Pocket Reference for ICU Staff

Critical Care Medicine Services

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Information in this booklet should be used as a guide only. The prescriber is responsible for the verification of indications and dosages listed in the manufacturers' package insert for the individual drugs, from which most information for this dosing guide is obtained. The prescriber should also not utilize the information provided in chart or table form without first consulting the references from which the information was extracted. These and other references are available on request.

This booklet is intended for the sole use of the patient care staff at Tripler Army Medical Center, Honolulu HI and not for general distribution or sale.

Special thanks to all of the TAMC ICU Nurses, Residents, and Interns for information and feedback that contributed to the compilation of this edition of the ICU Handbook.

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Table of Contents

SECTION I - DRUG GUIDELINES

IV Drip Guidelines IV Push Medications Acetazolamide Activated charcoal Adenosine Albuterol Alteplase Amiodarone Bretylium Bumetanide Buspirone Carvedilol Cisatracurium Dantrolene Desmopressin Digoxin Diaibind Diltiazem Dobutamine **Dopamine Infusion Chart** Dopamine Enalaprilat Epinephrine Esmolol Esmolol Infusion Chart Epoprostenol **Epoprostenol Dilution Chart** Etomidate Fentanyl Flumazenil Furosemide Glucagon Haloperidol Hvdralazine Insulin Isoproterenol Ketamine Labetalol Lidocaine Lorazepam Magnesium Metoprolol Midazolam Milrinone Infusion Chart Milrinone Naloxone Nitroglycerin Infusion Chart Nitroglycerin Nitroprusside Nitroprusside Infusion Chart Norepinephrine Infusion Chart Norepinephrine Phenylephrine Propofol Infusion Chart Propofol Procainamide Succinylcholine Thiopental Tromethamine Vasopressin Vecuronium Infusion Chart Vecuronium Verapamil

ELECTROLYTE REPLACEMENT

Potassium Magnesium Phosphate Calcium

Drug Compatibility Chart

SECTION II - Central Nervous System

Status epilepticus Increased intra-cranial pressure Glasgow Coma Scale Acute Management of Spinal Cord Injury Comparison of neuromuscular blockers Comparison of narcotic agonists Sedation—Agitation Scale Dermatome Chart

SECTION III - Cardiovascular System

Comparison of sympathomimetic agents Comparison of vasodilators Hemodynamic parameters (measured) Hemodynamic parameters (calculated) Oxygen delivery and consumption calculations Comparison of thrombolytic agents Indications for thrombolytic therapy Contraindications for thrombolytic therapy

SECTION IV - Pulmonary System

Interpretation of blood gases - primary Interpretation of blood gases - secondary Interpretation of blood gases - compensatory Ventilation/oxygenation parameters (measured) Ventilation/oxygenation parameters (calculated) Criteria for initiating ventilatory support Initial ventilator settings Modes of ventilatory support Troubleshooting the ventilator Common ventilator problems Predicting successful weaning from the ventilator Extubation procedure Failure to wean mnemonic Non-invasive positive pressure ventilation (NIPPV)

SECTION V - Fluids, Electrolytes, and Nutrition

Electrolyte content of common IV replacement fluids Electrolyte composition of gastrointestinal fluids Agents used in the treatment of hyperkalemia Adult Nutrition Decision Flowsheet Nutrition guidelines **Total Parenteral Nutrition guidelines** TAMC Enteral Formulary Guidelines for Monitoring of Nutrition Status in the ICU Miscellaneous facts and formulas Recommendations for SRMD prophylaxis Acid base disorders - anion gap calculation Acid base disorders - metabolic acidosis Acid base disorders - respiratory acidosis Acid base disorders - metabolic alkalosis Acid base disorders - respiratory alkalosis Management of metabolic alkalosis

SECTION VI - Renal System

Urine anion gap Causes of renal failure Causes of intrinsic azotemia Urine laboratory indices Urine disease diagnostic indices Causes of renal tubular acidosis

SECTON VII - Hematological System

Heparin protocol for systemic anticoagulation Transfusion guidelines Tests related to blood transfusions Blood Components and Plasma Derivatives In-Vitro Properties of Blood Clotting Factors Coagulation Cascade Transfusion reactions

SECTION VIII - Endocrine System

Glucose monitoring during insulin administration Acute Adrenal Insufficiency & ACTH Stimulation Testing Steroid potency / conversion chart & Stress Dosing Steroids Laboratory Analysis of Hypothyroidism

SECTION IX - Infectious Disease

Treatment of Specific Noscomial Infections Once Daily Aminoglycoside Dosing

SECTION X – Skin and Wound Care

Beds and Specialty Beds Available at TAMC Staging Criteria of Pressure Ulcers

SECTION XI - Pediatric Critical Care

Routine Sedation for Diagnostic and Non-Emergent Therapeutic Procedures Pediatric NPO Guidelines Inpatient & Postoperative Analgesia and Analgesia Hemodynamic Exam and Monitoring Pediatric Vasoactive Support Mechanical Ventilation Extubation Pediatric Transfusion Medicine Pediatric Nutrition Decision Flowsheet Pediatric Equipment

Standard Drug Dilutions & Maximum Concentrations

DRUG	DILUENT	STANDARD DILUTIION	MAX CONCENTRATION			
Aminophylline	NS,D5W	500mg/500ml (1mg/ml)	1250mg/250ml (5mg/ml)			
Amiodarone	D5W only	Load 150mg/100ml	900mg/250ml			
	5	Then 900mg/500ml (1.8mg/ml)	6			
Bretylium	NS, D5W	2gm/500ml (4mg/ml)	2gm/250ml (8mg/ml)			
Calcium gluconate	NS, D5W	1-3gm/100ml	undiluted 100mg/ml			
Cis-Atracurium	NS, D5W	40mg/200ml (0.2mg/ml)	80mg/200ml (0.4mg/ml)			
Diltiazem	NS, D5W	125mg/125ml (1mg/ml)	125mg/125ml (1mg/ml)			
Dobutamine	NS,D5W	250mg/250ml D5W premix (1mg/ml)	1000mg/250ml (4mg/ml)			
Dopamine	NS,D5W	400mg/250ml D5W premix (1.6mg/ml)	800mg/250ml (3.2mg/ml)			
Ephedrine	NS, D5W	50mg/250ml (0.2mg/ml)	50mg/250ml (0.2mg/ml)			
Epinephrine	NS,D5W	4mg/250ml (16mcg/ml)	8mg/250ml (32mcg/ml)			
Esmolol	NS,D5W	2.5gm/250ml (10mg/ml)	2.5gm/250ml (10mg/ml)			
Fentanyl	NS, D5W	2500mcg/50ml own diluent	2500mcg/50ml own diluent			
Furosemide	NS, D5W	100mg/100ml (1mg/ml)	500mg/100ml (5mg/ml)			
Glucagon	NS, D5W	10mg/100ml (0.1mg/ml)	10mg/100ml (0.1mg/ml)			
Heparin	NS, D5W	20,000u/500ml D5W premix (40u/ml)	40,000u/500ml (80u/ml)			
Regular Insulin	NS only	100mg/100ml (1mg/ml)	100mg/100ml (1mg/ml)			
Labetalol	NS, D5W	200mg/100ml (2mg/ml)	400mg/100ml (4mg/ml)			
Lidocaine	NS, D5W	2gm/500ml (4mg/ml) premix	2gm/250ml (8mg/ml)			
Magnesium	NS, D5W	4gm/100ml premix	Max 200mg/ml			
Midazolam	NS, D5W	50mg/50ml (1mg/ml)	50mg/50ml (1mg/ml)			
Milrinone	NS, D5W (premix)	40mg/200ml premix (0.2mg/ml)	40mg/200ml premix (0.2mg/ml)			
Nitroglycerin	NS, D5W	50mg/250ml D5W premix (0.2mg/ml)	100mg/250ml (0.4mg/ml)			
Nitroprusside	D5W preferred	50mg/250ml (0.2mg/ml)	50mg/250ml (0.2mg/ml)			
Norepinephrine	D5W only	4mg/250ml (16mcg/ml)	16mg/250ml (64mcg/ml)			
Phenylephrine	NS, D5W	40mg/500ml (80mcg/ml)	40mg/500ml (80mcg/ml)			
Procainamide	NS, D5W	1gm/250ml (4mg/ml)	1gm/250ml (4mg/ml)			
Vecuronium	NS, D5W	100mg/250ml (0.4mg/ml)	100mg/100ml (1mg/ml)			

INTRAVENOUS PUSH (IVP) MEDICATIONS

All of the following medications may be administered IVP by the RN to patients within the critical care section except for those that are annotated for a specific patient population.

Adenosine (Adenocard) Albumin Ativan Atropine Benadryl (Diphenhydramine) Bretylium (Bretylol) Bumex (Bumetanide) Calcium Chloride Calcium Gluconate Cardizem (Diltiazem) Compazine (Prochlorperazine)* DDAVP (Desmopressin Acetate) Decadron (Dexamethasone) Demerol (Meperidine) Dextrose 50% Diazoxide (Hyperstat) Digoxin (Lanoxin) Enalapril (Vasotec) Epinephrine Esmolol HCL (Brevibloc) Fentanyl (Sublimase) Haldol (Haloperidol) Heparin Hydralazine (Apresoline) Inapsine (Droperidol) Inderal (Propanalol HCL) Insulin Ketamine Lasix (Furosemide) Lidocaine

Lopressor (Metoprolol Tartrate) Mannitol Morphine Sulfate Narcan (Naloxone HCL) Neo-Synephrine (Phenylephrine HCL) Norcuron (Vecuronium)** Ondansetron (Zofran) Pavulon (Pancuronium Bromide)** Phenergan (Promethazine) Phosphenvtoin* Procainamide (Pronestyl, Procan) Protamine Sulfate Regitine (Phentolamine Mesylate) Reglan (Metoclopramine) Robinul (Glycopyrrolate) Romazicon (Fulmazenil) Sodium Bicarbonate Solu-Cortef (Hydrocortisone) Solu-Medrol (Methylprednisone) Tensilon (Edrophonium Chloride) Thiamine Thorazine (Chlorpromazine) Toradol (Ketoralac Tromethamine) Valium (Diazepam) Verapamil (Calan) Versed (Midazolam HCL) Vitamin K (AquaMephytoin) Vistaril (Hydroxyzine HCL) Zemuron (Rocuronium Bromide)**

*NOT TO BE GIVEN IV PUSH TO PEDIATRIC PATIENTS **MUST BE ON MECHANICAL VENTILATION

Acetazolamide (Diamox®)

Use: Diuretic, urine alkalinization, lowers intraocular pressure, adjunct tx of refractory seizures, acute altitude sickness, and centrencephalic epilepsies.

Dose: Edema: Oral, IV, IM: 250-375 mg or 5 mg/kg once daily

Anticonvulsant: 8-30 mg/kg/24 hrs in divided doses Q 6-12 hours

Urinary alkalinization: 5 mg/kg/dose Q 8-12 hours

Mix: 500mg diluted in 5ml SWFI. May be given direct IV or further diluted in 50ml NS/D5W.

Mechanism: Inhibition of carbonic anhydrase resulting in reduction of H⁺ ion secretion at renal tubule and an increased renal excretion of sodium, potassium, bicarb, and water.

Dosing adjustment in renal impairment:

Clcr 10-50 ml/min: administer every 12 hours

Cl_{cr} < 10 ml/min: avoid use - ineffective

Monitoring: Intraocular pressure, potassium, serum bicarb, serum electrolytes, periodic CBC with differential

Activated Charcoal

Use: drug overdose

Dose: 30-100gm/dose, or 1gm/kg

MDAC: multiple doses may be given (every 2-4 hours) for drugs which undergo enterohepatic recycling; 1-2 doses/day may be given mixed with sorbitol to enhance elimination; use of premixed AC/sorbitol may lead to severe dehydration if administered with every dose; doses should be held if the patient does not have active bowel sounds **Adverse events:** Diarrhea; potential for aspiration in patients unable to protect airway

Adenosine (Adenocard®)

Use: Treatment of paroxysmal supraventricular tachycardia (PSVT) and diagnostic use in atrial fibrillation/flutter or atrial/ventricular tachycardias

Dose: 6 mg IVP peripherally (3mg IVP centrally) over 1-2 seconds; if unsuccessful may repeat after 1-2 minutes with 12 mg IVP peripherally (6mg IVP centrally) to a maximum of 30mg; each dose should be followed immediately by a 20ml saline flush

Mechanism: complex conduction slowing in AV node

Elimination: cellular Half-life: <10 seconds

Adverse effects: transient dyspnea, chest pain, flushing, bradycardia or sinus pause. Drug

interaction with dipyridamole (potentiation of adenosine effects), and theophylline (potential for bronchoconstriction)

Albuterol (Proventil®, Ventolin®) for nebulization

 Use:
 reversible bronchospasm

 Dose:
 0.5ml in 3ml NS every 2-6 hours or 2.5ml of 0.083% premixed solution

 Onset:
 within 5 minutes

 Duration:
 3-8 hours

 Mechanism:
 β₂-agonist, bronchodilator

 Adverse events:
 tachycardia, hypokalemia

Alteplase (Activase®, TPA)

 Use:
 thrombolytic agent used in the management of acute myocardial infarction and acute ischemic stroke

 Mix:
 100mg in 100mL 0.9% Sodium chloride injection for total volume of 200mL

 Dose (MI):
 Bolus:
 15mg (30mL) over 1-2 minutes

Load: 50mg (100mL) over 30 minutes Maint: 35mg (70mL) over 60 minutes Dose (PE): 100mg (200mL) over 2 hours Onset: within minutes Half life: minutes Mechanism: local fibrinolysis by binding to fibrin in the thrombus and converts entrapped

plasminogen to plasmin

Adverse events: hypotension, hemorrhage

Amiodarone (Cordarone®)

Use:	initial treatment and prophylaxis of recurring ventricular fibrillation or ventricular tachycardia, alternative agent for rate control and NSR conversion in atrial fibrilla						
Dose:	Load-1	150mg over 10 minutes					
	Load-2	360mg over next 6 hours					
	Load-3	540mg over next 18 hours					
	Maint	0.5 mg/min					
Mix:	150mg (3	mL) in 100mL D5W for Load-1 and administer over 10 minutes THEN					
	900mg (1	8mL) in 500mL D5W and administer at 33 mL/hr for 6 hours for Load-2 THEN					
	at 16 mL	/hr for 18 hours for Load-3 THEN 900mg (18mL) in 500mL for maintenance					
Mechani	ism:	Class III anti-arrhythmic agent which decreases AV conduction and sinus					
		node function, prolongs action potential and refractory period, and inhibits					
		adrenergic activity					
Eliminati		hepatic metabolism with active metabolites Half-life: 40-55 days					
Adverse	events:	hypotension, nausea, vomiting, alveolitis, pulmonary fibrosis, interstitial pneumonitis, hypo- or hyperthyroidism, cardiac arrhythmias					
IV to PO:	1	< 1 week IV infusion administer 800-1600 mg PO / day					
		1-3 week IV infusion administer 600-800 mg PO / day					
		> 3 week IV infusion administer 400 mg PO / day					

Bumetanide (Bumex®)

Use: diuretic

 Dose: 0.5-1mg/ dose IV push over 1-2 mins; maximum 10 mg/day

 Continuous IV infusion: 0.9-1 mg/hour

 Mix: may be given undiluted

 Mechanism: inhibits reabsorption of sodium and chloride in the ascending loop of Henle and proximal renal tubule.

