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Therapeutic Drug Monitoring (TDM) Guidelines for Pediatrics and Adults

(Commonly prescribed drugs are highlighted in gray)

Drug	Specimen	Sampling Time	Steady State Reference Intervals	Time to Steady State
Acetaminophen [1,5] (Tylenol®)	Serum or plasma (EDTA) **Note**: Two levels are needed	First Level 4 hours after acute ingestion Second Level: 4-8 hours later	Therapeutic: 10-30 µg/mL 2 hours post dose 5-20 µg/mL Toxic: 4 hours post dose >200 µg/mL 12 hours post dose >50 µg/mL	Peak: 1-2 hours
Amikacin [7,9] (Amikin®)	Serum or plasma (EDTA)	Peak: 30-60 minutes post IV infusion; 60-90 minutes post IM injection Trough: Within 30 minutes before next dose Daily Dosing: Random Times: 8-12 hours after dose Trough: Within 30 minutes before next dose	Therapeutic: Peak: 25-35 µg/mL Trough: Less severe infection 1-4 µg/mL Life-threatening infection 4-8 µg/mL Toxic: Peak: >35 µg/mL Trough: >10 µg/mL Daily Dosing: Therapeutic: <3 µg/mL Toxic: 3 µg/mL	Neonate: 10-45 hours Child: 2.5-12.5 hours Adult: 10-15 hours **(Note: 2)**
Amitriptyline [3] (Elavil®) See Nortriptyline metabolite	Serum or plasma (EDTA), do not use SST tubes	Trough: 10-14 hours post dose	Therapeutic: 120-250 ng/mL Toxic: >500 ng/mL	Adult: 3-8 days
Amobarbital, Quant. [9] (Amytal®)	Serum	Trough: Before next dose	Therapeutic: 1-5 µg/mL Sedative Hypnotic: 5-8 µg/mL Toxic: >10 µg/mL	Adult: 1.7-5 days **(Note: 2)**
Amphetamine [1,9] Also see methamphetamine	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 20-120 ng/mL Toxic: >200 ng/mL	Uncontrolled Urine pH: 60 hours Acidic Urine pH: 20-40 hours **(Note: 2)**
Caffeine [5,9] **Note**: Theophylline should also be monitored in infants.	Serum or plasma (Heparin or EDTA)	Trough: Before next dose Peak: 2 hours after slow release oral dose	Therapeutic: 3-15 µg/mL Neonate 8-20 µg/mL Premature Apnea 6-13 µg/mL Toxic: 0 months - 5 months >20 µg/mL 6 months - Adult >50 µg/mL	Premature infant: 8.5-48 days Adult: 17.5 hours (**Note: 2**)
Carbamazepine [2,9] (Tegretol®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 4-12 µg/mL With concurrent Phenytoin therapy 4-8 µg/mL Toxic: Initial >15 µg/mL Serious 50 µg/mL Concurrent phenytoin 8 µg/mL	Variable due to autoinduction Adult: 1.70-4.2 days (**Note: 2**)
Carbamazepine, Free	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 0.6-4.1 µg/mL (66-84% bound)	Variable due to autoinduction Adult: 1.7-4.3 days (**Note: 2**)

