 mg) orally every 8 h to complete 5–7 days quinine in total*
	GFR 10–50 mL/min	*648 mg (10 mg/kg) orally every 12 h (33 % decrease)*
	GFR <10 mL/min	*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)*
	Hemodialysis	*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)*
	CAPD	*648 mg orally every 24 h*
	CRRT	*648 mg orally every 8–12 h or 15–20 mg/kg/day in divided doses*

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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*

Ranitidine (Enteral) - Selected References

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Zantac® tablet film coated, effervescent, syrup [package insert]. Research Triangle Park: GlaxoSmithKline; 2011.

Ranitidine (Enteral)/Zantac® **{Antacid; histamine H_2 receptor antagonist}**

Usual initial dose: 150 mg orally

Usual maintenance dose: 150 mg orally twice daily or 300 mg orally after the evening meal or at bedtime

Typical maximum dose: 600 mg/day

Proportion eliminated unchanged: 80 % (30 % of an oral dose appears unchanged in urine)

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL <50 mL/min*	*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.*
Alternative adjustment:	*GFR >50 mL/min*	*150–300 mg orally at bedtime*
	GFR 10–50 mL/min	*75 mg orally twice daily or 150 mg orally every 24 h*
	GFR <10 mL/min	*75 orally twice daily or 150 mg orally every 24 h*
	Hemodialysis	*75 mg orally twice daily or 150 mg orally every 24 h; give after hemodialysis on dialysis days.*
	CAPD	*75 mg orally twice daily or 150 mg orally every 24 h*
	CRRT	*150 mg orally every 12–24 h*

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Zantac® injection [package insert]. Research Triangle Park: GlaxoSmithKline; 2009.

Ranitidine (IV)/Zantac® IV {Antacid; histamine H_2 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

FDA-approved product labeling:	*CrCL <50 mL/min*	*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.*
	Hemodialysis	*50 mg IV every 18–24 h; dose after dialysis*
Alternative adjustment:	*GFR >50 mL/min*	*50 mg IV every 8 h*
	GFR 10–50 mL/min	*50 mg IV every 12 h*
	GFR <10 mL/min	*50 mg IV every 24 h*
	Hemodialysis	*50 mg IV every 24 h; administer after hemodialysis on dialysis days.*
	CAPD	*50 mg IV every 24 h*
	CRRT	*50 mg IV every 12 h*

Ranolazine - Selected References

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Ranolazine/Ranexa® **{Antianginal}**

Usual initial dose: 500 mg orally twice daily

Usual maintenance dose: 1,000 mg orally twice daily

Typical maximum dose: 2,000 mg/day

Proportion eliminated unchanged: 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*

Repaglinide - Selected References

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Repaglinide/Prandin® **{Antidiabetic; meglitinide derivative; insulin secretogogue}**

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

FDA-approved product labeling:	*Mild to moderate renal dysfunction*	*Initial dose adjustment does not appear to be necessary.*
	Severe renal function impairment	*Initiate therapy with 0.5 mg orally with meals; subsequently patient's dose should be carefully titrated.*
	CrCL <20 mL/min	*No data*
	Hemodialysis	*No data*
Alternative adjustment:	*eCrCL >80 mL/min*	*1–4 mg orally three times daily with meals*
	eCrCL 30–80 mL/min	*0.5–2 mg orally three times daily with meals; initiate with low doses, titrate carefully, and monitor for hypoglycemia.*
	eCrCL 5–30 mL/min	*0.5–2 mg orally three times daily with meals; initiate with low doses, titrate carefully, and monitor for hypoglycemia.*
	Hemodialysis	*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.*
	CRRT	*Not applicable; avoid*

Reserpine - Selected References

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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:

GFR >50 mL/min	*0.1–0.25 mg orally once daily*
GFR 10–50 mL/min	*0.1–0.25 mg orally once daily*
GFR <10 mL/min	*Preferably avoid due to often delayed and unreliable responses*
Hemodialysis	*Preferably avoid due to often delayed and unreliable responses*
CAPD	*Preferably avoid due to often delayed and unreliable responses*
CRRT	*Not applicable; preferably avoid*

Ribavirin (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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Ribavirin (Oral)/Rebetol®, RibaPak®, Ribasphere®, Copegus® {Antiviral; ℞ 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*[a]	*Duration*
Hepatitis C Genotypes 1, 4	*180 µg*	*<75 kg = 1,000 mg*	*48 week*
		≥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

[a]*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*
eCrCL 60 mL/min	*400 mg/day*	*600 mg/day*	*800 mg/day*
eCrCL 40 mL/min	*200 mg/day*	*400 mg/day*	*600 mg/day*
eCrCL 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*

Rifabutin - 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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Rifabutin/Mycobutin® **{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

FDA-approved product labeling:	*CrCL <30 mL/min*	*150 mg orally once daily (50 % decrease)*
Alternative adjustment:	*GFR >50 mL/min*	*300 mg orally once daily*
	GFR 10–50 mL/min	*300 mg orally once daily*
	GFR <10 mL/min	*300 mg orally once daily*
	Hemodialysis	*300 mg orally once daily*
	CAPD	*150–300 mg orally once daily*
	CRRT	*300 mg orally once daily*

Rifampin - Selected References

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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

FDA-approved product labeling:	*CrCL <50 mL/min*	*10 mg/kg not to exceed 600 mg orally or IV once daily (100 % of usual dose)*
	Hemodialysis	*10 mg/kg not to exceed 600 mg orally or IV once daily (100 % of usual dose)*
Alternative adjustment:	*GFR >50 mL/min*	*10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose)*
	GFR 10–50 mL/min	*5–10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose)*
	GFR <10 mL/min	*5–10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose)*
	Hemodialysis	*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*
	CAPD	*5–10 mg/kg not to exceed 600 mg orally or IV every 24 h (50–100 % of usual dose)*
	CVVH	*300–600 mg IV every 12–24 h*
	CVVHD	*300–600 mg IV every 12–24 h*
	CVVHDF	*300–600 mg IV every 12–24 h*

Rimantadine - Selected References

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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