 Elimination: renal
 Half-life: 1-1.5 hours

 Adverse effects: hyperurecemia, hypochloremia, hypokalemia, azotemia

Bretylium (Bretylol®)

Use:	second line for ventricular fibrillation (VF), pulseless ventricular tachycardia							
Dose:	Load:	(PVT) 5-10mg/kg diluted in 50ml D5W over 8-10 minutes, then maintenance						
		(VF) 5mg/kg IVP; repeat with 10mg/kg every 5 minutes prn to max of 30mg/kg						
	Maint	1-4mg/min						
Mix:	2gm in 25	iomi D5W/NS						
Mechan	ism:	Class III antiarrhythmic, prolongs repolarization						
Eliminat	ion:	renal Half-life: 7-11 hours						
Adverse	e events:	proarrhythmia, possible initial hypertension followed by hypotension						
		refractory to epinephrine may occur (use dopamine), nausea, vomiting						

Bretylium Infusion Chart

Cha	art						
	Bretylium	2gm in	250mL	D	5W/N	S	
_							

Dose is mg/min	1	1.5	2	2.5	3	3.5	4	4.5	5
Rate is mL/hr	8	11	15	19	23	26	30	34	38

Buspirone (BuSpar®)

Use: Non-Benzodiazepine Antianxiety Agent Dose: Start 5mg po TID. May increase every 2-3 days in 5mg increments, up to max. total daily dose of 60mg. Mechanism: Serotonin and dopamine receptor agonist. Can not be used to treat benzodiazepine withdrawal Elimination: Hepatic Half-life: 2-3 hours

Adverse effects: Dizziness, lightheadedness, headache, restlessness, nausea. Can increase AST and ALT.

Carvedilol (Coreg®)

Use: Treatment of congestive heart failure of ischemic or cardiomyopathic origin in conjunction with digitalis, diuretics, and ACE inhibitors

Dose: Starting 3.125mg po BID for 2 wks. Then double the dose every 2 wks. To the maximum tolerated dose or up 25mg BID for pts <85kg or 50mg BID for pts. >85kg

Mechanism: Nonselective β -adrenergic blocking agent with α_1 - blocking activity

Elimination: Hepatic Half-life: 7-10 hours Adverse events: Bronchospasm, hypotension, and bradycardia

Cis-atracurium (Nimbex®)

Use: relaxation of skeletal muscles during surgery or mechanical ventilation; this agent has no analgesic or amnestic properties

Dose: I oad 0.1 mg/kg

Maint 0.5 - 10.2 mcg/kg/min with usual dose of 3 mcg/kg/min; dose should be titrated using a peripheral nerve stimulator to a train-of-four (TOF of 1-2 out of 4).

2-2.5 minutes; maximum block within 3-5 minutes Onset:

40mg in 200ml D5W/NS Mix:

Mechanism benzylisoquinolinium neuromuscular blocker; competitive antagonism of acetylcholine

Elimination: Hoffmann degradation Half-life: 20-30 minutes

Adverse events: rare bronchospasm

Dantrolene (Dantrium®)

Use: Treatment of malignant hyperthermia. Potentially effective in neuroleptic malignant syndrome Dose:

3 mg/kg IV bolus. Repeat every 30 min. up to 10 mg/kg total dose.

Mix: Reconstitute each 20mg vial with 60 ml sterile water for injection only. Each vial contains 3000 mg of mannitol. Protect from light. Use within 6hrs.

Mechanism: In skeletal muscle dantrolene dissociates excitation-contraction coupling, probably by interfering with the release of Ca⁺⁺ from the sacroplasmic reticulum,

reestablishing the myoplasmic calcium equilibrium

Half-life: 4-8 hours

Onset: 5-30 minutes Monitor: Follow arterial blood gases. Support Airway, Breathing & Circulation

Adverse events: Muscle weakness (may potentiate muscle relaxants), Drowsiness and dizziness

Desmopressin Acetate (DDAVP®)

Use: Treatment of bleeding complications related to Hemophilia A, von Willebrand's Disease (Type I), and following complex cardiopulmonary bypass procedures. Also used to treat

central diabetes insipidis via either IV, SQ, or Intranasal routes.

Bleeding: 0.3 mcg/kg IV over 15-30 min. Dose:

DI: 2-4 mcg IV or SQ in two divided doses daily or as dictated by water balance and/or urine output. Mix: Dilute in 50 ml NS for IV administration

Mechanism: Induces release of von Willebrand's factor necessary for adequate activity of factor VIII and optimal adhesion of platelets.

Onset: 30 min

Half-life: 75 min

Adverse events: Water intoxication and hyponatremia. Transient hypotension can be seen with rapid IV injection.

Digoxin (Lanoxin®)

Use: atrial flutter or atrial fibrillation, PSVT to control ventricular rate

Dose: Load 10-15mcg/kg IVP (usually 1mg) divided with the first half given immediately, then 1/4 of the doses given every 6 hours times 2 doses 0.125-0.25mg/day PO or IVP; monitor serum levels periodically Maint

IV within 5-30 minutes; peak within 1.5-3 hours Onset: Increases vagal activity through AV node, inhibition of Na-K ATPase pump Mechanism: Half-life: 1.4 days Elimination: renal Monitor: hypercalcemia, hypokalemia, hypomagnesemia (all predispose to dig toxicity), renal. digoxin levels

Adverse events: first degree heart block, bradycardia, escape arrhythmias, nausea, vomiting

Digoxin Fab (Digibind®)

Use: life-threatening digoxin toxicity

available as 40mg/vial; calculate dose below and order as number of vials Dose:

closest to dose. Using serum concentration, dose = conc (ng/ml) x wt (kg) x 0.373

Mechanism: antibody complex formation to digoxin

Elimination: Renal Half-life: 15-20 hours

Adverse events: Exacerbation of heart failure or a-fib due to withdrawal of digoxin; potential for complex dissociation with repeat toxicity in end-stage renal disease,

hypersensitivity; digoxin levels meaningless for 7 days post Digibind use

Diltiazem (Cardizem®)

Use:	control ve	entricular response in atrial fibrillation, atrial flutter, or supraventricular tachycardia
Dose:	Load	20mg over 2 min, may repeat in 15 min with 25mg (or 0.25mg/kg), may repeat
		again in 15 min with 0.35mg/kg
	Maint	10-20mg/hr
Mix:	125mg in	125ml of D5W/NS (1:1 mix)
Mechan	ism:	Inhibition of slow calcium channel in vascular and cardiac muscle tissue with decreased sinus node automaticity and decreased AV node conductivity
Eliminat	tion:	biliary Half-life: 4-6 hours
Adverse	e events:	hypotension, bradycardia, dizziness
IV to PC	convers	ion: $[(mg/hr \times 3) + 3] \times 10 = daily oral dose$

Dobutamine

first line inotropic support Use:

Dose: 2-15mcg/kg/min, maximum dose 40mcg/kg/min

Mix: Standard premixed solution: 250mg in 250ml D5W (1mg/ml)

Mechanism: β_1 inotrope at doses less than 10mcg/kg/min; β_2 vasodilation at doses greater than 10mcg/kg/min, a2 vasodilation may occur

Onset: 1-2 minutes Elimination: hepatic Half-life: 2 minutes

Adverse events: tachycardia, hypotension (generally with doses >10mcg/kg/min)

Dopamine

Use: renal and mesenteric perfusion, inotropic effect, vasopressor Dose: Low (renal and mesenteric protective dose) 1-3 mcg/kg/min Mid (inotropic dose) 2-10mcg/kg/min High (vasopressor dose) >10mcg/kg/min Mix: Standard premixed solution: 400mg in 250mL D5W or 1600mcg/mL (see drip chart) Mechanism: low dose for renal and mesenteric perfusion, mid dose for β_1 inotropic effect, high dose for α_1 (vasoconstrictor) effect **Onset:** within 5 minutes

Elimination: hepatic Half-life: 2 minutes Adverse events: tachycardia, hypertension at high doses

Dopamine Infusion Chart

Dopamine 400mg in 250mL D5W (Rate is mL/hr) mcg/kg/min

			-									
	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30
50 kg	5	9	14	19	23	28	33	38	42	47	52	56
55 kg	5	10	15	21	26	31	36	41	46	52	57	62
60 kg		11	17					45		56		
65 kg			18		30						67	73
70 kg		13	20									
75 kg		14	21									84
80 kg			23									
85 kg												
90 kg			25								93	
95 kg												
100 kg	9	19	28	38	47	56	66	75	84	94	103	113

Enalaprilat (Vasotec® IV)

mild to moderate hypertension, afterload reduction Use:

Dose: 1.25-5mg IVP over 5 minutes every 6 hours

Onset: within 15 minutes; peak effects may be delayed with first dose

Mechanism: Angiotensin-converting enzyme inhibitor

Elimination: Renal Half-life: 35-40 hours

Adverse events: hyperkalemia, angioedema, cough, nausea, hypotension in volume depleted patients or patients receiving diuretics

IV to PO conversion: same total dose administered once daily as lisinopril

Epinephrine

Use: inotropic support, bronchospasm, anaphylaxis, vasopressor at high doses

Dose: Vasopressor 1-10mcg/min

ACLS class IIb recommendation 0.1mg/kg or 5mg IVP as single dose OR continuous infusion of 0.2mg/min (1mg every 5 minutes)

Mix: Vasopressor 4mg in 250ml D5W/NS

ACLS 30mg in 250ml D5W/NS

Adverse events: tachyarrhythmias and hypertension at high doses

Esmolol (Brevibloc®)

Use: hypertension, control ventricular response in atrial fibrillation/flutter or SVT

Dose: Load 0.25-0.5mg/kg over 1 minute (use with caution)

Maint 25mcg/kg/min, increase by 25mcg/kg/min every 5 min to a maximum of 300mcg/kg/min

Mix: 2.5 gm in 250ml D5W/NS

Mechanism: Class II antiarrhythmic, beta-adrenergic blockade (1>>2)

Elimination: plasma esterases Half-life: 8 minutes (20 minutes clinically)

Adverse events: hypotension, bradycardia, heart block, sudden cardiac death

Esmolol Infusion Chart

Esmolol 2.5gm in 250mL D5W/NS (Rate is mL/hr)

	ncy/k	<i>y</i> /111111										
	25	50	75	100	125	150	175	200	225	250	275	300
50 kg	8	15	23	30	38	45	53	60	68	75	83	90
55 kg		17	25		41					83	91	99
60 kg				36	45					90	99	108
65 kg				39	49					98	107	117
70 kg			32		53			-		105	116	126
75 kg				45	56					113	124	135
80 kg			36		60					120	132	144
85 kg					64		89			128	140	153
90 kg			41		68 71					135	149 157	162 171
95 kg										143		
100 kg	15	30	45	60	75	90	105	120	135	150	165	180

Epoprostenol (Prostacycline) (Flolan®)

Use: treatment of primary pulmonary hypertension

Dose: Acute dose ranging: initial infusion rate 2ng/kg/min, increased in increments of 2ng/kg/min every 15 mins or longer until dose limiting effects seen (chest pain, anxiety, dizziness, changes in heart rate, dyspnea, nausea, vomiting, headache, hypotension and/or flushing)

Continuous chronic infusion: initial infusion rate 4ng/kg/min **less** than maximum tolerated acute rate. If max tolerated rate is <5ng/kg/min then chronic rate should be ½ the maximum tolerated rate.

Infusion rate (ml/hr) = Dose (ng/kg/min) X Weight in Kg X 60 min/hr

Final concentration (ng/ml)

Mechanism: a naturally occuring prostaglandin. Directly vasodilates pulmonary and systemic arterial vascular beds and inhibits platelet aggregation.

Stability: reconstituted solutions must be refrigerated and protected from light. Stable in IV pump reservoir only 8 hours at room temperature. Use of frozen gel packs can extend reservoir life to 24 hours.

Adverse reactions: chest pain, anxiety, dizziness, changes in heart rate, dyspnea, nausea, vomiting, headache, hypotension and/or flushing

Mix: **use only supplied diluent**

To make 100 ml of solution with concentration:	
	Directions
3000 ng/mi	Dissolve one 0.5 ml vial with supplied diluent, withdraw 3 ml, add to sufficient diluent to make a total of 100 ml
5000 mg/ml	Dissolve one 0.5 ml vial with 5 ml supplied diluent, withdraw entire vial contents, add a sufficient volume of diluent to make a total of 100 ml
10,000 ng/ml	Dissolve two 0.5 mg vials each with 5 ml supplied diluent, withdraw entire vial contents, add a sufficient volume of diluent to make a total of 100 ml
15,000 ng/ml	Dissolve one 1.5 ml vial with 5 ml supplied diluent, withdraw entire vial contents, add a sufficient volume of diluent to make a total of 100 ml

Etomidate (Amidate®)

 Use:
 Induction of general anesthesia, adjunct for intubation

 Dose:
 Load
 0.2 - 0.6 mg/kg with usual induction dose of 0.3 mg/kg

 Mix:
 use undiluted by intravenous push over 30-60 seconds

 Mechanism:
 non-barbiturate carboxylated imidazole hypnotic

 Elimination:
 hepatic
 Half-life:
 30-75 minutes

 Adverse events:
 hypotension with rapid administration, transient skeletal muscle movements, transient decrease in cerebral blood flow, pain at injection site

Fentanyl (Sublimaze®)

Use: analgesia and sedation Dose: Load 50-150mcg Maint 50-100mcg/hr and titrate to effect Mix: undiluted as 2500mcg in 50 ml Mechanism: opiate narcotic (mu receptor agonist) Elimination: Half-life: 3-5 hours hepatic Adverse events: cardiovascular depression with high dose and rapid administration, constipation, urinary retention

Flumazenil (Romazicon®)

Use: reversal of benzodiazepine-induced sedation, will not reverse respiratory depression
Dose: Load 0.2mg (2ml) IVP; may repeat with 0.1mg-0.2mg every minute to a maximum of 1mg
Mechanism: competitive inhibition of the benzodiazepine receptor causing inhibition of the
central pharmacological effects of standard benzodiazepines
Elimination: hepatic Half-life: 1 hour
Adverse events: nausea and vomiting, seizures, possible residual sedation with
inadequate therapy

Furosemide (Lasix®)

Use: diuretic Dose: Load 20-80mg 5-20mg/hr initially, titrate to effect with max of 1mg/kg/hr Maint Mix: 100mg in 100ml D5W/NS Mechansim: inhibition of reabsorption of sodium and chloride in the ascending loop of Henle. Metolazone 5-10mg (max 15mg) po 30 minutes prior or chlorothiazide 500mg WPB immediately prior to bolus dose will potentiate effect Half-life: minutes Elimination: renal Adverse effects: hypokalemia, hypotension, ototoxicity at high doses IV to PO Conversion: IV dose x 2 = PO dose

Glucagon

Use:	beta-ad	Irenergic antagonist o	verdose
Dose:	Load	5-10mg IVP	
	Maint	1-5mg/hr	
Mix:	10mg in	100ml D5W/NS	
Mechar	nism:	adrenal release of synthesis	catecholamines and enhanced calcium-dependent cAMP
Elimina	tion:	hepatic	Half-life: 3-10 minutes
Advers	e event	s: hypoglycemia,	erglycemia, hypokalemia, nausea, vomiting, hypotension

Glucagon Infusion Chart

Glucagon 10mg in 100mL D5W/NS

Dose is mg/hr	1	1.5	2	2.5	3	3.5	4	4.5	5
Rate is mL/hr	10	15	20	25	30	35	40	45	50

Haloperidol (Haldol®)

Use: agitation or psychotic behavior

Dose: Load 2.5mg; dose may be doubled every 20 minutes until desired response to a maximum single dose of 200mg, some data suggest maximum antipsychotic

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effect seen at 20mg with only sedative effects at higher doses.
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- Maint 1/4-1/2 of max loading dose every 4-6 hours or as infusion at 1-40 mg/hr
- Mix: 50 mg in 50 ml D5W/NS
- **Mechanism:** competitive blockade of postsynaptic dopamine receptors
- Elimination: hepatic Half-life: 20 hours

Adverse events: extrapyramidal symptoms, neuroleptic malignant syndrome, anticholinergic effects

IV to PO Conversion: IV dose = PO dose X 0.6 (6mg IV Haldol = 10 mg PO Haldol)

Hydralazine (Apresoline®)

Use: Management of moderate to severe hypertension, congestive heart failure, hypertension secondary to pre-eclampsia/eclampsia, treatment of primary pulmonary hypertension
 Dose: IV push: 10-20 mg/dose Q 4-6 hours as needed, may increase to 40mg/dose.
 Mechanism: Direct vasodilation of arterioles with decreased systemic resistance.
 Elimination: 14% excreted unchanged in urine