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Chloral Hydrate[1, 9] (Noctec®)	Serum	Trough: Before next dose	As Trichloroethanol: Therapeutic: 2-12 µg/mL Toxic: >20 µg/mL	Adult: (as trichloroethanol) 20-68 hours (**Note: 2**)
Chlordiazepoxide[1,9] (Librium®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 1-3 µg/mL Norchlordiazepoxide 0.2-0.7 µg/mL Nordiazepam 0.1-0.8 µg/mL Toxic: >5 µg/mL	Adult: 37-62 hours (**Note: 2**)
Chlorpromazine[1,9] (Thorazine®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: Adult 50-300 ng/mL Child 40-80 ng/mL Toxic: >750 ng/ml	Adult: 6.3 days (**Note: 2**)
Clonazepam[1,9] (Klonopin®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 15-60 ng/mL Toxic: >80 ng/mL	Adult: 4.2-12.5 days (**Note: 2**)
Clorazepate[1,9] (Tranxene®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	As desmethyldiazepam: Therapeutic: 0.1-0.8 µg/mL Toxic: >2 µg/mL	Adult: 8.3-20.8 days (**Note: 2**)
Cocaine[1,9]	Serum or plasma (Heparin or EDTA Urine on ice	Trough: Before next dose	Serum/Plasma Therapeutic: 25-75 ng/mL Toxic: >1,000 ng/mL Urine	Adult: as cocaine 5 hours (**Note: 2**)
Codeine[1,9]	Serum	Trough: Before next dose	Therapeutic: 10-100 ng/mL Toxic >200 ng/mL	Adult: 12.5-15 hours (**Note: 2**)
Cyclosporine[8]	Whole blood (EDTA)	Trough: 12-24 hours post dose	Up to 6 months post-transplant 250-375 ng/mL Greater than 6 months post-transplant 100-250 ng/mL Toxic: 450 ng/mL	Varies by patient and type of transplant
Desipramine[3,9] (Norpramin®)	Serum (non-SST) or plasma (Heparin or EDTA)	Trough: 12 or more hours after last dose	Therapeutic: 150-250 ng/mL Toxic: >500 ng/mL	Adult: 4.1-18.7 days (**Note: 2**)
Diazepam[1,9] (Valium®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose-	Therapeutic: 0.2-2.0 µg/mL Toxic: >5 µg/mL Nordiazepam 0.1-0.8 µg/mL	Adult: 12.5-56 days (**Note: 2**)
Digoxin[1,4] (Lanoxin®)	Serum or plasma (heparin or EDTA), do not use SST tubes	8-12 hours, or more, post dose	Therapeutic: CHF 0.8-1.5 ng/mL Arrthymias 1.5-2.0 ng/mL Toxic: Adult >2.5 ng/mL Child >3.0 ng/mL	Adult: 5-7 days
Diphenhydramine	Serum or plasma		Therapeutic: 20-150 µg/mL Marked Sedation: >70 µg/mL Toxic: >200 µg/mL	
Disopyramide[1,4] (Norpace®)	Serum of plasma (Heparin or EDTA), do not use SST tubes	1 hour before next dose	Therapeutic: Arrthymias: Atrial 2.8-3.2 µg/mL Ventricular 3.3-7.5 µg/mL Toxic: >7 µg/mL	Adult: 1-2 days