FDA-approved product labeling:	*Renal insufficiency*	*Monitor for adverse effects and adjust dose as necessary.*
	Elderly nursing home patients	*100 mg orally once daily*
	CrCL ≤10 mL/min	*100 mg orally once daily*
Alternative adjustment:	*GFR >50 mL/min*	*100 mg orally twice daily*
	GFR 10–50 mL/min	*100 mg orally once daily*
	GFR <10 mL/min	*100 mg orally once daily*
	Hemodialysis	*100 mg orally once daily (supplemental dose after dialysis not required or recommended)*
	CAPD	*Data not available*
	CRRT	*100 mg orally twice daily*

Risedronate - Selected References

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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*

Risperidone (Oral) - Selected References

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Risperidone/Risperdal®, Risperdal® Consta {Atypical antipsychotic; benzisoxazole derivative}

Usual initial dose:	1 mg orally twice daily
Usual maintenance dose:	2–8 mg/day orally in one or two divided doses or 25 mg IM every 2 weeks
Typical maximum dose:	16 mg/day
Proportion eliminated unchanged:	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

FDA-approved product labeling:	*Severe renal impairment*	*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.*
Alternative adjustment:	*GFR >50 mL/min*	*1–3 mg orally twice daily*
	GFR 10–50 mL/min	*0.5–2 mg orally twice daily or 12.5 mg IM every 2 weeks*
	GFR <10 mL/min	*0.5–2 mg orally once daily; begin with modest doses and titrate carefully.*
	Hemodialysis	*0.5–4 mg orally once daily; supplemental dose after dialysis is not necessary; begin with modest doses and titrate carefully.*
	CAPD	*Data not available*
	CRRT	*Data not available*

Rivaroxaban - Selected References

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Rivaroxaban/Xarelto® **{Direct thrombin inhibitor; antithrombotic}**

Usual initial dose: 20 mg orally

Usual maintenance dose: 10–20 mg orally once daily with the evening meal

Typical maximum dose: 20 mg/day

Proportion eliminated unchanged: 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.

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Rosuvastatin/Crestor® **{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:

eGFR 50–80 mL/min	*5–20 mg orally once daily*
eGFR 30–49 mL/min	*5–20 mg orally once daily*
eGFR <30 mL/min	*5 mg orally once daily; titrate as necessary up to 10 mg orally once daily.*
Hemodialysis	*2.5–10 mg orally once daily*
CAPD	*Data not available*
CRRT	*Data not available*

Ruxolitinib - Selected References

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Ruxolitinib/Jakafi™ **{Janus tyrosine kinase 1–2 inhibitor; ℞ for myelofibrosis}**

Usual initial dose: 15–20 mg orally

Usual maintenance dose: 15 mg orally twice daily for patients with a platelet count between 100 and 200×10^9/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.

Typical maximum dose: 25 mg orally twice daily

Proportion eliminated unchanged: 0.11 % (plus 74 % of the absorbed dose as active metabolites which confer 18 % of the pharmacodynamic actions of ruxolitinib)

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL 30–50 mL/min*	*Reduce starting dose 10 mg orally twice daily in patients with a platelet count between 100 and 150×10^9/L; dose modifications should be made with careful monitoring of safety and efficacy; avoid if platelet count is $<100 \times 10^9$/L.*
	CrCL 15–29 mL/min	*Reduce starting dose 10 mg orally twice daily in patients with a platelet count between 100 and 150×10^9/L; dose modifications should be made with careful monitoring of safety and efficacy; avoid if platelet count is $<100 \times 10^9$/L.*
	Hemodialysis	*15 mg orally twice daily for patients with a platelet count between 100 and 200×10^9/L or 20 mg orally twice daily for patients with a platelet count $>200 \times 10^9$/L; dose modifications should be made with careful monitoring of safety and efficacy; administer after hemodialysis on dialysis days.*
	CrCL <15 mL/min (not requiring hemodialysis)	*Avoid*
Alternative adjustment:	*Data not available*	

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Salsalate/Disalicylic Acid, Disalcid®, Amigesic® **{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*

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Saxagliptin/Onglyza™ **{Antidiabetic; dipeptidyl peptidase-4 inhibitor}**

Usual initial dose: 2.5 mg orally

Usual maintenance dose: 2.5–5 mg orally once daily

Typical maximum dose: 10 mg/day

Proportion eliminated unchanged: 24 % plus 36 % as active metabolite (5-hydroxy saxagliptin)

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL >50 mL/min*	*2.5–5 mg orally once daily*
	CrCL ≤50 mL/min	*2.5 mg orally once daily*
	Hemodialysis	*2.5 mg orally once daily; administer after hemodialysis on dialysis days.*
	CAPD	*No data*
Alternative adjustment:	*GFR >55 mL/min*	*2.5–5 mg orally once daily*
	GFR ≤55 mL/min	*2.5 mg orally once daily*

Silodosin - Selected References

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Silodosin/Rapaflo™ **{Adrenergic α_1 blocker; ℞ 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*	

Sitagliptin - Selected References

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Sitagliptin/Januvia® **{Antidiabetic; dipeptidyl peptidase-4 inhibitor}**

Usual initial dose:	100 mg orally
Usual maintenance dose:	100 mg orally once daily
Typical maximum dose:	100 mg/day
Proportion eliminated unchanged:	79 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL ≥50 mL/min or*	
	SCr ≤1.7 mg/dL in men or	
	SCr ≤1.5 mg/dL in women	*100 mg orally once daily*
	CrCL 30–50 mL/min or	
	SCr 1.7–3 mg/dL in men or	
	SCr 1.5–2.5 mg/dL in women	*50 mg orally once daily*
	CrCL <30 mL/min or	
	SCr >3 mg/dL in men or	
	SCr >2.5 mg/dL in women or	
	ESRD requiring hemodialysis or peritoneal dialysis	*25 mg orally once daily; may be given without regard to time of dialysis*
Alternative adjustment:	*Data not available*	

Sodium Citrate and Citric Acid - Selected References

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Sodium Citrate and Citric Acid/Bicitra®, Cytra-2 {Systemic alkalizer}

Usual initial dose:	10–30 mL diluted in 30–90 mL of water orally	
Usual maintenance dose:	10–30 mL diluted in 30–90 mL of water orally after meals and at bedtime daily	
Typical maximum dose:	120 mL/day	
Proportion eliminated unchanged:	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)*

Solifenacin - Selected References

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Solifenacin/Vesicare® **{Anticholinergic agent; ℞ 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*	

Sorafenib - Selected References

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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:

eCrCL ≥60 mL/min	*400 mg orally twice daily without food*
eCrCL 40–59 mL/min	*400 mg orally twice daily without food*
eCrCL 20–39 mL/min	*200 mg orally twice daily without food*
eCrCL <20 mL/min	*Insufficient data; dose not defined*
Hemodialysis	*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.)*

Note: Neurological, hematological, cardiovascular, or other considerations may suggest further dosage adjustments.