Half-life: Normal renal function: 2-8 hours, ESRD: 7-16 hours

IV to PO Conversion: IV dose X 2 = PO dose

Insulin Regular Human, Intravenous use

Use: hyperglycemia, hyperkalemia

Dose: for hyperkalemia 5-10 units IVP given with 25-50gm dextrose 5%

for hyperglycemia

Load 0.1 unit/kg IVP

Maint 0.1 units/kg/hr, titrate to desired blood glucose

Mix: 100 units in 100 ml D5W/NS Elimination: renal

renal Half-life: minutes

Monitoring: blood glucose every 2 hours with continuous or intermittent intravenous administration and every 4 hour for subcutaneous administration

Adverse events: hypoglycemia, hypokalemia

Isoproterenol (Isuprel®)

Use: hemodynamically significant bradycardia, refractory torsades de pointes, 2nd and 3rd degree heart block for chronotropic effect

Dose: 2-20 mcg/min

Mix: 2mg in 250ml D5W/NS

Mechanism: direct β-1 and β-2 adrenergic stimulation Elimination: hepatic Half-life: 2-5 minutes

Adverse events: ventricular arrhythmias, tachycardia, profound hypotension

Ketamine

Use: Dose:	Continuous Sedation or General Anesthesia Induction: 1– 2mg/kg IV bolus Continuous Infusion: 1– 4 mg/kg/hr IV (Usual 2 mg/kg/hr)							
Mix:	3000mg in 100ml NS/D5W							
Mechan	sm: direct action on the cortex and limbic system							
Eliminat	on: N-demethylation and hydroxylation, eliminated in urine							
Duration	of action: Anesthesia: 5-10 minutes, recovery: 1-2 hours							
Adverse	events: hypertension, tachycardia, increased cardiac output, paradoxical myocardial depression, vivid dreams, visual hallucinations, tonic-clonic movements, tremors							

Labetalol (Trandate® or Normodyne®)

Use:	hyperten	sion
Dose:	Load	10-20mg slow IVP, may repeat in 10 minutes
	Maint	0.5-3mg/min
Mix:	200mg in	100ml D5W/NS
Mechan	ism:	direct β blockade (non-selective) which depresses contractility and slowsheart rate with
mild/mode	erate α-1 I	blockade for arterial and venous dilatation
		(β effects > α effects at a ratio of 3:1 for oral and 7:1 for IV)
Eliminat	ion:	hepatic Half-life: 6 hours

Adverse events: hypotension, bradycardia, AV conduction block, bronchospasm

Lidocaine

Use: ventricular tachycardia or ventricular fibrillation

Dose: Load 1-1.5mg/kg IVP followed by 0.1-1mg/kg every 5-10 minutes until arrhythmia controlled or a total of 3 mg/kg (give 1/2 load in patients with CHF), use higher doses in patients that have failed defibrillation and epinephrine Maint 1-4mg/min

Onset: 45-90 seconds

Mix: 2grams in 500ml D5W/NS

Mechanism: Class Ib antiarrhythmic, membrane stabilizing and mild Na channel effects

Elimination: hepatic Half-life: 1.5-2 hours

Adverse events: CNS disturbances, seizures, proarrhythmia; elderly patients extremely sensitive to adverse effects of lidocaine

Lidocaine Infusion Chart

Lidocaine 2gm in 500mL D5W/NS (4mg/ml)

						<u> </u>	/			
Dose is mg/min	1	1.5	2	2.5	3	3.5	4	4.5	5	
Rate is mL/hr	15	22.5	30	37.5	45	52.5	60	67.5	75	

Lorazepam (Ativan ®)

Use: Management of anxiety, status epilepticus, preoperative sedation

Dose: 2-6mg/day IV push in 2-3 divided doses for anxiety and sedation

2-4mg PO at bedtime for insomnia

1-2mg/hr (titrate to effect) for IV drip

Mix: 25 or 50mg in 250ml D5W (nonlinear stability: see stability chart)

Mechanism: Depresses CNS through increased action of GABA, which is a major inhibitory neurotransmitter in the brain. **Elimination** Urinary excretion

Half-life: 13-16 hours, ESRD 32-70 hrs

Adverse events: Respiratory depression, tachycardia, drowsiness, confusion,

diaphoresis, paradoxical excitement

Lorazepam Stability in D5W

Formulation

Concentration	2 mg/ml	4 mg/ml
0.04 mg/ml 0.08 mg/ml		stable for 24 hrs in glass not tested in PVC
0.1 mg/ml 0.16mg/ml		stable for 12 hrs in PVC and 24 hrs in glass
0.2mg/ml		stable for 12 hrs in PVC not tested in glass
0.5mg/ml	questionable stability, not recommended	not stable
1mg/ml	stable for 24 hrs in PVC not tested in glass	not stable
2 mg/ml		stable for 24 hrs in PVC not tested in glass

Magnesium Sulfate (for Magnesium repletion see electrolyte section)

adjunctive therapy for postinfarction ventricular arrhythmias, recurrent or refractory ventricular fibrillation or Use: tachycardia, bronchoconstriction

Dose:	for post-MI	Load 1-2gm IVPB over 5-60 minutes
	·	Maint 0.5-1gm/hr cont infusion up to 24 hours
	for VE or VT	1-2am IV/PB over 1-2 minutes

for post-MI loading dose or VF/VT mix dose in 100ml D5W/NS

Mix: for post-MI maint dose mix 40gm in 1000ml SWFI premix (25ml/hr yields 1gm/hr)

Mechanism: activates Na-K ATPase, coenzyme involved in muscle contraction,

mitochondrial function, cell membrane permeability and resting membrane Elimination: renal Half-life: NA

potential

Metoprolol (Lopressor®)

hypertension, rate control with PSVT or atrial fibrillation/flutter Use: Dose: hypertension/ rate control 2.5-20mg slow IVP every 6 hours post-MI 5mg slow IVP every 15 min to total of 15mg Mechanism: direct β -1 selective blockade (ratio oral:IV is 2.5:1) Half-life: 3-7 hours Elimination: hepatic Adverse events: hypotension, bradycardia, AV conduction block, bronchospasm IV to PO Conversion: IV dose X 2 = PO dose (divided into BID dosing)

Midazolam (Versed®)

Use: sedation, amnesia Dose: Load 0.5 mg/kg or 2.5-5mg Maint 0.3 mg/kg/hr or 1-3 mg/hr, titrate to effect Mix: 50mg in 50ml D5W/NS benzodiazepine, CNS depression through increase in GABA Mechanism: Elimination: hepatic Half-life: 3-5 hours Adverse events: transient hypotension, benzodiazepine withdrawal possible following prolonged use

Milrinone (Primacor®)

Use: second line inotropic/afterload reduction agent Dose: Load 50mcg/kg over 10 minutes 0.25-0.75 mcg/kg/min Maint Mix: 40mg in 200 ml NS (premixed) Mechanism: inhibition of phosphodiesterase causing an increase in intracellular cyclic AMP Elimination: renal Half-life: 2 hours Adverse events: ventricular arrhythmias and ventricular ectopy, hypotension

Milrinone Infusion Chart

Milrinone 40mg in 200mL D5W (Rate is mL/hr)

_	mcg	j/kg/mi	n									
	0.125	0.25	0.375	0.5	0.625	0.75	0.875	1	1.125	1.25	1.375	1.5
50 kg	2	4	6	8	9	11	13	15	17	19	21	23
55 kg	2	4	6	8	10	12	14	17	19	21	23	25
60 kg	2	5	7	9	11	14	16	18	20	23	25	27
65 kg	2	5	7	10	12	15	17	20	22	24	27	29
70 kg	3	5	8	11	13	16	18	21	24	26	29	32
75 kg	3	6	8	11	14	17	20	23	25	28	31	34
80 kg	3	6	9	12	15	18	21	24	27	30	33	36
85 kg	3	6	10	13	16	19	22	26	29	32	35	38
90 kg	3	7	10	14	17	20	24	27	30	34	37	41
95 kg	4	7	11	14	18	21	25	29	32	36	39	43
100 kg	4	8	11	15	19	23	26	30	34	38	41	45
J												

Naloxone (Narcan®)

Use: reversal of CNS and respiratory depression associated with an opiate overdose

Dose: for IVP 0.4-2 mg every 2-3 min to a max of 10mg; may need to repeat effective dose every 20-60 min to maintain effect for continuous infusion initiate therapy as above,

once effective bolus dose is determined initiate continuous infusion using 2/3 of effective dose on an hourly basis, rebolus with 1/2 of effective dose after 15 min

Mix: 2mg in 500 ml D5W/NS yields 4mcg/ml

Mechanism: competitive displacement of opiates at receptor sites

Elimination: hepatic Half-life: 1-1.5 hours

Adverse events: nausea, vomiting, hypertension, tachycardia, ventricular arrhythmia, can

precipitate neurogenic pulmonary edema from catecholamine surge in postsurgical patients

Nitroglycerin

Use: myocardial ischemia, maintain patency of IMA graft

Dose: 10-20 mcg/min; titrate by 10mcg/min every 5 minutes as needed to max of 150- 300mcg/ min, or 0.25-1mcg/kg/min

Mix: 50mg in 250 ml D5W/NS premix

Mechanism:low dose (<100-150 mcg/min) direct venous dilation
high dose (>150-300mcg/min) direct venous and arterial dilation
rhodanase enzymes in RBC Half-life: minutes

Adverse events: hypotension, tachycardia, headache, paradoxical bradycardia, tachyphylaxis

Nitroglycerin Infusion Chart

Nitroglycerin 50mg in 250ml D5W/NS (Rate is mL/hr)

_		mcg	/kg/mi	in								
	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3
50 kg	4	8	11	15	19	23	26	30	34	38	41	45
55 kg	4	8	12	17	21	25	29	33	37	41	45	50
60 kg	5	9	14	18	23	27	32	36	41	45	50	54
65 kg	5	10	15	20	24	29	34	39	44	49	54	59
70 kg	5	11	16	21	26	32	37	42	47	53	58	63
75 kg	6	11	17	23	28	34	39	45	51	56	62	68
80 kg	6	12	18	24	30	36	42	48	54	60	66	72
85 kg	6	13	19	26	32	38	45	51	57	64	70	77
90 kg	7	14	20	27	34	41	47	54	61	68	74	81
95 kg	7	14	21	29	36	43	50	57	64	71	78	86
100 kg	8	15	23	30	38	45	53	60	68	75	83	90

Nitroprusside

Use: hypertension

Dose: 0.1-0.5 mcg/kg/min, increase by 0.5mcg/min every 5 min as needed to a max of 10mcg/kg/min

Mix: 50mg in 250ml D5W/NS

Mechanism:direct venous and arteriolar dilationHalf-life:minutesElimination:hepatic/renal rhodanse enzymes for cyanide and renal for thiocyanatehepatic/renal rhodanse enzymes for cyanide and renal for thiocyanateAdverse events:hypotension, tachycardia, nausea and vomiting, impaired renal function or
doses >3mcg/kg/min for >72 hours may cause thiocyanate toxicity
(thiocyanate >20mg/l); thiocyanate levels should be monitored in all patients
receiving >48 hours of nitroprusside, cyanide toxicity also possible;
treatment includes amyl nitrate, sodium nitrite and sodium thiosulfate

Nitroprusside Infusion Chart

Nitroprusside 50mg in 250 D5W/NS (Rate is mL/hr)

_	n	ncg/kg	g∕min									
	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3
50 kg	4	8	11	15	19	23	26	30	34	38	41	45
55 kg	4	8	12	17	21	25	29	33	37	41	45	50
60 kg	5	9	14	18	23	27	32	36	41	45	50	54
65 kg	5	10	15	20	24	29	34	39	44	49	54	59
70 kg	5	11	16	21	26	32	37	42	47	53	58	63
75 kg	6	11	17	23	28	34	39	45	51	56	62	68
80 kg	6	12	18	24	30	36	42	48	54	60	66	72
85 kg	6	13	19	26	32	38	45	51	57	64	70	77
90 kg	7	14	20	27	34	41	47	54	61	68	74	81
95 kg	7	14	21	29	36	43	50	57	64	71	78	86
100 kg	8	15	23	30	38	45	53	60	68	75	83	90

Norepinephrine (Levophed®)

Use:hypotension, shockDose:2-40 mcg/min or 0.05-0.25 mcg/kg/min doses of greater than 75 mcg/min or 1mcg/kg/min have been usedMix:4 mg in 250 ml D5WMechanism:primary α -1 vasoconstriction effect (minor β -1 inotropic)Elimination:hepaticHalf-life:minutes

Adverse events: tachyarrhythmias, hypertension at high doses

Norepinephrine Infusion Chart

Norepinephrine 4 mg in 250 ml D5W (Rate is ml/hr)

_				rr	icg/kg	/min						
	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.20	0.30
50 kg	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1	19.0	38.0	57.0
55 kg		4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0	42.0	63.0
60 kg		4.6	6.9	9.2	11.5	13.8	16.1	18.4	20.7	23.0	46.0	69.0
65 kg		4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0	48.0	72.0
70 kg		5.2	7.8	10.4	13.0	15.6	18.2	20.8	23.4	26.0	52.0	78.0
75 kg		5.6	8.4	11.2	14.0	16.8	19.6	22.4	25.2	28.0	56.0	84.0
80 kg		6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	60.0	90.0
85 kg		6.4	9.6	12.8	16.0	19.2	22.4	25.6	28.8	32.0	64.0	96.0
90 kg		6.8	10.2	13.6	17.0	20.4	23.8	27.2	30.6	34.0	68.0	102
95 kg		7.2	10.8	14.4	18.0	21.6	25.2	28.8	32.4	36.0	72.0	108
100 kg	3.8	7.6	11.4	15.2	19.0	22.8	26.6	30.4	34.2	38.0	76.0	114

Phenylephrine (Neosynephrine®)

Use: hypotension and shock

Dose: Load 40-100mcg bolus IVP if indicated

Maint 50-300 mcg/min

Mix: 30 mg in 500 ml D5W/NS

Mechanism: pure α_1 vasoconstriction effect

Elimination: hepatic Half-life: minutes

Adverse events: hypertension at high doses, bradycardia

Propofol (Diprivan®)

Use: non-amnestic sedation

Dose:	Load	1-2 mg/kg IVP; do not load if patient is hypotensive or volume depleted
	Maint	initial dose of 5-20 mcg/kg/min, may titrate to effect (20-65 mcg/kg/min)
Mix:	undiluted	(10mg/ml) 100ml vial
Mechani	ism:	diisopropyl phenolic compound with intravenous general anesthetic
		properties unrelated to opiates, barbiturates, and benzodiazepines

Elimination: hepatic Half-life: 30 minutes Adverse events: hypotension, nausea, vomiting, seizures, hypertriglyceridemia, hyperlipidemia

Propofol Infusion Chart

Propofol 10mg/mL (premixed) (Rate is mL/hr)

	_		m	cg/kg/i	min	0	, i		,				
		10	15	20	25	30	35	40	45	50	55	60	65
Γ	50 kg	3	5	6	8	9	11	12	14	15	17	18	20
	55 kg		5	7	8	10	12	13	15	17	18	20	21
	60 kg		5	7	9	11	13	14	16	18	20	22	23
	65 kg		6	8	10	12	14	16	18	20	21	23	25
	70 kg		6	8	11	13	15	17	19	21	23	25	27
	75 kg		7	9	11	14	16	18	20	23	25	27	29
	80 kg		7	10	12	14	17	19	22	24	26	29	31
	85 kg		8	10	13	15	18	20	23	26	28	31	33
	90 kg		8	11	14	16	19	22	24	27	30	32	35
	95 kg		9	11	14	17	20	23	26	29	31	34	37
	100 kg	6	9	12	15	18	21	24	27	30	33	36	39

Procainamide

Use: ventricular tachycardia, supraventricular arrhythmias

- Dose: Load 17mg/kg (or 1 gm), administer no faster than 20-30 mg/min; discontinue if QT interval increases by >50%, hypotension occurs, or arrhythmia ceases
 - Maint 1-6 mg/min or 1-2.7 mg/kg/hr