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Doxepin[3] (Sinequan®, Adapin®) Includes metabolite: N-desmethyldoxepin	Serum or plasma (Heparin or EDTA)	10-14 hours post dose	Therapeutic: (total) 150-250 ng/mL Toxic: (total) >500 ng/mL	Adult: 2-8 days
Ethosuximide[9] (Zaronin®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 40-100 µg/mL Toxic: >100 µg/mL	(**Note: 2**)
Ethotoin[10] Ethylphenylhydantoin (Peganone®)	Serum or plasma	Trough: Before next dose	Therapeutic: 15-50 µg/mL Toxic: Not established	Adult: 15-45 days (**Note: 2**)
Felbamate	Serum	Trough: Before next dose	Therapeutic: 40-100 µg/mL Toxic: Not established	Adult: 3-4 days
Flecainide[4] (Tambocor®)	Serum or plasma (Heparin or EDTA)	Trough: 1 hour before next dose	Therapeutic: 0.2-1.0 µg/mL Toxic: >1.0 µg/mL	Adult: 3-5 days
Flurazepam[9] (Dalmane®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: <20 ng/mL Toxic: >70 ng/mL	Adult: 2.1-20.4 days (**Note: 2**)
Gentamicin[7,9] (Garamycin®)	Serum or plasma (EDTA)	Peak: 30-60 minutes post IV infusion 60-90 minutes post IM injection Trough: Within 30 minutes before next dose Daily Dosing: Random Times: 8-12 hours after dose Trough: Within 30 minutes before next dose	Therapeutic: Peak: Less severe infection 5-8 µg/mL Severe infection 8-12 µg/mL Trough: Less severe infection <1 µg/mL Moderate infection <2 µg/mL Severe infection >2 µg/mL Daily Dosing: Therapeutic: <3 µg/mL Toxic: 3 µg/mL Toxic: Peak: 10-12 µg/mL Trough: 2-4 µg/mL	Adult: 10-15 hours (**Note: 2**)
Glutethimide[1,9] (Doriden®)	Serum	Trough: Before next dose	Therapeutic: 2-6 µg/mL Toxic: >5 µg/mL	Adult: 1.0-4.6 days (**Note: 2**)
Haloperidol[1,9] (Haldol®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 7-20 ng/mL Toxic: >29 ng/mL	Adult: 11.5-122 hours (**Note: 2**)
Ibuprofen[5,9] (Motrin®)	Serum or plasma (EDTA)	Trough: Before next dose	Therapeutic: 10-50 µg/mL Toxic: >100 µg/mL	Adult: 10 hours (**Note: 2**)
Imipramine[3] (Tofranil®) Includes metabolite: desipramine	Serum or plasma (Heparin or EDTA), do not use SST tubes	10-14 hours post dose Trough: ≥12 hours after dose	Therapeutic: (total) 180-350 ng/mL Toxic: (total) >500 ng/mL Therapeutic: (total) 150-250 ng/mL Toxic: (total) >500 ng/mL	Adult: 2-5 days
Lamotrigine[2]	Serum or plasma	Trough: Before next dose	Therapeutic: Not established Toxic: Not established	Adult: 30 hours - 2 weeks

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Lidocaine[4] (Xylocaine®) **Note**: MEGX is an active metabolite	Serum or plasma (Heparin or EDTA, do not use SST tubes	<30 minutes post IV dose	Therapeutic: 15-50 μg/mL Toxic: CNS, Cardiovascular depression 6-8 μg/mL Seizures, obtundation, decreased cardiac output >8 μg/mL MEGX: 0.5-2.0 μg/mL	Adult: 0.5-1.5 hours with loading dose 5-10 hours without loading dose
Lithium[3] (Eskalith®)	Serum or plasma (Heparin or EDTA), do not use lithium heparin tubes	6-12 hours post dose	Therapeutic: 0.5-1.2 mmol/L Toxic: >1.5 mmol/L	Adult: 4-6 days
Lorazepam[9] (Ativan®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 50-240 ng/mL Toxic: Not established	Adult: 1.7-5.2 days (**Note: 2**)
Meperidine[9] (Demerol®) Includes metabolite: normeperidine	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 70-500 ng/mL Toxic: 1,000 ng/mL	Adult: 18 hours (**Note: 2**)
Mephenytoin[10], Methoin, Pemantoin, Methylphenethylhydantion (Mesantoin®) Includes metabolite: 5-phenyl-5-ethylhydantoin	Serum	Trough: Before next dose	Therapeutic: 25-40 μg/mL Toxic: >50 μg/mL	
Mephobarbital[10] (Mebaral®) Includes metabolite: Phenobarbital	Serum	Trough: Before next dose	Therapeutic: 1-5 μg/mL Toxic: >40 μg/mL	See phenobarbital
Mepivicaine[10] (Carbocaine, Polocaine®)	Serum	Trough: Before next dose	Therapeutic: 0.2-5 μg/mL Toxic: >8 μg/mL	
Meprobamate[9] (Equanil®)	Serum	Trough: Before next dose	Therapeutic: 8-27 μg/mL Toxic: Slow acetylator >35 μg/mL Fast acetylator >70 μg/mL	Adult: 56.5 hours (**Note: 2**)
Methadone[9] (Dolophine®)	Serum or plasma (Heparin or EDTA)		Therapeutic: Single dose 30-80 ng/mL Maintenance 200-1,100 ng/mL Toxic: >2,000 ng/mL	Adult: 75-125 hours (**Note: 2**)
Methamphetamine[13] (Desoxyn®) Also see amphetamine	Serum		Therapeutic: 10-50 ng/mL Toxic: >200 ng/mL	
Metharbital (Gemonil) (as barbital)	Serum or plasma		Therapeutic: 15-35 μg/mL Toxic >40 μg/mL	
Methotrexate[10,9] (Rheumatrex, Folex)	Serum or plasma (Heparin or EDTA)	Collect at 0.5 hours post IV or oral low dose. For high dose collect at 25, 48 and 72 hours post dose.	Therapeutic: (see toxic) Varies with time and dose Toxic: 1-2 hours after low-dose therapy >0.02 μmol/L 24 hours after high-dose therapy ≥5 μmol/L 48 hours after high-dose therapy ≥0.5 μmol/L 72 hours after high-dose therapy ≥0.05 μmol/L	Adult: 40-75 hours (**Note: 2**)