Sotalol - Selected References

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Sotalol/Betapace®, Betapace AF®, Sorine® **{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

CrCL (mL/min)	*Dosage*
(a)	
>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)*
(b)	
>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*

Alternative adjustment:

GFR >50 mL/min	*80–160 mg orally every 12 h*
GFR 10–50 mL/min	*80–160 mg orally every 24–48 h*
GFR <10 mL/min	*80–160 mg orally every 48–72 h*
Hemodialysis	*80–160 mg orally every 48–72 h; administer after hemodialysis on dialysis days.*
CAPD	*80–160 mg orally every 48–72 h*
CRRT	*80–160 mg orally every 24–48 h; titrate.*

Note: Electrocardiographic considerations such as QT interval prolongation may suggest further dosage adjustments.

Spironolactone - Selected References

Aldactone® tablet film coated [package insert]. New York: GD Searle LLC Division of Pfizer Inc; 2008.

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Spironolactone/Aldactone® **{Diuretic; aldosterone antagonist}**

Usual initial dose: 25 mg orally

Usual maintenance dose: 12.5–200 mg orally once daily

Typical maximum dose: 400 mg/day

Proportion eliminated unchanged: 30 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Anuria, acute renal insufficiency, significant impairment of renal excretory function*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*25–100 mg orally every 12–24 h*
	GFR 30–50 mL/min	*12.5–25 mg orally every 12–24 h*
	GFR <30 mL/min	*Preferably avoid due to risk for hyperkalemia.*
	Hemodialysis	*Preferably avoid due to risk for hyperkalemia.*
	CAPD	*Preferably avoid due to risk for hyperkalemia.*
	CRRT	*Preferably avoid due to risk for hyperkalemia.*

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.

Stavudine - Selected References

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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*

	Recommended dose	
CrCL (mL/min)	*Patient weight ≥60 kg*	*Patient weight <60 kg*
>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:

GFR >50 mL/min	*30 mg orally every 12 h (if <60 kg); 40 mg every 12 h (if ≥60 kg)*
GFR 21–50 mL/min	*15 mg orally every 12–24 h (if <60 kg); 20 mg every 12–24 h (if ≥60 kg)*
GFR 10–20 mL/min	*15 mg orally every 24 h (if <60 kg); 20 mg every 24 h (if ≥60 kg)*
Hemodialysis	*15 mg orally every 24 h (if <60 kg); 20 mg every 24 h (if ≥60 kg); administer after hemodialysis on dialysis days.*
CAPD	*Data not available*
CRRT	*30 mg orally every 12 h (if <60 kg); 40 mg every 12 h (if ≥60 kg)*

Streptomycin - Selected References

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Streptomycin {Antibacterial; aminoglycoside}

Usual initial dose: 15 mg/kg (max 1,000 mg) IM

Usual maintenance dose: 15 mg/kg (max 1,000 mg) IM once daily or 25–30 mg/kg (max 1,500 mg) IM twice weekly

Typical maximum dose: 1,500 mg/day

Proportion eliminated unchanged: 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.*

Alternative adjustment:

GFR >50 mL/min	*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.*
GFR 10–50 mL/min	*15 mg/kg (max 1,000 mg) IM or IV over 30 min every 24–72 h*
GFR <10 mL/min	*15 mg/kg (max 1,000 mg) IM or IV over 30 min every 72–96 h*
Hemodialysis	*1,000 mg IM or IV over 30 min every 72–96 h; administer 500–1,000 mg IM after hemodialysis on dialysis days.*
CAPD	*Add to dialysate qs 20–40 mg/L*
CRRT	*15 mg/kg (max 1,000 mg) IM or IV over 30 min every 24–72 h; monitor levels.*

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.

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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*	

Sulfamethoxazole and Trimethoprim (Enteral) - Selected References

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Sulfamethoxazole and Trimethoprim (Enteral)/

Co-trimoxazole,TMP-SMX, Bactrim™, Septra®, Sulfatrim® **{Antibacterial; sulfonamide}**

Usual initial dose: 800/160 mg orally

Usual maintenance dose: 800/160 mg (1 DS tablet, 2 SS tablets, or 20-mL suspension) enterally every 12 h for 10–14 days

Typical maximum dose: 20 mg (trimethoprim)/kg/day

Proportion eliminated unchanged: 85 %/67 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Sulfamethoxazole and trimethoprim dosage for patients wit impaired renal function*

CrCL (mL/min)	*Recommended dosage regimen*
>30	*Usual standard regimen*
15–30	*One-half the usual regimen*
<15	*Use not recommended*

Alternative adjustment:

GFR >50 mL/min	*800/160 mg enterally every 12 h for 10–14 days*
	Serious/life-threatening infections, 12–20 mg (trimethoprim)/kg/day in two to three divided doses
	Prophylaxis of Pneumocystis carinii infection, 150 mg (trimethoprim)/m^2/day in two divided doses on 3 consecutive days each week
GFR 10–50 mL/min	*800/160 mg enterally once followed by 400/80 mg enterally every 12 h*
GFR <10 mL/min	*Avoid unless no suitable alternative exists; if necessary, 800/160 mg enterally once followed by 400/80 mg enterally every 24 h*
Hemodialysis	*800/160 mg enterally once followed by 400/80 mg enterally every 24 h; administer after hemodialysis on dialysis days.*
CAPD	*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*
CRRT	*2.5–7.5 mg (trimethoprim)/kg enterally every 12 h*

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^2.