Mix: 1gm in 250ml D5W/NS

Mechanism:	Class Ib antiarrhythmic, membrane stabilizing and mild Na channel effects
Elimination:	hepatic Half-life: 1.5-2 hours
Adverse events:	hypotension, QT prolongation, QRS widening, confusion, tachycardia,
	torsades de pointes, and SLE
Monitoring:	Procainamide levels 4-10 are associated with efficacy; a sum of procainamide and NAPA levels greater than 30 has been associated with toxicity
IV to PO conversi	ion: Total daily IV dose divided by four = PO Dose given QID

Procainamide Infusion Chart

Procainamide 1gm in 250mL D5W/NS Dose is mg/min 1 1.5 2 2.5 3 3.5 4 4.5 5 Bate is ml /br 16 22 30 38 46 52 60 68 76									
<u> </u>									

Thiopental (Pentothal®)

Use: induction of general anesthesia, treatment of refractory status epilepticus, treatment of refractory increased intra-cerebral pressure

Dose:	Induction: 3-5 mg/kg								
	Status epilepticus: 75-250 mg/dose, repeat as needed								
	Increased	ICP: 1.5-5 mg/kg/dose, repeat as need	ed						
Mix:	prepare as a 25mg/mL solution								
Mechan	ism:	barbiturate producing CNS depression							
Eliminat	ion:	liver	Half-life:	3-11.5 hrs					
Onset:		30-60 seconds	Duration:	5-30 minutes					
Adverse	Adverse events: pain on injection, hypotension, myocardial depression								

Succinylcholine (Anectine®)

Use: Dose: Mix:	skeletal muscle relaxation during surgery and intubation Load 0.5 - 1.5 mg/kg IV with usual induction dose of 1.0 mg/kg. IM dose: 2-5 mg/kg. administer undiluted as intravenous push or IM injection							
Mechan	mpetitive antagonism of							
		acetylcholine						
Eliminat	tion:	hydrolyzed by plasma pseudocholinesterases	Half-life: seconds					
Onset:		30-60 seconds	Duration: 5-10 minutes					
Adverse events: increased intraocular pressure, bradycardia, hypotension, transient hyperkalemia, triggering drug for malignant hyperthermia								

Tromethamine (THAM®)

Use: Dose:		nt of metabolic acidosis e dose using the following equation.
Dose:		
		nl of 0.3 molar solution) = lean body weight (kg) X base deficit (mmol/L)
	Administ	ter over 2-4 hours. Max. daily dose 15 mmol/kg (3.5L of 0.3 molar solution in a 50kg adult)
Mix:	0.3 mola	r solution 500 ml premix bottle
Mechan	ism:	Biologically inert amino alcohol buffer solution. Supplements the buffering capacity of the blood bicarbonate system, accepting a proton, generating bicarbonate and decreasing the partial pressure of carbon dioxide in arterial blood.
Eliminat	tion:	Renal Half-life: 4-6 hrs.
Advers	e events	: respiratory depression, hypoglycemia, nausea and vomiting

Vasopressin (Pitressin®)

Use: Treatment of diabetes insipidis. Treatment of GI hemorrhage and esophageal varices. Some case reports showing benefit in vasodilatory shock states.

Dose: GI Hemorrage: 0.2-0.4 mcg/min, titrate as needed, if bleeding stops continue 12 hrs taper off in 24-48 hrs

DI: 5-10 Units SubQ

Vasodilatory Shock: 0.01- 0.1 mcg/min. Start 0.05 mcg/min or 3.25 ml/hr

Mix: 200 units in 250ml D5W (0.8 Units/ml)

Mechanism: vasoconstriction, increases water permeability in renal tubules

Elimination: metabolized by liver and kidneys, eliminated in urine

Adverse events: increased blood pressure, bradycardia, arrhythmias, venous thrombosis

Vecuronium (Norcuron®)

Use: skeletal muscle relaxation during surgery or mechanical ventilation, this agent has no amnestic or analgesic properties

Dose: Load 0.05-0.1mg/kg

Maint 0.8-1.2 mcg/kg/min; dose should be titrated using a peripheral nerve stimulator to a train-of-four (TOF) of 1-2 out of 4

Mix: 100mg in 250ml D5W/NS

Mechanism:steroidal neuromuscular blocker; competitive antagonism of acetylcholineElimination:spontaneous de-acetylationHalf-life:Adverse events:urticaria, bronchospasm, potential for prolonged paralysis/weakness with
prolonged administration especially in patients receiving systemic steroids

Vecuronium Infusion Chart

Vecuronium 100mg in 250mL D5W/NS (Rate is mL/hr)

		r	ncg/k	g/min							
	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8
50 kg	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0
55 kg	6.6	8.3	9.9	11.6	13.2	14.9	16.5	18.2	19.8	21.5	23.1
60 kg	7.2	9.0	10.8	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.2
65 kg		9.8	11.7	13.7	15.6	17.6	19.5	21.5	23.4	25.4	27.3
70 kg		10.5	12.6	14.7	16.8	18.9	21.0	23.1	25.2	27.3	29.4
75 kg		11.3	13.5	15.8	18.0	20.3	22.5	24.8	27.0	29.3	31.5
80 kg		12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8	31.2	33.6
85 kg		12.8	15.3	17.9	20.4	23.0	25.5	28.1	30.6	33.2	35.7
90 kg		13.5	16.2	18.9	21.6	24.3	27.0	29.7	32.4	35.1	37.8
95 kg		14.3	17.1	20.0	22.8	25.7	28.5	31.4	34.2	37.1	39.9
100 kg	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0	39.0	42.0

Verapamil (Isoptin®, Calan®)

paroxysmal supraventricular tachycardia, control ventricular response rate in atrial fibrillation or atrial flutter 2.5-5mg over 1-2 minutes every 15-30 minutes to a max of 20mg Use:

Dose calcium channel blocker

Mechanism:

Elimination: hepatic Half-life: 2-8 hours

Adverse events: heart block, hypotension (reversible with calcium chloride 0.5-1gm IV), depression of ventricular function

Electrolyte Replacement Recommendations

Potassium Chloride

Central line: 20 mEq/hr max rate Premixed Solutions: 20 mEq in 50ml NS 30 mEq in 50ml NS 40 mEq in 100ml NS Peripheral line: 10 mEq/hr max rate Standard Peripheral Solution: 10-40 mEq in 250ml NS Standard KCI Scale (UOP>25ml/hr and Creatinine <____)

K+>4.3 mEq/L, give 0 KCI K+ 4.2-4.3 mEq/L, give 10 mEq KCL IV over 1 hr. K+ 3.8-4.1 mEq/L, give 20 mEq KCL IV over 1 hr. K+ 3.4-3.7 mEq/L, give 40 mEq KCL IV over 2 hr. K+ 2.8-3.3 mEq/L, give 60 mEq KCL IV over 3 hr. K+ <2.8 mEq/L, give 60 mEq KCL IV over 3 hr, and call HO d/c all KCI in IV solution if serum K+ >5.0 mEq/L **Renal Failure KCL Scale** (UOP <25cc/hr and Creatinine \ge ____) K⁺ \ge 4.0 mEq/L, give 0 KCL K⁺ 3.8-3.9 mEq/L, give 10 mEq KCL IV over 1hr. K⁺ 3.4-3.7 mEq/L, give 20 mEq KCL IV over 1hr. K⁺ 2.8-3.3 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. K⁺ <2.8 mEq/L = 2.0 mEq/L

K+>4.3 mEq/L, give 0 KCl K+ 4.2-4.3 mEq/L, give 20 mEq po/ngt K+ 3.8-4.1 mEq/L, give 40 mEq po/ngt K+ 3.4-3.7 mEq/L, give 40 po/ngt and repeat in two hours K+ 2.8-3.3 mEq/L, give 40 po/ngt and repeat in two hours x 2 K+ <2.8 mEq/L, give 40 mEq KCL po/ngt and repeat in two hours x2 and call HO d/c all KCl in IV solution and oral KCl if serum K+ >5.0 mEq/L

Renal Failure KCL Scale (UOP <25cc/hr and Creatinine ≥____)

 $K^+ \ge 4.0 \text{ mEq/L}$, give 0 KCL K^+ 3.8-3.9 mEq/L, give 10 mEq KCL IV over 1hr. K^+ 3.4-3.7 mEq/L, give 20 mEq KCL IV over 1hr. K^+ 2.8-3.3 mEq/L, give 30 mEq KCL IV over 1.5hr. K^+ <2.8 mEq/L, give 30 mEq KCL IV over 1.5hr. and call HO D/C all KCL in IV solution if serum $K^+ \ge 4.0 \text{ mEq/L}$

Magnesium

Standard MgSO₄ Scale **Premix Solution:** 4 gm in 50cc NS)

 $Mg_{2^{+}}^{2^{+}}$ > 2.0 mEq/L, give 0 MgSO₄ Mg_{2^{+} 1.8-2.0 mEq/L give 2 gms. MgSO₄ IV over 1hr.

 Mg^{2+} 1.5-1.7 mEq/L give 4 gms. MgSO₄ IV over 2hr. Mg²⁺ <1.4 mEq/L give 4 gms. MgSO₄ IV over 2hr. and call HO

Calcium

Standard Ca²⁺ Scale (20cc of 10% Calcium Gluconate in 100cc NS). Always check ionized Ca²⁺ in patients with renal failure Ca²⁺ 6.0-7.5 g/dl check ionized Ca²⁺ :

if ionized $Ca^{2+} \ge 1.0$ give 0 Calcium Gluconate if ionized $Ca^{2+} \ge 1.0$ give 2 gms Calcium Gluconate IV over 30min. $Ca^{2+}_{2} 4.1-5.9$ g/dl give 2 gms Calcium Gluconate IV over 30min.

 $Ca^{2+} \leq 4.0$ g/dl give 2 gms Calcium Gluconate IV over 30min, and call HO

Phosphate

Standard PO₄ Scale

If $K^+ < 4.0$ and Creatinine \leq use Potassium Phosphate (1.5mEq K^+/mM phosphate) Central: 30mM in 50cc NS

Peripheral: 30mM in 250cc NS

PO₄ 1-2.4 mg/dl give 30mM KPO₄ IV over 4hrs.

PO₄ <1 mg/dl give 60mM KPO₄ IV over 6hrs (8hrs if peripheral) and call HO

use Sodium Phosphate (1.3mEq Na/mM phosphate) If $K^+ \ge 4.0$ or Creatinine \ge 30mM in 50cc NS

PO₄⁻ 1-2.4 mg/dl give 30mM NaPO₄⁻ IV over 4hrs.

PO₄ <1 mg/dl give 60mM NaPO₄ IV over 6hrs (8hrs if peripheral) and call HO

Drug Compatibility Chart

	Calcium Chloride	Cisatracurium	Dobutamine	Dopamine	Fentanyl	Furosemide	Heparin	Insulin (Regular)	Lidocaine	Magnesium Sulfate	Midazolam	Nitroglycerin	Nitroprusside	Norepinephrine	Phenylephrine	Procainamide	Potassium Chloride	Sodium Bicarhonate
Calcium Chloride	-	С	С	С	С	С	С	С	С	Ι	С	С	С	С	С	С	С	I
Cisatracurium	С	-	С	С	С	I	I	N	С	С	С	С	Ι	С	С	С	С	I
Dobutamine	С	С	-	С	С	I	N	Ι	С	С	С	С	С	С	С	С	С	I
Dopamine	С	С	С	-	С	С	С	N	С	С	С	С	С	С	С	С	С	D
Fentanyl	С	С	С	С	-	С	С	С	С	С	С	С	С	С	С	С	С	С
Furosemide	С	I	I	С	С	-	С	С	С	D	Ι	С	С	I	С	С	С	С
Heparin	С	I	N	С	С	С	-	С	С	С	С	С	С	С	С	С	С	С
Insulin (Regular)	С	N	I	N	С	С	С	-	С	С	D	С	С	I	I	С	С	С
Lidocaine	С	С	С	С	С	С	С	С	-	С	С	С	С	С	С	С	С	С
Magnesium Sulfate	I	С	С	С	С	D	С	С	С	-	С	С	С	С	С	С	С	С
Midazolam	С	С	С	С	С	I	С	D	С	С	-	С	С	С	С	С	С	I
Nitroglycerin	С	С	С	С	С	С	С	С	С	С	С	-	С	С	С	С	С	С
Nitroprusside	С	I	С	С	С	С	С	С	С	С	С	С	-	С	С	С	С	С
Norepinephrine	С	С	С	С	С	I	С	I	С	С	С	С	С	-	С	С	С	I
Phenylephrine	С	С	С	С	С	С	С	I	С	С	С	С	С	С	-	С	С	С
Procainamide	С	С	С	С	С	С	С	С	С	С	С	С	С	С	С	-	С	С
Potassium Chloride	С	С	С	С	С	С	С	С	С	С	С	С	С	С	С	С	-	С
Sodium Bicarbonate	I	I	I	D	С	С	С	С	С	С	I	С	С	I	С	С	С	-

Status epilepticus

- Establish the diagnosis by observing one additional seizure in a patient who has seized or by observing a continuous seizure for more than 10 minutes.
- ABCs and establish intravenous access with normal saline, dextrose is incompatible with phenytoin.
- Send a CBC, P1, and any anti-epileptic drug levels, if indicated.
- Administer thiamine 100mg IM (if there is any suspicion of alcohol abuse) followed by dextrose 50% 50mL.
- Administer lorazepam 0.1mg/kg IV.
- If seizure persists, administer phenytoin 20mg/kg IVPB at a rate of ≤ 50mg/min. Monitor EKG and BP. If seizure persists, administer phenytoin 5mg/kg.
- If seizure persists, intubate (if not already accomplished) and administer phenobarbital 20mg/kg at a rate of ≤ 100mg/min.
- If seizure persists, initiate a barbiturate coma. Patient will require intubation. Administer pentobarbital 5mg/kg IV loading dose followed by a continuous infusion of 0.5 2mg/kg with the goal of achieving an EEG demonstrating a burst suppression pattern. Achieving this EEG pattern is more important than specific blood levels.

Increased Intra-cranial pressure/brain herniation

- Establish clinical suspicion of increased ICP, for example, by neurological exam (unilateral dilated pupil in a comatose patient), neuroimaging (diffuse edema, mass lesion, etc) or in cases of traumatic injury, GCS of ≤ 8.
- ABCs and establish intravenous access.
- Elevate head of bed to 30° and be certain head is midline (use towel rolls or soft neck collar if necessary).
- Intubate patient and begin with ventilatory rate of 12-14 breathes per minute with a goal of hyperventilating the patient to a P_aCO₂ of 28-34 mmHg. Check ABG.
- Administer mannitol 0.5gm/kg IV over 20 minutes
- Consider ICP monitoring and jugular bulb catheter/oximetry.
- Wean off hyperventilation as soon as ICP control is achieved.
- If increased ICP persists, proceed to pentobarbital coma (see Status Epilepticus section).

Points	Best Eye	Best Verbal	Best Motor
6	-	-	obeys commands
5	-	oriented	localized pain
4	opens spontaneously	confused	withdraws to pain
3	opens to speech	inappropriate	flexor (decorticate)
2	opens to pain	incomprehensible	extensor (decerebrate)
1	none	none	none

Glasgow Coma Scale (best score is 15)

Acute Management of Spinal Cord Injury

The Third National Acute Spinal Cord Injury Study 1997

- Methylprednisolone improves neurologic recovery after acute spinal cord injury.
- Patients who receive methylprednisolone within 3 hours of injury should be maintained on the treatment regimen for 24 hours.
- When methylprednisolone is initiated within **3 to 8** hours of injury, the patient should be maintained on the treatment regimen for **48** hours.