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Methsuximide[9] (Celontin®) Includes metabolite: N-desmethylmethsuximide	Serum	Trough: Before next dose	Therapeutic: 10-40 µg/mL Toxic: >40 µg/mL	Adult: 10-20 hours Adult Metabolite: 150-200 hours (**Note: 2**)
Mtehyprylon[9] (Nodular®)	Serum	Trough: Before next dose	Therapeutic: 1-10 µg/mL Toxic: 20 µg/mL	Adult: 20 hours (**Note: 2**)
Mexiletine[9] (Mexitil®)	Serum	Trough: Before next dose	Therapeutic: 1.0-2.0 µg/mL Toxic: >1.5 µg/mL	Adult: 38-66 hours (**Note: 2**)
Morphine[1,9]	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 10-70 ng/mL Toxic: >200 ng/mL	Adult: 9-21 hours (**Note: 2**)
N-acetylprocainamide[4] (NAPA) **Note**: Must also determine procainamide	Serum or plasma (Heparin or EDTA)	Trough: 1 hour before next dose	Therapeutic: (total) 10-20 µg/mL Toxic: (total) >40 µg/mL	Adult: 31 hours (**Note: 2**)
Nortriptyline[9] (Aventyl®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose Trough: ≥12 hours after dose	Therapeutic: 50-150 ng/mL Toxic: >500 ng/mL	Adult: 90-450 hours (**Note: 2**)
Oxazepam (Serax®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 0.2-1.4 µg/mL Toxic: >2.0 µg/mL	
Oxycodone[9] (Percodan®)	Serum	Trough: Before next dose	Therapeutic: 10-100 ng/mL Toxic: >200 ng/mL	Adult: 20-25 hours (**Note: 2**)
Pentobarbital[9] (Nembutal®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: Hypnotic 1-5 µg/mL Therapeutic Coma 20-50 µg/mL Toxic: >10 µg/Ml	Adult: 74-139 hours (**Note: 2**)
Phencyclidine[9] (PCP) (Sernylan®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 20-90 ng/mL Toxic: 90-800 ng/mL Fatal: 500-4,000 ng/mL	Adult: 35-230 hours (**Note: 2**)
Phenobarbital[2] (Luminal®)	Serum or plasma (Heparin or EDTA)	Any time after Steady State Trough: Before next dose	Therapeutic: Adult 15-40 µg/mL Infant 20-60 µg/mL Toxic: Critical-Adult >40 µg/mL Critical-Infant (up to 12 months) >60 µg/mL Slowness, ataxia nystagmus 35-80 µg/mL Coma with reflexes 65-117 µg/mL Coma without reflexes (serious) >100 µg/mL	Newborn: 0-4 weeks: 21-28 days 4 weeks- 12 months: 12-14 days Child: 10-29 days Adult: 10-29 days (**Note: 2**)