Sulfamethoxazole and Trimethoprim (IV) - Selected References

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Sulfamethoxazole and Trimethoprim (IV)/
Co-trimoxazole,TMP-SMX, Bactrim™, Septra® **{Antibacterial}**

Usual initial dose: 10 mg (trimethoprim)/kg IV

Usual maintenance dose: *Pneumocystis carinii pneumonia*: 5 mg (trimethoprim)/kg IV every 6–8 h (15–20 mg [trimethoprim]/kg/day) for 14–21 days

Severe urinary tract infections and shigellosis: 8–10 mg (trimethoprim)/kg/day IV in two to four equally divided doses for up to 14 days

Typical maximum dose: 20 mg (trimethoprim)/kg/day

Proportion eliminated unchanged: 85 %/67 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Sulfamethoxazole and trimethoprim dosage for patients wit impaired renal function*

CrCL (mL/min)	*Recommended dosage regimen*
>30	*Usual standard regimen*
15–30	*One-half the usual regimen*
<15	*Use not recommended*

Alternative adjustment:

GFR >50 mL/min	*4–5 mg (trimethoprim)/kg IV every 6 h (16–20 mg [trimethoprim]/kg/day)*
GFR 10–50 mL/min	*4–5 mg (trimethoprim)/kg IV every 12 h (8–10 mg [trimethoprim]/kg/day)*
GFR <10 mL/min	*Avoid unless no suitable alternative exists; if necessary, 2.5–5 mg (trimethoprim)/kg IV every 24 h*
Hemodialysis	*2.5–5 mg (trimethoprim)/kg IV every 24 h; administer after hemodialysis on dialysis days.*
CVVH	*2.5–7.5 mg (trimethoprim)/kg IV every 12 h*
CVVHD	*4–5 mg (trimethoprim)/kg IV every 6–8 h*
CVVHDF	*4–5 mg (trimethoprim)/kg IV every 6–8 h*

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^2.

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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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Tadalafil/Adcirca™ **{Phosphodiesterase-5 enzyme inhibitor; ℞ 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

FDA-approved product labeling:	*CrCL >80 mL/min*	*40 mg orally once daily*
	CrCL 51–80 mL/min	*20 mg orally once daily; may increase to 40 mg once daily based on individual tolerability*
	CrCL 31–50 mL/min	*20 mg orally once daily; may increase to 40 mg once daily based on individual tolerability*
	CrCL <30 mL/min	*Avoid*
	Hemodialysis	*Avoid*
	CRRT	*Data not available*
Alternative adjustment:	*Data not available*	

Tamsulosin - Selected References

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Tamsulosin/Flomax® **{Adrenergic α1 blocker; ℞ 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

FDA-approved product labeling:	*CrCL ≥10 mL/min*	*0.4–0.8 mg/day*
	CrCL <10 mL/min	*Has not been studied in patients with end-stage renal disease*
Alternative adjustment:	*eCrCL ≥10 mL/min*	*0.4–0.8 mg/day*
	eCrCL <10 mL/min	*0.4 mg/day*
	Hemodialysis	*0.4 mg/day (very limited data)*
	CRRT	*Not applicable; preferably avoid*

Tapentadol - Selected References

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Tapentadol/Nucynta®, Nucynta ER® **{Analgesic; opioid μ-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

FDA-approved product labeling:	*Mild to moderate renal impairment*	*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)*
	Severe renal impairment	*Use not recommended due to lack of data in this population*
Alternative adjustment:	*Data not available*	

Telavancin - Selected References

Clouse FL, Hovde LB, Rotschafer JC. In vitro evaluation of the activities of telavancin, cefazolin, and vancomycin against methicillin-susceptible and methicillin-resistant *Staphylococcus aureus* in peritoneal dialysate. Antimicrob Agents Chemother. 2007;51:4521–4.

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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*

Telithromycin - Selected References

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Telithromycin/Ketek® **{Antibacterial; ketolide}**

Usual initial dose: 800 mg orally

Usual maintenance dose: 800 mg orally once every 24 h for 7–10 days

Typical maximum dose: 800 mg/day

Proportion eliminated unchanged: 18 % in healthy subjects, 6 % in patients with severe renal impairment

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL ≥30 mL/min*	*800 mg orally once every 24 h for 7–10 days*
	CrCL <30 mL/min	*600 mg orally once daily*
	CrCL <30 mL/min with coexisting hepatic impairment	*400 mg orally once daily*
	Hemodialysis	*600 mg orally once daily; administer after hemodialysis on dialysis days*
Alternative adjustment:	*GFR >50 mL/min*	*800 mg orally once daily*
	GFR 10–50 mL/min	*800 mg orally once daily (no adjustment needed)*
	GFR <10 mL/min	*600 mg orally once daily (no adjustment needed)*
	Hemodialysis	*600 mg orally once daily; administer after hemodialysis on dialysis days*
	CAPD	*Data not available*
	CRRT	*800 mg orally once daily (no adjustment needed unless clearance <30 mL/min, then 600 mg orally once daily)*

Tenofovir - Selected References

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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*

CrCL (mL/min)	*Tenofovir dosage*
≥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*

Alternative adjustment:

GFR >50 mL/min	*300 mg orally every 24 h*
GFR 30–50 mL/min	*Preferably avoid unless no suitable alternative exists; if indeed necessary, 300 mg orally every 48 h*
GFR 10–29 mL/min	*Preferably avoid unless no suitable alternative exists; if indeed necessary, 300 mg orally every 72–96 h*
GFR <10 mL/min	*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*

Terbinafine - Selected References

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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)*

Terbutaline - Selected References

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Terbutaline/Bricanyl® **{Bronchodilator; β_2-adrenergic agonist}**

Usual initial dose: 0.25 mg subcutaneously or 5 mg orally

Usual maintenance dose: 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)

Typical maximum dose: 0.5 mg subcutaneously/4-h period or 15 mg/day orally

Proportion eliminated unchanged: 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*

Alternative adjustment:	*GFR >50 mL/min*	*0.25 mg subcutaneously; may repeat in 15–30 min or 17.5–30 μg/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)*
	GFR 10–50 mL/min	*0.125 mg subcutaneously; may repeat in 15–30 min or 8.75–15 μg/min continuous IV infusion (50 % decrease); avoid oral administration*
	GFR <10 mL/min	*Data not available; preferably avoid*
	Hemodialysis	*7 μg/kg subcutaneously*
	CAPD	*Data not available; preferably avoid*
	CRRT	*0.25 mg subcutaneously; may repeat in 15–30 min or 17.5–30 μg/min IV; avoid oral administration*