Treatment Regimen

Load: Methylprednisolone(Solumedrol[®]) 30 mg/kg IV bolus given over 15 min. **Maintainence:** Methylprednisolone(Solumedrol[®]) 5.4 mg/kg/hr IV infusion

Comparison of neuromuscular blockers

Agent	Class	Onset	Duration	Features	Uses	Elimination
Succinylcholine (Anectine)	depolarizing	1-2 min	4-6 min	multiple side effects and contraindications	Intubation	plasma cholinesterase
Mivacurium Mivacron)	Nondepol benzyl	2.5 min	15-20 min	histamine release hypotension	short procedures	plasma cholinesterase
/ecuronium Tracrium)	Nondepol steroid	2.5-3 min	25-40 min	minimal cardiovascular side effects	maitenance infusion	biliary; renal for active metabolites
Rocuronium (Zemuron)	Nondepol steroid	1 min	30 min	rapid onset	intubation	hepatic/biliary
Cisatracurium (Nimbex)	Nondepol benzyl	2-2.5 min	35-45 min		maintenance infusion	Hofmann degradation; ester hydrolysis
Pancuronium (Pavulon)	Nondepol steroid	4 min	100 min	hypertension, tachycardia	bolus for maintenance infusion	renal
Doxacurium (Nuromax)	Nondepol benzyl	5 min	100 min	minimal cardiovascular side effects	bolus for maitenance infusion	renal/biliary

Nondepol steroid - Nondepolarizing aminosteroid

Nondepol benzyl - Nondepolaring bis quaternary benzylisoquinolinium diester

Comparison of Narcotic Agonists

				Equianalgesic Doses	
Agent	Onset	Peak	Duration	IM	Oral
Codeine	po: 30-60 min IM: 10-30 min	30-60 min	4-6 hr	120mg	200mg
Fentanyl	IM: 7-15 min	Immediate	1-2 hr	100mcg	na
Fentanyl transdermal	18 hr	NA	72 hr	100mcg	na
Hydrocodone	na	na	4-8 hr	na	na
Hydromorphone	PO: 15-30 min	30-60 min	2-4 hr	1.5mg	7.5mg
Meperidine	PO: 10-15 min IV: ≤5 min	30-60 min	2-4 hr	75mg	300mg
Methadone	PO: 30-60 min IV: 10-20 min	30-60 min	4-6 hr (acute) > 8 hr (chronic)	10mg	20mg
Oxycodone	PO: 15-30 min	1 hr	4-6 hr	na	30mg
Vorphine	IV: 15-60 min	20-60 min	3-7 hr	10mg	60mg
_evorphanol	PO: 10-60 min	30-60 min	4-8 hr	2mg	4mg
Remifentanil	IV: 1 min	1 min	5 min	10mcg	na

Sedation – Agitation Scale (SAS)

Score	Description	Observations
7	Dangerous Agitation	Pulling at ET tube, trying to remove catheters, climbing over bed rail, striking at staff, thras hing side-to-side
6	Very Agitated	Does not calm, despite frequent verbal reminding of limits; requires physical restraints, biting ET tube
5	Agitated	Anxious or mildly agitated, attempting to sit up, calms down to verbal instructions
4	Calm and cooperative	Calm, awakens easily, follows commands
3	Sedated	Difficult to arouse, awakens to verbal stimuli or gentle shaking but drifts off again, follows simple commands
2	Very Sedated	Arouses to physical stimuli but does not communicate or follow commands, may move spontaneously
1	Unarousable	Minimal or no response to noxious stimuli, does not communicate or follow commands

*Goal for ICU sedation should be SAS 3 or 4. May need patient more deeply sedated for procedures and/or difficult

to tolerate therapies (i.e. inverse ratio ventilation, prone positioning).

Agent	a 1	\mathbf{a}_{2}	b 1	b ₂	DA
Dopamine	0 to +++	+	++	+	+++
Norepinephrine	+++	+++	+++	0	0
Epinephrine	+++	+++	+++	++	0
Isoproterenol	0	0	+++	+++	0
Dobutamine	+	0	++	+	0
Milrinone	0	0	0	0	0
Phenylephrine	+++	++	0	0	0

Relative Selectivity of Sympathomimetic Agents for Adrenergic Receptors

Hemodynamic Actions of Various Intravenous Vasodilators

Agent	Arterial Dilation	Venous Dilation	PCWP	SVR	СО	HR	MVO ₂	CBF
Phentolamine	$\uparrow \uparrow \uparrow$	↑	\downarrow	$\downarrow\downarrow$	$\uparrow\uparrow$	↑	\downarrow	\uparrow
Nitroprusside	$\uparrow \uparrow \uparrow$	$\uparrow\uparrow$	$\downarrow\downarrow$	$\downarrow \downarrow \downarrow$	$\uparrow\uparrow$	$\leftrightarrow\uparrow$	\downarrow	\uparrow
Nitroglycerin	$\uparrow \uparrow$	$\uparrow \uparrow \uparrow$	$\downarrow\downarrow$	\downarrow	\uparrow	$\leftrightarrow\uparrow$	\downarrow	\uparrow
Hydralazine	$\uparrow \uparrow \uparrow$	$\leftrightarrow \uparrow$	\downarrow	$\downarrow\downarrow$	$\leftrightarrow \uparrow$	\uparrow	$\downarrow \leftrightarrow \uparrow$	\uparrow

Hemodynamic Parameters

	Normal Values
Systolic Blood Pressure (SBP)	120 mm
Diastolic Blood Pressure (DBP)	80 mm
Cardiac Output (CO) measured by thermodilution technique	4 - 6 L/min
Heart Rate (HR)	60 - 100 bpm
Body Surface Area (BSA)	1.73 m² average
Right Atrial Pressure (RAP)	0 - 6 mm Hg
Right Ventricular Pressure (RVP) (Sys/Dia)	15-30 / 0-4 mm Hg
Pulmonary Artery Pressure (PAP) (Sys/Dia)	15-30 / 6-12 mm Hg
Pulmonary Artery Mean (MPAP or MAP)	10-18 mm Hg
Pulmonary Capillary Wedge Pressure (PCWP)	6-12 mm Hg
Central Venous Pressure (CVP)	0 - 6 mm Hg

Calculated Parameter

	Formula	Normal Value
Mean Arterial Pressure (MAP)	MAP = 1/3 (SBP-DBP) + DBP MAP = CI × SVRI	85-95 mm Hg
Cardiac Output (CO)	CO = HR × SV	4 - 6 L/min
Cardiac Index (CI)	CI = CO / BSA	2.5 - 4 L/min/m ²
Stroke Volume Index (SVI)	SVI = CI/HR × 1000	36 - 48 mL/b/m ²
Left Ventricular Stroke Work Index (LVSWI)	LVSWI = (MAP - PCWP) × SVI × 0.0136	44 - 56 gm × m/m²
Systemic Vascular Resistance (SVR)	SVR = [(MAP - CVP) × 79.9]/ CO	770-1500 dyne×sec/cm⁵
Systemic Vascular Resistance Index (SVRI)	SVRI = [(MAP - CVP) × 79.9]/CI	1200 - 2500 dyne×sec/cm ⁵ ×m ²
Pulmonary Vascular Resistance Index (PVRI)	PVRI = [(MPAP - PCWP) × 79.9]/CI	80 - 240 dyne×sec/cm ⁵ ×m²

Oxygen delivery and consumption calculations

Parameter	Formula	Normals
Alveolar oxygen tension (P _A 0 ₂)	$(F_1O_2 \times 713) - (P_aCO_2/0.8)$	100 - 673 mm Hg
Oxygen content (C _a O ₂)	$(1.34 \times \text{Hgb} \times \text{S}_{a}\text{O}_{2}) + (0.003 \times \text{P}_{a}\text{O}_{2})$	16-22mL O ₂ / 100 mL
Oxygen delivery indexed (DO ₂)	$CI \times C_aO_2 \times 10$	520 - 720 ml/min×m ²
Venous oxygen content (C_VO_2)	$(1.34 \times \text{Hgb} \times \text{S}_{V}\text{O}_{2}) + (0.003 \times \text{P}_{V}\text{O}_{2})$	12-17mL O ₂ / 100 mL
Oxygen consumption indexed (VO ₂)	$CI \times (C_aO_2 - C_VO_2) \times 10$	110 - 160 ml/min×m ²
Oxygen extraction ratio (O2ER)	VO ₂ / DO ₂ × 100	22 - 32%
Arterial – Venous Oxygen Difference	$C_aO_2 - C_VO_2$	3.5 – 5.5 ml O₂/dl
Cardiac Output using the Fick Equation	$CO = 10 \times VO_2 / [1.34 \times Hgb(S_aO_2 - S_VO_2)]$	3-7 liters/min

Indications for thrombolytic therapy

- definitely effective when given within 6 hours of onset of symptoms; probably effective when given within 12 hours of onset
- ECG showing definite ST-segment elevation in any anatomic distribution or a bundle branch block; not shown effective in patients with ST-segment depression
- patients with or without history of prior infarction
- no age limit; however limited clinical data on elderly patients

Contraindications to thrombolytic therapy

- any active or recent bleeding; excluding menstrual bleeding
- intracranial or intraspinal neoplasm, aneurysm, or AVM
- stroke or neurosurgical procedure within 6 weeks
- other recent surgery or trauma that might increase the risk of bleeding

Comparison of thrombolytic agents

	Streptokinase	Alteplase	APSAC
Dose	1.5 mill u	100 mg	30 u
Administration	1 hr inf	3 hr inf	5 min bolus
Systemic lysis	High	Low	High
Bleeding risk	High	High	High
Antigenic	Yes	No	Yes
Hypotension	Yes	No	Yes
Acute patency	40-60%	60-80%	60-70%

Blood Gas Interpretation

	Primary Acid Base Disorders		
Variable	Primary Disorder	Normal Range Arterial Gas	Primary Disorder
рН	Acidemia	7.35 - 7.45	Alkalemia
pCO ₂	Respiratory Alkalosis	35 - 45	Respiratory Acidosis
HCO ₃	Metabolic Acidosis	22 - 26	Metabolic Alkalosis

Rule 1 - Look at the pH, determine primary disorder, assess for expected compensatory changes **Rule 2** - Calculate the anion gap (Calc AG = Na - $[CI + HCO_3]$)

Rule 3 - Calculate the excess anion gap (Excess AG = Calc AG -12, the add excess AG to measured HCO_3 , if sum > 30 then underlying primary metabolic alkalosis, if sum < 23 then underlying nonanion gap metabolic acidosis in addition to any other primary process already identified

Other points

1. ABG bicarbonate should be \pm 3 of serum bicarbonate for acceptable sample

2. Respiratory compensation for metabolic disorders is rapid. Full metabolic compensation for respiratory disorders takes 3-5 days (renal adjustment).

(from Haber RJ. A practical approach to acid-base disorders. W Med J 1991; Aug (155): 146

Blood gas interpretation

pH_{ABG}	pCO ₂	Primary Disorder	Formula	Secondary Disorder
Low	High	Respiratory acidosis	pH _c = 0.008 * (pCO ₂ - 40)	If $pH_{ABG} < 7.4 - pH_c$ then metabolic acidosis If $pH_{ABG} = 7.4 - pH_c$ then acute respiratory acidosis If $pH_{ABG} > 7.4 - pH_c$ then metabolic alkalosis
Low	Normal	Metabolic acidosis	(see below)	(see below)
Low	Low	Metabolic acidosis	pCO _{2(c)} = 1.5 * (HCO ₃) + 8	If $pCO_{2(ABG)} < pCO_{2(c)}$ then respiratory acidosis If $pCO_{2(ABG)} = pCO_{2(c)}$ then compensated met acidosis If $pCO_{2(ABG)} > pCO_{2(c)}$ then respiratory alkalosis
High	Low	Respiratory alkalosis	$pH_c = 0.008 * (40 - pCO_2)$	
High	Normal	Metabolic alkalosis	(see below)	chronic metabolic alkalosis
High	High	Metabolic alkalosis	$pCO_{2(c)} = 0.7 * (HCO_3) + 20$) If $pCO_{2(ABG)} < pCO_{2(c)}$ then respiratory alkalosis If $pCO_{2(ABG)} = pCO_{2(c)}$ then compensated met alkalosis If $pCO_{2(ABG)} > pCO_{2(c)}$ then respiratory acidosis

(adapted from Marino PL. The ICU Book. 1st Ed. Pennsylvania, Lea and Febiger, 1991: 418-420)

Blood Gas Interpretation Expected Compensatory Responses

Primary Disorder	Expected Response
Metabolic acidosis	Expected $pCO_2 = 1.5 \times HCO_3 + 8 (\pm 2)$
Metabolic alkalosis	Expected $pCO_2 = 0.9 \times HCO_3 + 9$
Respiratory acidosis	$\frac{\Delta pH}{\Delta pCO_2} = 0.008 \text{ (Acute)}$ $\Delta pCO_2 = 0.003 \text{ (Chronic)}$
Respiratory alkalosis	$\frac{\Delta pH}{\Delta pCO_2} = 0.008 \text{ (Acute)}$ 0.017 (Chronic)

Ventilatory/oxygenation parameters

Measured Parameters	Normals
Tidal Volume (V _T)	4-6 mL/kg
Vital Capacity (V _c)	65-75 mL/kg
Respiratory Rate (RR)	12 - 20 bpm
Alveolar carbon dioxide tension (PaCO2)	35 - 45 mm Hg
Mixed venous carbon dioxide tension (P_vCO_2)	41 - 51 mm Hg
Alveolar oxygen tension (PaO ₂)	70-100 mm Hg
Mixed venous oxygen tension $(M_{\nu}O_2)$ or $(P_{\nu}O_2)$	33-53 mm Hg
Arterial oxygen saturation (S _a O ₂)	93 - 98 %
Mixed venous oxygen saturation (S_vO_2)	68 - 77%
Anatomic dead space (V_{DS})	75 - 100 mL
Barometric pressure (at sea level)	760 mm
Partial pressure of water (P _{H2O})	47 mm

Ventilatory/oxygenation parameters

Parameter	Formula	Normals
Partial pressure of inspired oxygen (P02)	$F_{i}O_{2} \times (PB - P_{H_{20}})$	150 mm Hg
Alveolar oxygen tension (P _A 0 ₂)	(F _i 0 ₂ × 713) - (P _a CO ₂ /0.8)	100 - 673 mm Hg
Alveolar - arterial oxygen gradient ($O_{2 A-a}$)	$P_AO_2 - P_aO_2$	< 10 mm Hg
Effective PEEP (PEEP_{EFF})	Ventilator PEEP + Auto PEEP	variable
Dynamic compliance (C _{DYN})	V _T - V _{DS} / PIP - PEEP _{EFF}	50 - 80 mL/cm H₂O
Static compliance (C _{STAT})	V _T - V _{DS} / P _{PLAT} - PEEP _{EFF}	60 - 100 mL/cm H₂O
Minute ventilation (V _E)	V⊤ × RR	4 - 6 L/min
Oxygen content (C _a O ₂)	$(1.34 \times \text{Hgb} \times \text{S}_{a}\text{O}_{2}) + (0.003 \times \text{P}_{a}\text{O}_{2})$	16-22mL O ₂ / 100 mL
Oxygen delivery indexed (DO2)	$CI \times C_aO_2 \times 10$	520 - 720 ml/min×m²
Venous oxygen content (C_VO_2)	$(1.34 \times \text{Hgb} \times \text{S}_{\vee}\text{O}_2) + (0.003 \times \text{P}_{\vee}\text{O}_2)$	12-17mL O ₂ / 100 mL
Oxygen consumption indexed (VO ₂)	$CI \times (C_aO_2 - C_VO_2) \times 10$	110 - 160 ml/min×m²
Arterial – Venous Oxygen Difference	$C_aO_2 - C_VO_2$	3.5 – 5.5 ml O ₂ /dl
Oxygen extraction ratio (O ₂ ER)	VO ₂ / DO ₂ × 100	22 - 32%
Cardiac Output using the Fick Equation	$CO = 10 \times VO_2 / [1.34 \times Hgb(S_aO_2 - S_VO_2)]$	3-7 liters/min