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Phenobarbital, Free	Serum or plasma (Heparin or EDTA)	Any time after Steady State Trough: Before next dose	Therapeutic: 4-8 µg/mL	Newborn: 0-4 weeks: 21-28 days 4 weeks- 12 months: 12-14 days Child: 10-29 days Adult: 10-29 days (**Note: 2**)
Phensuximide[9] (Milontin®) Both parent and N-desmethyl metabolites	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: (total) 40-60 µg/mL Toxic: (total) Not established	Adult: 20 hours (**Note: 2**)
Phenylbutazone[9] (Butazolidin®)	Plasma (EDTA)	Trough: Before next dose	Therapeutic: (not well defined) 50-100 µg/mL Toxic: >100 µg/mL	Adult: 10-15 days (**Note: 2**)
Phenytoin[2] (Dilantin®)	Serum or plasma (Heparin or EDTA) do not use SST tubes	Trough: Before next dose	Therapeutic: Infant 6-11 µg/mL Adult 10-20 µg/mL Toxic: Total >30 µg/mL Serious >160 µg/mL	Adult: 1-3 weeks
Phenytoin, Free	Serum or plasma (Heparin or EDTA) do not use SST tubes	Trough: Before next dose	Therapeutic: 1-2 µg/mL Toxic: >3 µg/mL	Newborn: 1-3 weeks
Prazepam[9] (Centrax®)	Serum	Trough: Before next dose	Therapeutic: 0.1-1.0 µg/mL Toxic: Not established	Adult: 7.5-42 days (**Note: 2**)
Primidone[2,9] (Mysoline®) **Note**: Includes metabolite, Phenobarbital	Serum or plasma	Trough: Before next dose	Therapeutic: 5-12 µg/mL Toxic: Initial >15 µg/mL Serious >40 µg/mL	Adult: 16-64 hours (**Note: 2**)
Procainamide[4] (Pronestyl®) Must also determine NAPA	Serum or plasma (Heparin or EDTA)	Trough: 1 hour before next dose	Therapeutic: 4-8 µg/mL Toxic: >10 µg/mL	Adult: 15-25 hours
Propanolol[9] (Inderal®)	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: 50-100 ng/mL Toxic: Not established	Child: 10-20 hours Adult: 20-30 hours (**Note: 2**)
Propoxyphene[9] (Darvon®) Includes metabolite: norpropoxyphene	Plasma (EDTA)	Trough: Before next dose	Propoxyphene: Therapeutic: 0.1-0.4 µg/mL Toxic: >5 µg/mL Norpropoxyphene: Therapeutic: 0.1-1.5 µg/mL Toxic: >2.0 µg/mL	Adult: 1.7-5.0 days

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Protriptyline (Vivactil®)	Serum or plasma (Heparin or EDTA)	Trough: ≥12 hours after dose	Therapeutic: 70-260 ng/mL Toxic: >500 ng/mL	Adult: 14-19 days
Quinidine[4]	Serum or plasma (EDTA) do not use SST tubes	Trough: 1 hour before next dose	Therapeutic: 2.0-5.0 µg/mL Toxic: >6 µg/mL	Adults; 2 days (oral dosing)
Salicylates[9]	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Therapeutic: Analgesia, antipyresis 20-100 µg/mL Anti-inflammatory 150-300 µg/mL Toxic: Gastric intolerance, impaired homeostasis >100 µg/mL Deafness, headache, vertigo, tinnitus 150-300 µg/mL Nausea, vomiting, hyperventilation 250-400 µg/mL Intoxication: >500 µg/mL	Adult: 12-15 hours (**Note: 2**)
Secobarbital[9] (Seconal®)	Serum	Trough: Before next dose	Therapeutic: 2-5µg/mL Toxic: >7 µg/mL	Adult: 4-7 days (**Note: 2**)
Tacrolimus[12], FK506 (Prograf®)	Whole blood (EDTA)	Trough: Before next dose: Early post transplant	Therapeutic: 12 Hours: 5-20 ng/mL 24 hours: 33-50% less	Adult: 58.5-106 hours Children are ½ the time (**Note: 2**)
Theophylline[1,6] **Note**: Caffeine should also be monitored in infants.	Serum or plasma (Heparin or EDTA)	At 1-2 half-lives and 5 half-lives initially. Varies with type of administration. (**Note: 1**)	Therapeutic: Bronchodilator 8-20 µg/mL Premature apnea, 0-5 months 6-11 µg/mL Toxic: 0-5 months 15 µg/mL 6 months - Adult >20 µg/mL	Premature: 6 days Newborn: 5 days Infant: 1-5 days Child: 1-2 days Adult: 2-3 days
Thiocyanate[11]	Serum	Trough: Before next dose	Non-smoker: 1-4 µg/mL Smoker: 3-12 µg/mL Nitroprusside: 6-29µg/mL Toxic: >35 µg/mL	
Thiopental[9] (Sodium pentothal) Includes metabolite: pentobarbital	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Hypnotic: (total) 1-5 µg/mL Coma: (total) 30-100 µg/mL Anesthesia: (total) 7-130 µg/mL Toxic Concentration: (total) >10 µg/mL	Adult: 30-35 hours (**Note: 2**)
Thioridazine[9] (Mellaril®) Includes metabolite: mesoridazine	Serum or plasma (Heparin or EDTA)	Trough: Before next dose	Thioridazine: Therapeutic: 1.0-1.5 µg/mL Toxic: >10 µg/mL Mesoridazine: Therapeutic: 0.2-1.5 µg/mL Toxic: Not established	Adult: 2.1-7.5 days (**Note: 2**)