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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Tetracycline/Sumycin®, Aureomycin™ {Antibacterial}

Usual initial dose: 250 mg

Usual maintenance dose: 250–500 mg orally two to four times daily

Typical maximum dose: 2,000 mg/day

Proportion eliminated unchanged: 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*

Alternative adjustment:

GFR >50 mL/min	*250–500 mg orally every 8–12 h*
GFR 10–50 mL/min	*Preferably avoid unless no suitable alternative exists; if indeed necessary, 250–500 mg orally every 12–24 h*
GFR <10 mL/min	*Preferably avoid unless no suitable alternative exists; if indeed necessary, 250–500 mg orally every 24 h*
Hemodialysis	*Preferably avoid unless no suitable alternative exists; if indeed necessary, 250–500 mg orally every 24 h*
CAPD	*Preferably avoid unless no suitable alternative exists; if indeed necessary, 250–500 mg orally every 24 h*
CRRT	*Not applicable; avoid*

Thiopental - Selected References

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Thiopental/Pentothal® **{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)*

Ticarcillin and Clavulanate - Selected References

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Ticarcillin and Clavulanate/Timentin® {Antibacterial; extended-spectrum penicillin/β-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*

CrCL (mL/min)	*Dosage*
>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*

Tiludronate - Selected References

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Tiludronate/Skelid® **{Hypocalcemic agent; bisphosphonate; ℞ 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

FDA-approved product labeling:	*CrCL ≥30 mL/min*	*400 mg orally once daily before breakfast for 3 months*
	CrCL <30 mL/min	*Not recommended due to lack of clinical experience*
Alternative adjustment:	*eCrCL ≥30 mL/min*	*400–600 mg orally once daily before breakfast for 3 months*
	eCrCL <30 mL/min	*Data not available; preferably avoid*

Tinzaparin - Selected References

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Tinzaparin/Innohep® **{Antithrombotic; low-molecular-weight heparin}**

Usual initial dose: 175 units/kg subcutaneously

Usual maintenance dose: 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

Typical maximum dose: 175 units/kg/day

Proportion eliminated unchanged: 90 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*Renal insufficiency (CrCL >60 mL/min)*	*Elderly patients and patients with renal insufficiency may show reduced elimination of tinzaparin. It should be used with care in these patients*
	CrCL≤60 mL/min	*Contraindicated*
Alternative adjustment:	*CrCL≤60 mL/min*	*175 units/kg subcutaneously every 24 h*
	Hemodialysis	*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* *For hemodialysis catheter lock, 2,000 units per catheter line* *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*
	CRRT	*Data not available*

Tirofiban - Selected References

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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

	Most patients (CrCL ≥30 mL/min)		*Severe renal impairment (CrCL <30 mL/min)*	
Patient weight (kg)	*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)*

Tizanidine - Selected References

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Tizanidine/Zanaflex® {Antispasmodic; α_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 ≥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*

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Tobramycin/Nebcin® **{Antibacterial; aminoglycoside}**

Usual initial dose: 2–7 mg/kg IV (actual body weight [ABW] or ideal [IBW] + 0.4(ABW – IBW) if ABW > IBW)

Usual maintenance dose: 3–5 mg/kg/day IV in two to three divided doses*

Typical maximum dose: 10 mg/kg/day

Proportion eliminated unchanged: 95 %

Adjustment for Kidney Disease

FDA-approved product labeling:

CrCL ≤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)*

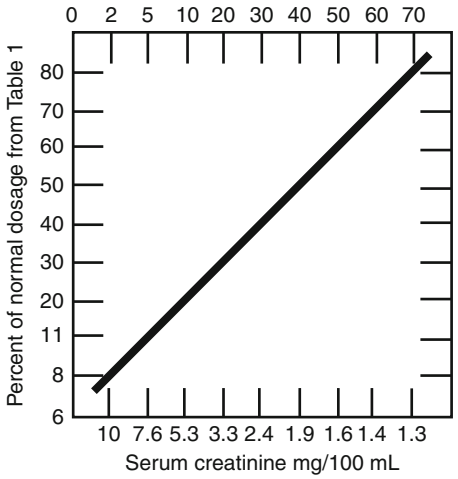

Fig. 19.1 Reduced dosage nomogram. Scales have been adjusted to facilitate dosage calculations

Alternative adjustment:

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 ≤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 ≤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 ≤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 ≤1 mg/L)**

***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*

Tolmetin - Selected References

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Tolmetin/Tolectin® **{Anti-inflammatory; analgesic; nonsteroidal anti-inflammatory drug}**

Usual initial dose: 400 mg orally

Usual maintenance dose: 400–600 mg orally three times daily

Typical maximum dose: 1,800 mg/day

Proportion eliminated unchanged: 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*

Tolterodine - Selected References

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Tolterodine/Detrol® **{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

FDA-approved product labeling:	*CrCL ≥30 mL/min*	*1–2 mg orally twice daily or 2–4 mg LA once daily*
	CrCL 10–30 mL/min	*1 mg twice daily or 2 mg LA once daily*
	CrCL <10 mL/min	*No data; use not recommended*
Alternative adjustment:	*Data not available*	

Tolvaptan - Selected References

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Tolvaptan/Samsca™ **{Vasopressin receptor antagonist; ℞ 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

FDA-approved product labeling:	*CrCL ≥80 mL/min*	*15–60 mg orally once daily*
	CrCL 10–79 mL/min	*15–60 mg orally once daily*
	CrCL <10 mL/min	*No data, not recommended*
	Hemodialysis	*No data, not recommended*
	Anuria	*Contraindicated; no benefit can be expected*
Alternative adjustment:	*Data not available*	

Topiramate - Selected References

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Topiramate/Topamax® **{Antiepileptic; adjunctive analgesic; ℞ 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*

Topotecan (Oral) - Selected References

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Hycamtin® capsule [package insert]. Research Triangle Park: GlaxoSmithKline; 2011.