Criteria for initiating ventilatory support

Ventilatory Mechanics	$V_T < 3 mL/kg$ RR > 35 bpm $V_E < 3 L/min or > 20 L/min$	V_{c} < 10-15 mL/kg NIF < neg 20-25 mm V_{D} / V_{T} > 0.6
Gas Exchange	$P_aO_2 < 55 \text{ mm on } F_1O_2 > 50\%$	$P_aCO_2 > 55$ with progressive acidosis
Other Clinical Indicators	Neuromuscular weakness Hyperventilation for CNS event Upper airway obstruction Airway protection Compromised mental status	Excessive work of breathing Inverse ratio ventilation

Initial ventilator settings

	Set by Physician	Set by Respire	atory Therapist
Mode: F _i O₂: V⊤: Rate: PEEP:	100% initially 6-10 mL/kg (lower end with noncompliant lungs)	Wave form: Decele Square wave for	40-60 L/min 2 cm H₂O 10 cm H₂O above initial rating wave for ARDS OAD esembles normal ventilation

Modes of mechanical ventilatory support

	Clinician Control Over		Patient Control Over	
Mode	Rate	Tidal Volume	Rate	Tidal Volume
PCV	Yes	Yes	No	a function of lung compliance and set pressure
AC	Yes (backup)	Yes (min volume)	Yes (demand assisted breaths)	No
IMV	Yes (minimum)	Yes (mandatory volume)	Yes (can take unassisted spontaneous breaths)	Only with unassisted spontaneous breaths
SIMV	Yes (backup)	Yes (min volume)	Yes (demand assisted breaths and take unassisted spontaneous breaths)	Only with unassisted spontaneous breaths
PSV	No	Indirectly	Yes	Yes
CPAP	No	No	Yes	Yes

PCV - Pressure controlled ventilation AC - Assist control ventilation

IMV - Intermittent mandatory ventilation SIMV - Synchronized intermittent mandatory ventilation PSV - Pressure support ventilation

CPAP - Continuous positive airway pressure

Troubleshooting the ventilator

Sudden patient distress:

- •Remove patient from the ventilator
- •Manually ventilate the patient with 100% oxygen
- •Perform a rapid physical examination
- •Check patency of the airway
- •If the patient is arresting, consider pneumothorax, airway obstruction, or lost airway
- •Once stabilized perform a detailed assessment
- •Order chest X-ray

Pressure Limiting

- central airway obstruction •
- massive atelectasis
- tube oculusion •
- mainstem intubation •
- pain, anxiety, or delirium •
- tension pneumothorax •
- irritative bronchospasm
- decreased chest wall compliance
- retention of secretions

Non-pressure limiting

- cuff deflation or tube withdrawal
- circuit disruption
- mechanical malfunction
- pneumothorax without tension •
- auto-PEEP
- hemodynamic crisis
- pulmonary embolism

Common ventilator problems

Problem	Possible causes
High peak and plateau pressures	pulmonary edema, consolidation, atelectasis, mainstem intubation, tension pneumothorax, chest wall constriction
Increased difference between peak and plateau pressure	bronchospasm, secretions, inspiratory circuit obstruction
Auto-peep	insufficient flow rate or expiratory time, expiratory circuit obstruction, AC circuit with agitated patient
Low exhaled volumes	circuit or cuff leak, insufficient flow rate, bronchopleural fistula
Increased respiratory rate	change in clinical status, low tidal volume, insufficient flow rate, or set ventilatory rate
High exhaled volumes	in line nebulizer therapy
High minute ventilation	hyper-ventilation (central, agitation, wrong ventilator settings) hyper-metabolism (increased CO ₂ production, excess caloric intake, sepsis, fever, seizures) inefficient ventilation (increased dead space due to COPD, PE, ARDS, or auto-PEEP)

-

Predicting successful weaning from mechanical ventilation

	Parameter	Assessment
1	Resolution of primary process	
2	Oxygenation	$pO_2 > 80$ on $FiO_2 < 0.40$
3	Ventilation	V_E < 10-15 L/min for pCO ₂ = 40 mm Hg
4	Ventilatory demand	required V $_{\rm e}$ = spontaneous V $_{\rm e}$
5	Ventilatory drive	spontaneous respiratory rate > 10 bpm and < 20 bpm
6	Ventilatory muscle strength	V _C > 10 mL/kg NIF > neg 20-25 cm H₂O V _T > 5 mL/kg
7	Breathing pattern	RR/V_T < 100 (during spontaneous breathing)
8	Clear respiratory tract secretions	Adequate cough reflex, frequency and amount of suctioning required
9	Patency of airway	Air leak around cuff when deflated
10	Electrolytes	K^{+} , Ca ⁺⁺ , Mg ⁺⁺ , Phos are within normal values

Extubation procedure

Explain procedure to patient

Prepare equipment:

- 1. laryngoscope, ET tube
- bag-mask-valve system with O₂ hook wall suction with Yankauer extension bag-mask-valve system with O2 hook-up
- 4. 10 mL syringe

Suction ET tube inside and around top of cuff

Instruct patient to (on demand) :

- take deep breath
 hold breath
- 3. exhale forcefully as the tube withdrawn

Have patient:

- take deep breath
 deflate balloon
- 3. withdraw ET tube as patient exhales

Support patient with aerosol mask (FiO₂ of 10% over previous setting). Monitor respiratory rate and S_aO₂. Encourage incentive spirometry and coughing

Failure to wean mnemonic

luid overload, diurese if pulmonary edema F

- irway resistance, size of ET tube important, minimum ET tube 8mm Α
- I nfection, pneumonia and/or systemic infection
- L ying down, bad V/Q match, elevate HOB
- thyroid, check thyroid functions tests U
- espiratory stimulation required (centrally), administer respiratory stimulants if indicated R
- E lectrolytes, correct potassium, magnesium, phosphate, and calcium
- oxicity of drugs especially beta blockers, sedatives, etc Т
- O xygen, increase FiO₂ by 10% as patient is taken off on ventilator
- heezing, treat bronchospasm with beta agonists W
- ating, nutrition is critical but excess calories and carbohydrates are bad Ε
- nti-inflammatory, steroids have shown to hasten recovery in COPD Α
- N euromuscular disease, think of myasthenia, ALS, critical illness polyneuropathy, others

Non-invasive positive pressure ventilation (NIPPV)

Patient selection

Respiratory insufficiency or impending failure without need for immediate intubation. Works best for a readily
reversible condition. Populations which may be appropriate include COPD or asthma exacerbation, premature
postoperative extubations, restrictive thoracic disease with transient increased work of breathing, congestive
heart failure, possibly pneumonia with underlying lung disease.

Exclusion criteria

 Uncooperative patientHemodynamically unstableActive arrthymias, ischemia, or UGI bleedingExcessive secretionsImpaired airway protectionFacial traumaPoorly fitting mask

Indicators of probable success

• Patient tolerates maskImprovement in acid-base status and gas exchange within first 2-3 hours of use

Complications

- Failure
- Skin breakdown at interface of mask (minimize with Duoderm at contact points
- Aspiration (avoid oral intake with mask and elevate HOB to 45°)

Non-invasive Positive Pressure Ventilation (NIPPV)

BiPAP (nasal or full mask administer by BiPAP machine)

- Proper mask fitting is critical
- Initial settings IPAP 8 cm H₂O, EPAP 3 cm H₂O
- O₂ flow rate adequate for acceptable saturation (actual F_i O₂ varies as per minute ventilation, maximum obtainable about 70%)
- Titrate IPAP in increments of 2 cm H₂O for improved ventilation as guided by ABGs
- EPAP functions like PEEP and may help improve oxygenation, increased levels may reduce tolerance
- Monitor patient closely for serial progress
- If effective, no firm guidelines as to weaning support. Consider 2-3 hours off support for eating, breaks, followed by return to support especially including at night initially. Increase duration of off periods as per patient tolerance and following rest and reversal of underlying process.

Non-invasive Positive Pressure Ventilation (NIPPV)

- Pressure Support (full fask mask with conventional 7200 ventilator)
- Connect ventilator to clear inflatable cuff face mask with conventional tubing
- Gently place mask over patient's face, with pressure support at 10 cm H₂O to ensure initial tolerance
- Secure mask with head straps
- Use humidifier without warmer
- Once mask is secured, set CPAP at 5 cm H₂O and titrate PS to tidal volume of 7 mL/kg, RR < 25, and as tolerated by patient
- Titrate F_iO₂ as per O₂ saturation
- Titrate CPAP like PEEP to get $F_iO_2 < 60\%$
- Wean by decreasing PS in conventional fashion or increasing duration of time off mask.

Electrolyte Content of Common IV Replacement Fluids

	Na mEq/L	K mEq/L	Cl mEq/L	Ca mEq/L	Gluc gm/L	Lac mEq/L	mOsm/L
Albumin 5%	130-160		130-160				308
Albumin 25%	130-160		130-160				1500
Plasma Protein Fraction 5% (PPF)*	130-160	< 2	130-160		167		290
Dextran 40**	(154)		(154)		(250)		278
Hetastarch 6% (Hespan)	154		154				310
D5W					250		278
NS	154		154				308
NaCl 3%	513		513				1025
Ringer's lactate	130	4	110	3		27	275

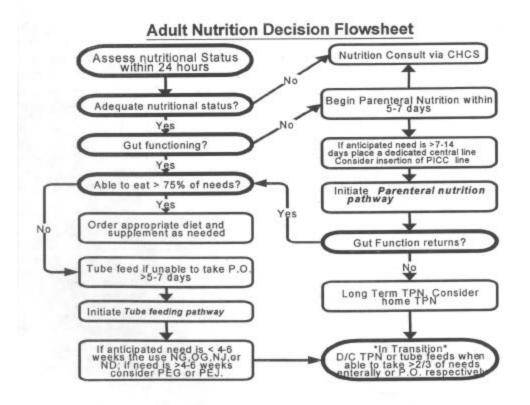
* - contains Albumin 44gm/L and globulin 6gm/L ** - available combined with either sodium chloride OR dextrose

Electrolyte composition of gastrointestinal fluids

Site	Electrolyte				Volume	
1	Na	К	CI	HCO ₃	L/day	
Saliva	30	20	35	15	1 - 1.5	
Gastric, pH<4	60	10	90		2.5	
Gastric, pH>4	100	10	100		2	
Bile	145	5	110	40	1.5	
Duodenum	140	5	80	50		
Pancreas	140	5	75	90	0.7 - 1	
lleum	130	10	110	30	3.5	
Cecum	80	20	50	20		
Colon	60	30	40	20		
New ileostomy	130	20	113	30	0.5 - 2	
Adapted ileostomy	50	5	30	25	0.4	
Colostomy	50	10	40	20	0.3	

Agents used in	the treatment of	of hyperkalemia
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Agent	Mechanism	Dosage	Onset of action	Duration
Calcium gluconate	Direct antagonism	n1-3 gm IV at 100mg/min	Immediate	
Sodium bicarbonate	Redistribution	50 mEq IV over 1-5 min	5-10 minutes	2 hours
Glucose/Insulin	Redistribution	50mL D50W with 10u of regular insulin IV then D10W 1000mL with regular insulin 25- 50u at 250mL/hr	30 minutes	4-6 hours
Albuterol	Redistribution	12.5mg in 2.5mL (0.083%) via nebulizer over 5 minutes	30 minutes	2 hours
Sodium polystyrene sulfonate	Increased elimination	25-50gm oral or rectal as retention enema up to 3-4 times daily	2-3 hours	6-8 hours



Nutrition guidelines

Protein requirements

- 0.8 gm/kg/d for normal adult maintenance
- 1.3 2 gm/kg/d in stress, possibly more with large external losses
- 0.8 1.2 gm/kg/d for renal or hepatic failure
- Use Travasol 10% for most patients. Consider using Freamine HBC 6.9% (high in branch chain amino acids) in very
 catabolic patients. Use Hepatamine 8% in patients with hepatic encephalopathy. Novamine 15% for fluid restricted
 patients.

Caloric requirements

- Harris-Benedict Equation for basal energy expenditure (BEE) for adults
 - Males = 66 + (13.7 * Wt in kg) + (5 * Ht in cm) (6.8 * age)
 - (if height is unknown then BEE = 24 cal/kg for normal size males)
 - Females = 655 + (9.7 * Wt in kg) + (1.8 * Ht in cm) (4.7 * age)

(if height is unknown then BEE = 20-23 cal/kg for normal size females)

- Activity Factors (AF) multiples: non-ambulatory = 1 1.2
 - sedated and ventilated = 0.8 1.0 inactive ambulatory = 1.2 active ambulatory = 1.3
- Stress Factor (SF) multiples: normal patients = 1.1 1.3
- Total Energy Expenditure (TEE) = BEE * AF * SF
- Most patients expend 25-30 calories/kg/day. Hypermetabolic patients may need 30-35 kcal/kg/day. Consider a 20% calorie reduction if heavily sedated or paralyzed.

Calories per gram of nutrient

Dextrose	3.4 cal/gm	Fat emulsion 10 cal/gm
Dietary fat	9 cal/gm	Protein 4 cal/gm (if oxidized for energy)
Additional caloric sou Propofol Peritoneal dial Dextrose 5% 1	ysis or CAVHD	1 cal/mL 35-45% of administered dextrose is absorbed 50gm dextrose

Nitrogen balance in adults with creatinine clearance > 50 mL/min

Total gms of nitrogen in (N_{IN}) = Total gm of protein in / conversion factor use a factor of 6.25 for food and enteral nutrition use a factor of 6.06 for parenteral nutrition Total gms of nitrogen out (N_{OUT}) = 24 hour UUN in gm + 4 gm insensible losses Nitrogen balance = $N_{IN} - N_{OUT}$ Goal is nitrogen balance = 0 to 3+

Total (central) parenteral nutrition guidelines

Weight calculation :

Lean Body Weight (LBW)=IBW + 0.4 (Actual body weight - IBW) Ideal Body Weight (IBW)=for males 50kg + (2.3kg for each in over 60[°]) =for females 45kg + (2.3kg for each in over 60[°])

• Use a lean body weight if patient is significantly edematous and/or obese

Daily protein requirements

• Calculate protein calories using protein requirements Grams of protein = _____ X 4 = protein calories

Daily calorie requirements

- Calculate non-protein calories
 Total calories = _____
 Protein calories = _____ (subtract)
 Non-proten calories = _____
- Calculate dextrose and lipid quantities
 Grams of dextrose = ______ = (0.7 x Non-protein calories) / 3.4
 Grams of lipid (fat) = ______ = (0.3 x Non-protein calories) / 10

Daily fluid requirements

 25-40 mL./kg for a normal adult. TPN orders for minimal volume will provide approximately 1mL of volume per calories using the previous guidelines

Daily mineral and electrolyte requirements

Sodium Potassium Calcium	60-80 mEq/day 80-120 mEq/day 10-15 mEq/day 10-30 mEq/day
Magnesium	10-30 mEq/day
Phosphorus	10-15 mM/1000 calories or 8-12 mM/L

- 1 mM of potassium phosphate contains 1.5 mEq potassium, 1 mM of sodium phosphate contains 1.3 mEq sodium.
- Multi-trace 5 contains zinc, copper, manganese, chromium, and selenium

Daily multivitamin requirements

 the parenteral MVI-12 for adults contains all vitamins except Vitamin K, which can be added to the TPN as 1mg/d if desired

Formula	Osmolite	Ensure with Fiber	Probalance	Peptamen	Twocal HN	Nepro
Caloric density (cal/cc)	1.06	1.06	1.2	1.0	2.0	2.0
,						
Protein (gm/L)	37.1	36	54	40	83.5	70
	0	14.4	10	0	0	0
Fiber						
Ca++	535 mg	1458 mg	1250 mg	800 mg	1055 mg	1370 mg
Phos	535 mg	1250 mg	1000 mg	700 mg	1055 mg	685 mg
Mg++	215 mg	416 mg	400 mg	300 mg	425 mg	215 mg
Iron	9.6 mg	19 mg	18 mg	18 mg	19 mg	19 mg
Copper	1.1 mg	2 mg	2.0 mg	2 mg	2.1 mg	2.1 mg
Mn	2.7 mg	5.4 mg	4.0 mg	2.8 mg	5.3 mg	5.3 mg
Zn	12 mg	16 mg	24 mg	24 mg	24 mg	24 mg
Na+	640 mg	833 mg	763 mg	560 mg	1460 mg	824 mg
K+	1020 mg	1542 mg	1560 mg	1500 mg	2450 mg	1060 mg
CI-	850 mg	1333 mg	1296 mg	1000 mg	1650 mg	1010 mg