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Tobramycin[9] (Nebcin®)	Serum or plasma (Heparin or EDTA)	Peak: 30-60 minutes, post IV infusion; 60-90 minutes post IM injection Trough: Within 30 minutes before next dose Daily Dosing: Random Times; 8-12 hours after dose	Therapeutic: Peak: Less severe infection 5-8 µg/mL Severe infection 8-10 µg/mL Trough: Less severe infection <1 µg/mL Moderate infection <1 µg/mL Severe infection <2 µg/mL Toxic: Peak 10-12 µg/mL Trough 2-4 µg/mL Daily Dosing: Therapeutic <3 µg/mL Toxic 3 µg/mL	Adult: 10-15 hours
Tocainide[7,9] (Tonocard®)	Serum	Trough: Before next dose	Therapeutic: 4-10 µg/mL Toxic: Not established	Adult: 2.3-3.3 days (**Note: 2**)
Tolbutamide[9] (Orinase®)	Serum	Trough: Before next dose	Therapeutic: (tentative) 80-240 µg/mL Toxic: (tentative) >640 µg/mL	Adult: 20-30 hours (**Note: 2**)
Topiramate[2] (Topamax®)	Serum or plasma, call lab	Not established	Therapeutic: 2-25 µg/mL Toxic: Not established	4-5 days
Valproic Acid[2], Total (Depakene®)	Serum or plasma (Heparin or EDTA)	Pre-dose, same time of day	Therapeutic: 50-120 µg/mL Toxic: Initial >120 µg/mL Serious >200 µg/mL	Newborn: 1.7 days Child: 1.7-2.3 days Adult: 1.7-3.1 days (**Note: 2**)
Valproic Acid, Free	Serum or plasma (Heparin or EDTA)	Pre-dose, same time of day	Therapeutic: 2-20 µg/mL	Newborn: 1.7 days Child: 1.7-2.3 days Adult: 1.7-3.1 days (**Note: 2**)
Vancomycin[1,7,8] (Vancocin®)	Serum or plasma (Heparin or EDTA)	Peak: Approximately 2 hours after a 60 minute infusion Trough: Within 30 mintues before next dose	Therapeutic: Peak 20-40 µg/mL Trough 5-10 µg/mL Toxic: Peak 80-100 µg/mL Trough >40 µg/mL	Adult: 23.5-39 hours (**Note: 2**)

NOTES AND COMMENTS:

1. Contact the physician or pharmacy pharmacokinetic specialist for patient-specific information.
2. Based on 5 half-lives.[9]

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