Topotecan (Oral)/Hycamtin® **{Antineoplastic; topoisomerase inhibitor}**

Usual initial dose: 2.3 mg/m^2

Usual maintenance dose: 2.3 mg/m^2 orally once daily for five consecutive days repeated every 21 days

Typical maximum dose: 2.3 mg/m^2/day

Proportion eliminated unchanged: 20 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL 50–80 mL/min*	*2.3 mg/m^2 orally once daily for five consecutive days repeated every 21 days*
	CrCL 30–49 mL/min	*1.8 mg/m^2 orally once daily for five consecutive days repeated every 21 days*
	CrCL <30 mL/min	*Insufficient data are available to provide a dosage recommendation; risk of toxic reactions may be greater in patients with impaired renal function*
Alternative adjustment:	*Data not available*	
	Note: Hematological and other considerations may suggest further dosage adjustments.	

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.

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Topotecan (IV)/Hycamtin® IV **{Antineoplastic; topoisomerase inhibitor}**

Usual initial dose: 1.5 mg/m^2 IV

Usual maintenance dose: 1.5 mg/m^2 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^2/day

Proportion eliminated unchanged: 50 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL 40–60 mL/min*	*1.5 mg/m^2 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^2 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^2 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^2 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^2 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	

Tositumomab and ^{131}I-Tositumomab - Selected References

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Tositumomab and ^{131}I-Tositumomab/Bexxar®	**{Antineoplastic; monoclonal antibody; radiopharmaceutical}**
Usual initial dose:	Dosimetric step—450 mg IV (tositumomab) and 35 mg IV (^{131}I-tositumomab)
Usual maintenance dose:	Therapeutic step—450 mg IV (tositumomab) and 35 mg IV (^{131}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 (^{131}I-tositumomab)
Proportion eliminated unchanged:	98 %
Adjustment for Kidney Disease	
FDA-approved product labeling:	*^{131}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 ^{131}I-tositumomab therapeutic regimen. There are no data regarding the safety of administration of the tositumomab and ^{131}I-tositumomab therapeutic regimen in patients with impaired renal function*
Alternative adjustment:	*Data not available*

Tramadol - Selected References

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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*

Trandolapril - Selected References

Aepfelbacher FC, Messerli FH, Nunez E, Michalewica L. Cardiovascular effects of a trandolapril/verapamil combination in patients with mild to moderate essential hypertension. Am J Cardiol. 1997;79:826–8.

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Bakris GL, Gaxiola E, Messerli FH, et al. Clinical outcomes in the diabetes cohort of the International Verapamil SR-Trandolapril Study. Hypertension. 2004;44:637–42.

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Trandolapril/Mavik® **{Antihypertensive, vasodilator, angiotensin converting enzyme (ACE)/renin inhibitor}**

Usual initial dose: 1 mg orally once daily in nonblack and 2 mg orally once daily in black patients

Usual maintenance dose: 2–4 mg orally once daily

Typical maximum dose: 8 mg/day

Proportion eliminated unchanged: 33 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL < 30 mL/min*	*Recommended starting dose is 0.5 mg daily; subsequently titrate to the optimal response*
Alternative adjustment:	*GFR >50 mL/min*	*1–4 mg orally once daily*
	GFR 10–50 mL/min	*0.5–4 mg orally once daily*
	GFR <10 mL/min	*0.5–2 mg orally once daily (50 % decrease)*
	Hemodialysis	*0.5–2 mg orally once daily (50 % decrease)*
	CAPD	*0.5–2 mg orally once daily (50 % decrease)*
	CRRT	*1–4 mg orally once daily*

Tranexamic Acid - Selected References

Al Ameel 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.

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Tranexamic Acid/Lysteda®, Cyklokapron® {Hemostatic agent; antifibrinolytic}

Usual initial dose: 1,300 mg orally or 10 mg/kg IV

Usual maintenance dose: 1,300 mg orally three times daily (max duration 5 days) or 10 mg/kg IV three to four times daily

Typical maximum dose: 3,900 mg/day orally

Proportion eliminated unchanged: 95 %

Adjustment for Kidney Disease

FDA-approved product labeling:

Tranexamic acid dosage adjustment for patients with renal impairment

SCr (mg/dL[a])	*Adjusted dose*	*Total daily dose (mg)*	*Maximum duration*
>1.4 to ≤2.8	*1,300 mg twice daily*	*2,600*	*5 days*
>2.8 to ≤5.7	*1,300 mg once daily*	*1,300*	*5 days*
>5.7	*650 mg once daily*	*650*	*5 days*

SCr (mg/dL[a])	*IV tranexamic acid dosage*
1.36–2.83	*10 mg/kg twice daily*
2.83–5.66	*10 mg/kg daily*
>5.66	*10 mg/kg every 48 h or* *5 mg/kg every 24 h*

[a]Not calibrated or traceable to isotope dilution mass spectrometry (IDMS) standards

Alternative adjustment:

GFR >50 mL/min	*10 mg/kg/dose IV three to four times daily*
GFR 10–50 mL/min	*6.25 mg/kg/dose IV three to four times daily (75 % decrease)*
GFR <10 mL/min	*2.5 mg/kg/dose IV three to four times daily (90 % decrease)*
Hemodialysis	*Avoid unless no suitable alternative exists; if indeed necessary, 5 mg/kg IV every 24 h*
CAPD	*Avoid unless no suitable alternative exists; if indeed necessary, 5 mg/kg IV every 24 h*
CRRT	*6.25 mg/kg/dose IV up to four times daily (75 % decrease)*

Triamterene - Selected References

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Triamterene/Dyrenium®	**{Diuretic; potassium-sparing agent}**
Usual initial dose:	50 mg orally
Usual maintenance dose:	100 mg orally twice daily after meals
Typical maximum dose:	300 mg/day
Proportion eliminated unchanged:	4 % (plus 51 % of the absorbed dose as active primary hydroxylated sulfate conjugate metabolite)

Adjustment for Kidney Disease

FDA-approved product labeling:	*Severe or progressive kidney disease or anuria/ CrCL <10 mL/min*	*Contraindicated*
Alternative adjustment:	*GFR >50 mL/min*	*50–150 mg every 12 h*
	GFR 10–50 mL/min	*Avoid due to risk for hyperkalemia and cardiac irregularities*
	GFR <10 mL/min	*Avoid due to risk for hyperkalemia and cardiac irregularities*
	Hemodialysis	*Avoid due to risk for hyperkalemia and cardiac irregularities*
	CAPD	*Avoid due to risk for hyperkalemia and cardiac irregularities*
	CRRT	*Not applicable; avoid*