TAMC ENTERAL FORMULARY (Contents per 1000cc) August 1999

Formula	Suplena	Pulmocare	Crucial	ProMod Powder	Polycose Powder	MCT Oil
Caloric density (cal/cc)	2.0	1.5	1.5	28 cal/scoop	8	7.7
Protein (gm/L)	30	62.6	94	5 gm/scoop	N/A	N/A
Fiber	0	0	0	0	0	0
Ca++	1430 mg	1060 mg	1000 mg	44 mg/scoop	1.9 mg/T	N/A
Phos	730 mg	1060 mg	1000 mg	33 mg/scoop	0.75 mg/T	N/A
Mg++	215 mg	425 mg	400 mg	N/A	N/A	N/A
Iron	19 mg	24 mg	18 mg	N/A	N/A	N/A
Copper	2.1mg	2.2 mg	3.0 mg	N/A	N/A	N/A
Mn	5.3 mg	5.3 mg	4.0 mg	N/A	N/A	N/A
Zn	24 mg	20 mg	36 mg	N/A	N/A	N/A
Na+	790 mg	1310 mg	1168 mg	15 mg/scoop	6.9 mg/T	N/A
K+	1120 mg	1960 mg	1872 mg	65 mg/scoop	0.6 mg/T	N/A
CI-	935 mg	1690 mg	1740 mg	N/A	13.9 mg/T	N/A

Guidelines for Monitoring of Nutrition Status in the ICU

Monitored Parameters	Initial Frequency	Francisco Stable
		Frequency when Stable
Laboratory		
CBC with differential	Weekly	Weekly
Glucose	TID(until <200mg/dl)	TID(until <200mg/dl)
Chem 7	Daily	Twice weekly
Ca ⁺⁺ , Mg ⁺⁺ , PO ₄ ⁻	Daily	Weekly
Hepatic	Twice weekly	Weekly
Triglycerides	Weekly (every 3 days if pt. receiving Propofol)	Weekly (every 3 days if pt. receiving Propofol)
Efficacy of Therapy		
24hr. UUN*	Weekly	Weekly
Prealbumin	Monday or Thursday	Weekly
C-Reactive Protein	Monday or Thursday	Weekly
Albumin	Monday or Thursday	Weekly

Miscellaneous facts and formulas

Parameters	Formula
Corrected Sodium	measured Na + {1.5 × [Glucose - 150)/100]}
Water deficit	0.6 × Wt × [1 - (140/Na)]
Fractional excretion of sodium	$100 \times [Na_u \times Creatinine_p]/ [Na_p \times Creatinine_u]$
Calculated osmolarity	(2 × Na) + (BUN/2.8) + (Glucose/18)
Creatinine clearance (calculated)	male = [(140-age) × Wt] / (S _{cr} × 72) female = male × 0.85
Creatinine clearance (measured)	Creatinine _{URINE} X 100 / Creatinine _{SERUM} x 1440

Recommendations for SRMD prophylaxis

Definite Indications

- Head trauma including neurosurgical procedures
- Burns with > 30% BSA)
- Recent (within 6 weks) history or active episode of peptic ulcer disease or upper gastrointestinal hemorrhage
- Coagulopathy (PT > 1.5 control, PTT > 2 control, PLTs < 50,000)
- Mechanical ventilation for > 48 hours

Relative Indications

- Remote history of PUD or UGIB
- Corticosteroid use
- NSAIDs use
- Systemic anticoagulation or thrombolysis
- Treatment
- Sucralfate via oral, NG, or OG tube preferred
- Rantidine intravenous if no gastric access available, consider changing to either oral rantidine as soon as possible (150mg po every 8 hours)
- Discontinue when patient is no longer at risk

Acid-Base disorders

Anion Gap (AG) (normal value 7-16) $AG = (Na + UC) - (CI + HCO_3 + UA)$ where UC is unmeasured cations UA is unmeasured anions

Changes independent of acid-base disorders

Increased AG	Decreased AG
Excessive exposure of serum sample to air causing HCO_3 decrease due to CO_2 release	Halide (bromide or iodide) intoxication causing a false elevation of CI measurement
	Hypertriglyceridemia causing false elevation of Cl measurement
	Exogenous administration of poorly absorbed cationic antibiotics (polymyxin B)
	Hypoalbuminemia

Metabolic acidosis

Increased production of acid
Ketoacidosis*
 Lactic acidosis "Nonketotic" hyperglycemia Myoglobinuric ARF from rhabdomyolysis Toxins (salicylates, methanol, paraldehyde) Decreased excretion of acid Acute renal failure
 Chronic renal failure * Note only acetoacetate is measured by standard tests even though beta-hydroxybutyrate is the major component by > 3-4:1 ratio

- Correct the underlying cause
- 2. Administration of Sodium Bicarbonate

 - a. Typically used when pH <7.2
 b. Patient must be capable of eliminating the CO₂ produced during buffering
 c. Patient must be able to tolerate the sodium load

 - d. NaHCO₃(mEq) = $0.3 \times \text{body wt.}$ (kg) x base deficit (mEq/l) Replace $\frac{1}{2}$ the deficit each time.
 - e. Frequent reassessments are required.
- 3. Administration of THAM
 - Calculate dose using the following equation.

THAM (ml of 0.3 molar solution) = lean body weight (kg) X base deficit (mmol/L) Administer over 2-4 hours. Max. daily dose 15 mmol/kg (3.5L of 0.3 molar solution in a 50kg adult)

Respiratory Acidosis

Inhibition of medullary respiratory	Acute
center	 drugs (opiates, anesthetics, sedatives)
	 oxygen in chronic hypercapnea
	cardiac arrest
	central sleep apnea
	Chronic
	 extreme obesityCNS lesions
Disorders of respiratory muscles	Muscle weakness Kyphoscoliosis Extreme obesity
Disorders affecting gas exchange across pulmonary capillary	Acute Exacerbationn of underlying lung disease ARDS Acute cardiogenic pulmonary edema Severe asthma or pneumonia Pneumothorax or hemothorax Chronic COPD

Metabolic alkalosis

Saline Responsive (Urine CI < 15 mEq/L)	Saline Unresponsive (Urine Cl > 15 mEq/L)
Vomiting	Excess mineralocorticord (High blood pressure)
Gastric drainage, NG tube, gastrostomy	Cushings syndrome
Diuretic therapy (contraction alkalosis) Relief from prolonged hypercapnea	 hyperaldosteronism
Congenital chloridorrhea	 ACTH-secreting tumors
Exogenous bicarbonate administration including	licorice ingestion
 citrate salts (transfusions, Bicitra, etc) 	 renal artery stenosis
lactate	 exogenous steroids
 acetate (parenteral nutrition) Renal failure and alkali therapy Milk-alkali syndrome 	Bartter's syndrome Severe potassium deficiency (Low blood pressure) Magnesium deficiency (Low blood pressure)

Respiratory alkalosis

Acute	Chronic
Errors in mechanical ventilation	Prolonged hypoxemia Cirrhosis Prolonged mechanical ventilation

Management of metabolic alkalosis

Chloride replacement

- Sodium chloride
- use when extravascular volume is low
- CI deficit = $0.3 \times \text{wt}$ (kg) \times (100-present CI)

Potassium chloride

- Magnesium must be repleted before potassium can be repleted
- Potassium chloride alone is not enough to replace chloride deficit however potassium must be corrected to prevent metabolic alkalosis from sustaining itself.

Hydrochloric acid

- Must administer via central line
- Endpoint is $HCO_3 < 35 \text{ mEq/L}$
- H^+ mEq deficit = 0.5 × wt (kg) × (present HCO₃ desired HCO₃)
 - Using 0.1M HCl volume (L) = H⁺ mEq deficit / 100 mEq/L
 - Using 0.25M HCl volume (L) = H^+ mEq deficit / 250 mEq/L
- Infusion rate = 0.2 mEq/kg per hour

Management of metabolic alkalosis

Drug Therapy

- Acetazolamide (Diamox)
- inhibits HCO₃ reabsorption in proximal renal tubuleMay be use when ECV is highDoes not correct underlying eletrolyte deficits, temporary interventionMay cause potassium and volume depletion (mild diuretic)
- Histamine 2 blockers
- > Examples include ranitidine, cimetidine, and famotidine
- ➢ In the presence of naso-gastric suction, H₂RA can limit H⁺ loss by limiting gastric secretion Gastric pH must monitored

Continuous Hemofiltration

• CAVH valuable when metabolic alkalosis is associated with increased ECVMust be combined with chloride containing solutions

Correcting Chloride-resistant Alkalosis

- ECV is high so saline does not correct alkalosis
- Potassium repletion and/or administration of mineralocorticord antagonists

Urine anion gap* Average Daily Urinary Excretion

Cations			Anions		
Sodium	127 ± 6 mEq / day	Chloride 1	35 ± 5 mEq / day		
Potassium	49 ± 2 mEq / day	Sulfate 3	34 ± 1 mEq / day		
Calcium	4 ± 1 mEq / day	Phosphate 2	$20 \pm 1 \text{ mEq} / \text{day}$		
Magnesium	11 ± 1 mEq / day	Organic ions 2	29 ± 1 mEq / day		
Ammonium	28 ± 2 mEq / day				
Interpretation**		 			
Highly negative	UAG (≤ - 23 mEq/day)		Appropriate rate of renal NH ₄ excretion		
		likely extrarenal caus	e of acidosis or proximal RTA		
Positive UAG (0 mEq/day)		inappropriately decre suggest renal cause	eased renal excretion of NH ₄ and		
Highly positive UAG (\geq 100 mEq/day)			increased excretion of urinary organic ions making interpretation problematic		

*UAG = Na + K - Cl

**Diagnostic value only if urinary pH < 6.4(from South Med J 1988; 81(2):229-237)

Causes of Acute Renal Failure

Prerenal azotemia	Decreased extracellular fluid volume gastrointestinal losses renal loss burns hemorrhagic shock Decrease effective volume cardiac failure cirrhosis/ascites positive pressure ventilation Third spaced fluids abdominal catashtropes soft tissue trauma hypoalbuminemia
Intrinsic azotemia	Glomerular disease Interstitial nephritis Vascular disease Acute tubular necrosis (ATN)
Postrenal azotemia	Anatomic obstruction Neurogenic bladder

Causes of intrinsic azotemia

Glomerular disease	Hemodynamic changes Hepatorenal syndrome Drugs Glomerulonephritis Infectious Vasculitis Goodpasture's syndrome Idiopathic 	
Interstitial nephritis	Allergic interstitial nephritis Infections Immune Infiltrative Tubular obstruction	
Vascular disease	Hypertensive Atherosclerotic (thrombotic, cholesterol microemboli) Traumatic Renal vein thrombosis/ligation Microangiopathy (HUS, TTP) Vasculitis	
Acute tubular necrosis	Ischemic Toxic	

Characteristic	Prerenal azotemia	Intrinsic azotemia	Postrenal azotemia
Urine specific gravity	> 1.020	1.012	1.012
Urine osmolarity (Mosm/L)	> 400	300 ± 20	300 ± 40
Urine/plasma osmaolarity	> 1.5	1	1
Urine sodium (mEq/L)	< 20	> 30	< 30
Fractional excretion of sodium (FeNa)	< 1%	> 1%	< 1%
BUN:Cr	20	10	10-20
Urine/plasma creatinine	> 40	< 20	< 20

Urine laboratory diagnostic indices

Urine disease diagnostic indices

Diagnosis		Urine sediment		
Prerena	l azotemia	Normal or nearly normal (hyaline casts and rare granular casts		
Postren	al azotemia	Normal or can have hematuria, pyuria, and crystals		
Intrinsic	azotemia			
•	Glomerular disease	RBC, RBC and granular casts; abundant proteinuria		
•	Interstitial nephritis	Pyuria, WBC casts, eosinophils, and eosinophilic casts		
•	Vascular disease	Often has RMC, eosinophiluria can occur with atheroembolic disease		
•	Acute tubular necrosis	Pigmented granular casts, renal tubular epithelial cells, and granular casts		

Causes of Renal Tubular Acidosis

Proximal RTA (Type 2) Impaired proximal bicarbonate reabsorption	Distal RTA (Type 1) Impaired distal hydrogen ion secretion	Hyperkalemic RTA (Type 4) Intact distal acidification but impaired ammoniagenesis	
Primary	Primary	Primary	
 Transcient (infantile) Persistent (familial, Vitamin D deficiency) 	 Transcient Persistent (classic adult, associated with bicarbonate wasting and nerve deafness) 	 Transient (early childhood) 	
 Secondary Fanconi syndrome Drugs and toxic substances (carbonic anhydrase inhibitors, tetracyclines, heavy metals) hyperparathyroidism nephrotic syndrome cyanotic heart disease 	 Secondary disorders of mineral metabolism hyperglobulinemic states drugs and toxins (amphotericin, lithium, amiloride) genetic disorders (adrenal hyperplasia, sickle-cell disease) renal disease (renal transplantation, medullary sponge kidney, obstructive uropathy) 	 Secondary aldosterone deficiency without renal disease hyporeninemic hypoaldosteronism in patients with chronic renal disease "chloride-shunt" syndrome primary or secondary pseudohypoaldosteroinism drugs (heparin, captopril, cylosporine, prostaglandin inhibitors) 	

Heparin Protocol for systemic anticoagulation

Weight based Nomogram	
Initial dose	80 u/kg bolus, then 18 u/kg per hour
APTT < 35 seconds (<1.2 \times control)	80 u/kg bolus, then 4 u/kg per hour
APTT 35 to 45 seconds (<1.2 to 1.5 \times control)	40 u/kg bolus, then 2 u/kg per hour
APTT 46 to 70 seconds (<1.5 to 2.3 \times control)	No change
APTT 71 to 90 seconds (<2.3 to 3 \times control)	decrease infusion rate by 2 u/kg per hour
APTT >90 seconds(>3 × control)	hold infusion 1 hour, then decrease infusion rate by 3u/kg per hour

Transfusion guidelines

General

- Blood Bank phone: 433-6042. Blood Bank physician is on call 24 hours a day 7 days a week
- Informed consent must be obtained once during each hospital stay using forms present in patient's chart
- Blood must be infused within 4hrs. It can be split into smaller aliquots.
- A unit of blood that has been issued and allowed to warm to 10 C but not used can not be reissued.
- Blood must not be stored in unmonitored refrigerators
- Standard blood filters have a pore size of 170 microns.
- Proper patient identification is essential, mislabeled specimens will not be accepted

Tests related to blood transfusions

Type and Screen

- ABO and Rh testing
- Screen for non-ABO antibodies

Type and Cross

- Same T and S with cross-match
- Use when transfusion is expected
- Use when transfusion is a possibility