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Trimethoprim/Primsol®, Proloprim® **{Antibacterial; purine biosynthesis blocker}**

Usual initial dose:	100 mg orally
Usual maintenance dose:	100 mg orally every 12 h or 200 mg orally every 24 h for 10 days
Typical maximum dose:	15–20 mg/kg/day
Proportion eliminated unchanged:	75 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*CrCL 15–30 mL/min*	*50 mg orally every 12 h*
	CrCL <15 mL/min	*Not recommended*
Alternative adjustment:	*GFR >50 mL/min*	*100 mg orally every 12 h or 200 mg orally every 24 h*
	GFR 31–50 mL/min	*100 mg orally every 12 h*
	GFR 10–20 mL/min	*100 mg orally every 12–24 h*
	GFR <10 mL/min	*100 mg orally every 24 h*
	Hemodialysis	*100 mg orally every 24 h; administer after hemodialysis on dialysis days*
	CAPD	*100 mg orally every 24 h*
	CRRT	*2.5–5 mg/kg enterally every 12 h (mild infections) or 10 mg/kg enterally every 12 h (severe infections)*

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Dosage Adjustment of Medications Eliminated by the Kidneys

Trimetrexate/Neutrexin® **{Antiparasitic; folate antagonist; antineoplastic; ℞ for Pneumocystis carinii pneumonia in immunocompromised patients}**

Usual initial dose: 45 mg/m^2 IV

Usual maintenance dose: 45 mg/m^2 IV once daily over 60 min (must be administered with concurrent leucovorin protection)

Typical maximum dose: 45 mg/m^2/day

Proportion eliminated unchanged: 30 %

Adjustment for Kidney Disease

FDA-approved product labeling:	*SCr >2.5 mg/dL*	*Interrupt therapy; avoid*
Alternative adjustment:	*GFR >50 mL/min*	*45 mg/m^2 IV every 24 h (with concurrent leucovorin)*
	GFR 10–50 mL/min	*Data not available*
	GFR <10 mL/min:	*Avoid due to risk for hematological toxicity*
	Hemodialysis	*Data not available*
	CAPD	*Data not available*
	CRRT	*Data not available*

Note: Hematological and other considerations may suggest further dosage adjustments

Tromethamine - Selected References

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Tromethamine/THAM® {Alkalinizing agent; H^+ 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

FDA-approved product labeling:	*Renal disease or reduced urinary output*	*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*
	Uremia and anuria	*Contraindicated*
Alternative adjustment:	*Data not available*	

Trospium - Selected References

Bödeker R-H, Madersbacher H, Neumeister C, Zellner M. Dose escalation improves therapeutic outcome: post hoc analysis of data from a 12-week, multicentre, double-blind, parallel-group trial of trospium chloride in patients with urge incontinence. BMC Urol. 2010;10:15. doi: 10.1186/1471-2490-10-15.

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Trospium/Sanctura® **{Anticholinergic agent; ℞ 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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Valacyclovir - Selected References

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Valacyclovir/Valtrex® {Antiviral}

Usual initial dose: 1,000 mg orally

Usual maintenance dose: 500–1,000 mg orally two to three times daily

Typical maximum dose: 8,000 mg/day

Proportion eliminated unchanged: 46 %

Adjustment for Kidney Disease

FDA-approved product labeling: *Valacyclovir dosage recommendations for adults with renal impairment*

Indications	*Normal dosage regimen (CrCL ≥50 mL/min)*	*CrCL (mL/min)* *30–49*	*10–29*	*<10*
Cold sores (Herpes labialis): do not exceed 1 day of treatment	*Two 2-g doses taken 12 h apart*	*Two 1-g doses taken 12 h apart*	*Two 500-mg doses taken 12 h apart*	*500 mg single dose*
Genital herpes: initial episode	*1 g every 12 h*	*No reduction*	*1 g every 24 h*	*500 mg every 24 h*
Genital herpes: recurrent episode	*500 mg every 12 h*	*No reduction*	*500 mg every 24 h*	*500 mg every 24 h*
Genital herpes: suppressive therapy				
Immunocompetent patients	*1 g every 24 h*	*No reduction*	*500 mg every 24 h*	*500 mg every 24 h*
Alternate dose for immunocompetent patients with recurrences/year	*500 mg every 24 h*	*No reduction*	*500 mg every 48 h*	*500 mg every 48 h*
HIV-infected patients	*500 mg every 12 h*	*No reduction*	*500 mg every 24 h*	*500 mg every 24 h*
Herpes zoster	*1 g every 8 h*	*1 g every 12 h*	*1 g every 24 h*	*500 mg every 24 h*

Alternative adjustment:

GFR >75 mL/min	*1,000 mg orally every 8 h; 2,000 mg orally four times daily for prophylaxis of cytomegalovirus disease following kidney transplantation*
GFR 51–75 mL/min	*1,000 mg orally every 8–12 h; 1,500 mg orally four times daily for prophylaxis of cytomegalovirus disease following kidney transplantation*
GFR 25–50 mL/min	*1,000 mg orally every 12 h; 1,500 mg orally three times daily for prophylaxis of cytomegalovirus disease following kidney transplantation*
GFR 10–24 mL/min	*1,000 mg orally every 24 h; 1,500 mg orally two times daily for prophylaxis of cytomegalovirus disease following kidney transplantation*
GFR <10 mL/min	*500 mg orally every 24 h; 1,500 mg orally every 24 h for prophylaxis of cytomegalovirus disease following kidney transplantation*
Hemodialysis	*500 mg orally every 24 h; dose after hemodialysis on dialysis days*
CAPD	*500 mg orally every 24 h*
CRRT	*Not applicable; (consider IV acyclovir)*

Valganciclovir - Selected References

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Valganciclovir/Valcyte® **{Antiviral; nucleoside analog; ℞ 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*

CrCL (mL/min)	*Initial dosage*	*Maintenance/prevention dosage*
≥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:

GFR >50 mL/min	*900 mg orally twice daily (induction); 900 mg orally once daily (maintenance)*
GFR 10–50 mL/min	*450 mg orally every 24–48 h*
GFR <10 mL/min	*450 mg orally twice weekly*
Hemodialysis	*Minimal data available; preferably avoid (consider IV ganciclovir)*
CAPD	*Minimal data available; preferably avoid*
CVVHF	*450 mg enterally every 48 h (consider IV ganciclovir)*

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.

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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*

	Actual body weight (kg)			
eGFR (mL/min/1.73 m2)	*<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.

Vandetanib - Selected References

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Vandetanib/Caprelsa® **{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*	

Varenicline - Selected References

Aveyard P, Begh R, Parsons A, West R. Brief opportunistic smoking cessation interventions: a systematic review and meta-analysis to compare advice to quit and offer of assistance. Addiction. 2011. Epub ahead of print. doi:10.1111/j.1360-0443.2011.03770.x.

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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*	

Venlafaxine - Selected References

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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

FDA-approved product labeling:	*CrCL 10–70 mL/min*	*112.5–150 mg/day in two to three divided doses (25 % decrease)*
	Hemodialysis	*75–112.5 mg/day in two to three divided doses (50 % decrease)*
Alternative adjustment:	*GFR >50 mL/min*	*37.5–225 mg (ER) orally every 24 h (~25 % decrease)*
	GFR 10–50 mL/min	*37.5–187.5 mg (ER) orally every 24 h (50 % decrease)*
	GFR <10 mL/min	*37.5–187.5 mg (ER) orally every 24 h (50 % decrease)*
	Hemodialysis	*37.5–187.5 mg (ER) orally every 24 h (50 % decrease)*
	CAPD	*37.5–187.5 mg (ER) orally every 24 h (50 % decrease)*
	CRRT	*37.5–187.5 mg (ER) orally every 24 h (50 % decrease)*

Vigabatrin - Selected References

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Vigabatrin/Sabril® **{Antiepileptic, γ-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

FDA-approved product labeling:	*Renal impairment*	*A lower dose is necessary in patients with mild, moderate, and severe renal impairment.*
	CrCL >50 to 80 mL/min	*1,125 mg orally twice daily (25 % decrease)*
	CrCL >30 to 50 mL/min	*750 mg orally twice daily (50 % decrease)*
	CrCL >10 to <30 mL/min	*375 mg orally twice daily (75 % decrease)*
Alternative adjustment:	*GFR >50 mL/min*	*1,000–2,000 mg orally every 24 h*
	GFR 10–50 mL/min	*1,000–2,000 mg orally every 48 h*
	GFR <10 mL/min	*1,000–2,000 mg orally every 48–72 h*
	Hemodialysis	*500 mg orally every 72 h; administer after hemodialysis on dialysis days*
	CAPD	*1,000–2,000 mg orally every 48–72 h*
	CRRT	*1,000–2,000 mg enterally every 48 h*

Voriconazole - Selected References

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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 (≥1 mg/L) and avoid toxicity.*
Alternative adjustment:	*GFR >50 mL/min*	*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*
	GFR ≤50 mL/min	*200 mg enterally every 12 h (avoid IV administration)*
	Hemodialysis	*200 mg enterally every 12 h (IV administration not recommended)*
	CAPD	*200 mg enterally every 12 h (avoid IV administration)*
	CVVH	*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)*
	CVVHD or CVVHDF	*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)*

Note: Patients weighing <40 kg should receive half the usually recommended dose.

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Zalcitabine - Selected References

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Zalcitabine/Hivid®, 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

FDA-approved product labeling:	*CrCL 10–40 mL/min*	*0.75 mg orally every 12 h*
	CrCL <10 mL/min	*0.75 mg orally every 24 h*
Alternative adjustment:	*GFR >50 mL/min*	*0.75 mg orally every 8 h*
	GFR 10–50 mL/min	*0.75 mg orally every 12 h*
	GFR <10 mL/min	*0.75 mg orally every 24 h*
	Hemodialysis	*Data not available*
	CAPD	*Data not available*
	CRRT	*0.75 mg orally every 12 h*

Zidovudine - Selected References

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Zidovudine/Retrovir® **{Antiretroviral, nucleoside analog reverse transcriptase inhibitor}**

Usual initial dose: 300 mg orally or 1 mg/kg IV over 1 h

Usual maintenance dose: 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)

Typical maximum dose: 600 mg/day orally or 6 mg/kg/day IV

Proportion eliminated unchanged: 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

FDA-approved product labeling:	*CrCL <15 mL/min*	*100 mg orally or 1 mg/kg IV every 6–8 h*
	Hemodialysis	*100 mg orally or 1 mg/kg IV every 6–8 h*
	CAPD	*100 mg orally or 1 mg/kg IV every 6–8 h*
Alternative adjustment:	*GFR >50 mL/min*	*200 mg orally every 8 h*
	GFR 10–50 mL/min	*200 mg orally every 8 h*
	GFR <10 mL/min	*100 mg orally every 8 h*
	Hemodialysis	*100 mg orally every 8 h*
	CAPD	*100 mg orally every 8 h*
	CRRT	*200 mg enterally every 8 h*

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Zoledronic Acid/Reclast®, Zometa® {Anti-osteoporotic, hypocalcemic agent; bisphosphonate}

Usual initial dose: 4–5 mg IV

Usual maintenance dose: 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)

Typical maximum dose: 5 mg/dose

Proportion eliminated unchanged: 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*

CrCL (mL/min)	*Recommended dose*
>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	
CrCL ≥35 mL/min	*5 mg IV over 15 min once a year*
CrCL <35 mL/min and/or evidence of acute renal impairment	*Contraindicated*

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.

Zonisamide - Selected References

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Zonisamide/Zonegran®

{Antiepileptic; sodium channel and voltage-dependent T-type Ca^{2+} channel blocker}

Usual initial dose: 100 mg orally once daily

Usual maintenance dose: 200–400 mg/day orally in one or two divided doses

Typical maximum dose: 600 mg/day

Proportion eliminated unchanged: 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:

GFR >50 mL/min	*50–300 mg orally twice daily (0–25 % decrease)*
GFR 10–50 mL/min	*50–200 mg orally twice daily (25 % decrease)*
GFR <10 mL/min	*25–150 mg orally twice daily (50 % decrease)*
Hemodialysis	*4–8 mg/kg/day orally once daily in the evening; administer after hemodialysis on dialysis days*
CAPD	*25–150 mg orally twice daily (50 % decrease)*
CRRT	*50–200 mg enterally twice daily (25 % decrease)*

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