Blood Components and Plasma Derivatives

Component/Product	Compostion	Volume		Expected Change
	RBCs (≈ HCT 40%); plasma;WBCs; platelets		Increase both red cell mass and plasma volume (WBCs and Platelets not functional; plasma deficient in labile clotting Factors V and VIII	One unit will increase Hbg 1gm/dl or Hct 3%
Red Blood Cells (PRBC)	RBCs (≈HCT 75%); reduced plasma; WBCs; platelets	250 ml	functional)	increase Hbg 1gm/dl or Hct 3%
Added	RBCs (⊲HCT 60%); reduced plasma; WBCs; platelets; 100ml of additive solution	330 ml	Increase red cell mass in symptomatic anemia(WBCs and platelets not functional)	increase Hbg 1gm/dl or Hct 3%
filtration)	>85% original vol. of PRBCs; <5 x 10 ⁶ WBC; few platelets; minimal plasma	225 ml	Increase red cell mass; <5 x 10 ⁶ WBCs to decrease the likelihood of febrile reactions, immunization to leukocytes (HLA antigens) or CMV transmission	One unit will increase Hbg 1gm/dl or Hct 3%
PRBC, Washed	RBCs (≈HCT 75%); <5 x 10 ⁸ WBC; no plasma	180 ml	Increase red cell mass; reduce the risk of allergic reactions to plasma proteins	
PRBC, Frozen & PRBC, Deglycerolized	RBCs (≈HCT 75%); <5 x 10 ⁸ WBC; no plasma, no platelets	180ml	Increase red cell mass; minimize febrile or allergic transfusion reactions; used for prolonged RBC storage	One unit will increase Hbg 1gm/dl or Hct 3%
Platelets	Platelets(>5.5 x 10 ¹⁰ /unit); RBC; WBC; plasma	50 ml	thrombocytopathy	One unit will increase platelet count by 5,000
Platelets, Pheresis	Platelets (>3 x 10 ¹¹ /unit); RBC; WBC; plasma	300 ml		One unit will increase platelet count by 30,000- 60,000
	Platelets(>3 x 10 ¹¹ /unit); <5 x 10 ⁶ WBC per final dose of pooled Platelets	300 ml	thrombocytopathy;<5 x 10 ⁶ WBCs to decrease the likelihood of febrile reactions, immunization to leukocytes (HLA antigens) or CMV transmission	One unit will increase platelet count by 30,000- 60,000
(FFP)	Plasma; all coagulation factors; complement; no platelets	220 ml		10-20ml/kg (4-6 units in adults) will increase coagulation factors by 20%
Cryoprecipitate	Fibrinogen; Factors VIII and XIII; von Willebrand factor	15 ml		One unit will increase fibrinogen by 5mg/dl

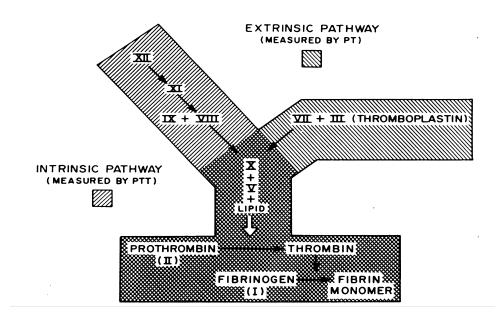
In-Vitro Properties of Blood Clotting Factors

Factor	Plasma Concentration Required for hemostasis	Half-Life of Transfused Factor	Recovery in Blood(as % of amount transfused)	Stability in Liquid Plasma and Whole Blood (4 C Storage)
1	100-150 mg/dl	3-6 days	50%	Stable
11	40 U/dl (40%)	2-5 days	40-80%	Stable
V	10-25 U/dl (15-25%)	15-36 hours	80%	Unstable
VII	5-20 U/dl (5-10%)	2-7 hours	70-80%	Stable
VIII	10-40 U/dl (10-40%)	8-12 hours	60-80%	Unstable
IX	10-40%	18-24 hours	40-50%	Stable
X	10-20%	1.5-2 days	50%	Stable
XI	15-30%	3-4 days	90-100%	Stable
XII				Stable
XIII	1-5%	6-10 days	5-100%	Stable
vWF	25-50%	3-5 hours		Unstable

*Upper limit usually refers to surgical hemostasis. **50% remains at 14 days

***25% remains at 24 hours

Clotting Pathways



Transfusion Reactions

 What to do STOP THE TRANSFUSION - assume that all reactions are potentially hemolytic and therefore potentially life-threatening Evaluate vitals Contact the Blood Bank, all reactions should be worked up - be safe Types of reactions	 What's next? Transfusion reaction workup will be done by the Blood Bank Send bag, red top, purple top, and all paperwork to the Blood Bank Send next urine for UA to look for hemoglobinuria
HemolyticMay be acute or delayed	AllergicUrticaria to anaphylaxis

Renal/vascular support are treatment keys

Febrile nonhemolytic

- Most common, benign but easily confused with acute hemolytic
- Premedication with acetaminophen and/or leukocyte reduction
- Most are mild and prevented/treated with diphenhydramine

Bacterial contaminations

- Uncommon
- Immediate broad spectrum antibiotic therapy necessary

Glucose monitoring guidelines during insulin administration

Insulin	Route of Administration	Onset 1	Peak	Duration	Glucose Monitoring
Regular	IV continuous infusion*	Immediate	15-30 minute	s 1-2 hours	every 2 hours
Regular	Intramuscular	5-30 minutes	s 30-60 minute	s 2-4 hours	every 4 hours
Regular	Subcutaneous	30 minutes	1½-3 hours	6-10 hours	every 6 hours

*Note: IV insulin boluses should be given only as an adjunct to continuous IV insulin therapy for glucose control or as part of the treatment of hyperkalemia.

Acute Adrenal Insufficiency

Suspected in the presence of unexplained <u>catecholamine – resistant</u> hypotension

- 1. If patient is in extremis, administer Dexamethasone 10mg IV (Will not interfere with Corticotropin Stimulation Test)
- 2. Perform short corticotropin stimulation test as soon as possible
- 3. Continue to treat suspected patients while awaiting laboratory confirmation (See Stress Replacement of Corticosteroids p.116)

Other signs or symptoms include:

- Hypotension
- Weakness
- Fatigue
- Anorexia
- Fever
- Nausea
- Hyponatremia (Renal sodium wasting)
- Hyperkalemia (Renal potassium retention)
- Hypoglycemia

Corticotropin Stimulation Test (ACTH Stim.Test)

- 1. Draw baseline serum cortisol and ACTH levels
- 2. Administer an ACTH analog (Cortrosyn 250mcg IV)
- 3. Obtain cortisol levels at 30 and 60 minutes after ACTH dose

Interpretation of results

Pituatary Adrenal Axis Status	ACTH Level	Baseline Cortisol	Cortisol Level After ACTH Stimulation
Normal	Normal	Normal	Increased
Primary Adrenal Failure	Marked Increase	Low	Low
Secondary Adrenal Failure	Low or Normal	Low (<25mcg/dl in the stressed ICU patient)	Mild or No Increase(Fails to exceed 25mcg/dl)
Post-Steroid Withdrawal	Low	Low or Normal	Mild Increase*

*Requires a 24 hr. ACTH infusion for confirmation

Steroid Potency/Conversion Chart

Agent	Approx. equiv. dose (mg)	Relative anti-inflammatory (glucocortlcoid) potency	Relative mineralocorticoid (Na⁺retaining) potency	Biologic half-life (hrs)
Cortisone	25	0.8	0.8	8-12
Hydrocortisone	20	1	1	8-12
Prednisone	5	4	0.8	18-36
Prednisolone	5	4	0.8	18-36
Methylprednisolone	5	5	0.5	18-36
Dexamethasone	0.75	25	0	36-54

Stress Replacement Doses of Corticosteroids

Dexamethasone	7.5 – 30 mg/day
Hydrocortisone	200 - 300 mg/day
Methylprednisolone	40 – 80 mg/day
Prednisone	50 - 100 mg/day

Laboratory Analysis of Hypothyroidism

Diagnosis	Total T4	Free T4	тѕн
Sic euthyroid	-	Normal or -	Normal
Primary Hypothyrroidism	-		-
Secondary Hypothyrroidism	-	-	[–] or 0

NOSOCOMIAL INFECTIONS

Consider if:

- 1. Hospitalized >72 hours
- 2. Hospitalized within past 3 mo.
- 3. Significant prior antibiotic use

Treatment of Specific Nosocomial Infections

Pneumonia

- 1. Cefepime 1gm BID (CrCl = 10-50 then 1gm QD, <10 500mg QD)
- 2. Piperacillin/tazobactam* 3.375gm QID
- 3. Meropenem^a 500mg TID (CrCl = 10-50 then 500mg BID, <10 500mg QD)
- 4. Clindamycin 300-600mg TID + ciprofloxacin**^a 400mg BID (CrCl = 10-50 then 300mg BID, <10 200mg BID)

*Use 4.5 gram dose of Pip/tazo if pseudomonas likely or documented outside the urinary tract. **Use cipro, not levofloxacin if pseudomonas is likely or documented outside the urinary tract.

^a Restricted to Infectious Disease Service

Always consider addition of an Aminoglycoside for life threatening sepsis

Sinusitis (Intubated patient)

- 1. Piperacillin/tazo
- 2. Meropenem
- 3. Clinda + cipro or levo
- 4. Cefepime/metronidazole

Intra-abdominal

Same as for sinusitis

Bacteremia/Sepsis

- 1. Cefepime + gentamicin (single-daily dose)
- 2. Consider vancomycin for patient with invasive lines
- 3. Remove or change invasive lines culture all line tips

Urinary Tract

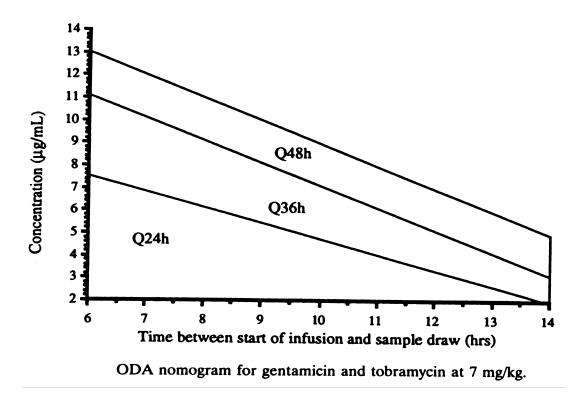
- 1. Remove Foley if possible
- 2. Cefepime or Piperacillin/tazo
- 3. Levofloxacin

Fungal Infections

Site	Treatment
	No treatment required.
Sputum	
Urine	Remove or change urinary catheter if possible. Treat with Fluconazole if urine fungus is found in the absence of a urinary catheter in a male patient.
Blood	Amphotericin B 50mg QD IV (0.5mg/kg)
Deep Space	Amphotericin B 50mg QD IV (0.5mg/kg)

Once Daily Aminoglycoside Dosing

- 1. Order 7mg/kg Gentamicin or Tobramycin
- 2. Draw serum level 8-12 hrs. post infusion
- 3. Adjust dose based on dosing nomogram below
- 4. Follow serum creatinine at least every 2-3 days



Beds and Specialty Beds Available at TAMC

Bed or Surface	Description	Indications	Candidate Selection	Advantages	Disadvantages	Daily Cost
Stryker Bed w/ Zonaire Mattress	Air bladder Over 5" foam mattress w/air bladder Has scale	Min Risk Score (17or >);	Pt can move Not Incontinent WT<400 lbs	Offers Pressure Reduction. Readily available upon admission	Can promote skin maceration in patients with increased skin moisture	\$0.00
Total Care Bed	Multiple features to facilitate pt transport and increased activity Has a scale	Mod to High Risk Prevention heel breakdown	Pt will be immobile for prolonged periods of time WT <400 lbs Pt not incontinent	Adjusts for optimal weight distribution Pressure reduction Can be tailored for pt comfort No code board needed	Electrically operated 2 hour battery back-up	\$0.00
Acucair	Continuous airflow; one zone. Goes over hospital mattress; do not require storage		Incontinent Increased moisture WT<250 lbs	Pressure Reduction Airflow can be adjusted to tissue load Maintains constant pressure regardless of position Easy pt placement Helps keep skin dryer if needed		\$23.50
Flexicair Eclipse	Mattress Replacement System - goes on the hospital bed frame. User needs to remove & store hospital mattress	treatment of most advanced stages of	Incontinent WT<300 lbs	Offers pressure relief Helps keep pts cooler and dryer Customized body support through 5 zones Reduces shear, friction, and maceration Built-in battery for transport	Needs to store hospital mattress Need code board	\$33.00
Flexicair MC 3	Low air loss therapy	Same as Regular Flexicair Has a scale	Regular Flexicai		Same as Regular Flexicair	\$67.00
Flexicair II(Regular Flexicair)	Complete Bed Unit with 5 cushion zones	High risk prevention Treatment of most advanced stages wounds (I-IV) Contractures, fractures, amputations Frequent transport, head elevation Risk excessive maceration	Incontinent WT<350 lbs	Don't need code board (5 CPR points) Customize body support through 5 zones Reduces shear, friction, and maceration Built-in battery for easy transport	No scale Can dry out skin if pt has no excess moisture Requires storage of hospital bed while in use	\$44.00
Clinitron II	High air loss or air fluidized	Highest risk for skin breakdown Treatment of multiple advanced pressure ulcers (III & IV)Flaps, grafts, burns, (especially wounds located on the back), intractable pain	WT<215 lbs	Pressure relief Virtual elimination of pressure, shear, friction, and maceration Minimizes shearing forces Keeps pt skin dry	Bed weighs 1680lbs Wide Requires storage of hospital bed while in use HOB does not elevate Can dry out skin	\$50.00
Clinitron Uplift	High air loss or air fluidized	Same as Clinitron II but has ability to elevate HOB	WT<215 lbs	Same as Clinitron II Head elevation	Bed weighs 1680 lbs Wide Requires storage of hospital bed while in use Can dry out skin	\$90.00
Efica CC	Continuous Lateral Rotation(CLRT)	Critically ill pt requiring prevention/treatment of pulmonary complications secondary to immobility	WT<400 lbs	5 modes of operation Secretion Management *Percussion *Vibration *Rotation*CLRT up to 40 degrees *Low air loss surface: Prevents and treats skin breakdown Cardiac Upright Position Doesn't need code board Built in XRay casssette holder	No rotation in sitting position Needs hospital bed to be stored	\$135.00
Magnum	Bariatric Care	Wide bed frame w/ a 5" foam mattress designed for the obese pt.	WT>400 lbs up to 800 lbs	Offers pressure reduction Could be used in conjunction w/flexicair eclipse ultra mattress Safer for staff and pt Comes to upright postion facilitating sitting up and moving out of bed Has a built in X-ray casssette holder Built in scale Siderails adjusts to added width		\$91.00

Staging Criteria for Pressure Ulcers

Stage I: Nonblanchable erythema of intact skin. Epidermis remains intact.

Stage II: Partial thickness loss of skin involving epidermis, dermis, or both. The ulcer is superficial and presents clinically as an abrasion, blister, or shallow crater.

Stage III: Full-thickness tissue loss involving damage to or necrosis of subcutaneous tissue that may extend down to, but not through, underlying fascia. The ulcer presents clinically as a deep crater with or without undermining of adjacent tissue.

Stage IV: Full thickness tissue loss with extensive destruction,

tissue necrosis or damage to muscle, bone or supporting structures like tendons or joint capsules. Undermining and sinus tracts also may be associated with this stage of lesion.

Routine Sedation for diagnostic or non-emergent therapeutic procedures

Prerequisites:

- 1. The patient really needs the study and needs to be sedated
- 2. Presedation History and Physical: Any patient that is greater than ASA I or II, or has any airway anomaly (i.e. Pierre-Robin, or Treacher-Collins) should not be done routinely without proper coordination with Anesthesia or Pediatric Critical Care. Additionally patients less than 50weeks post-conceptual age do not have normal respiratory responses to hypoxemia and hypercarbia and should not be "routinely" sedated. Other contraindications to routine sedation include but are not limited to GERD, Cerebral palsy with abnormal swallowing, history of apnea, neck instability (osteogenesis imperfecta, or Down's syndrome), poorly controlled seizure disorder, significant cardiopulmonary disease (cyanosis, or chronic hypoxemia), history of Malignant hyperthermia, and anticipated difficulty in obtaining IV access in an emergency.
- 3. Informed Consent
- 4. Appropriate NPO status: (This excludes meds and contrast needed for study but physician should be aware of the aspiration risks.)
- 5. Day of sedation evaluation to r/o significant changes
- 6. Pediatric weight based emergency drug sheet print out from CHCS
- 7. Appropriate monitors, equipment and personnel for the planned level of sedation. Remember that when an infant is in the MRI scanner and asleep that their level of sedation may be difficult to assess (i.e. from Asleep to general anesthesia). Appropriate personnel includes dedicated physician if IV meds are being given/titered.
- 8. Highly recommend avoidance of IM shots in patients that have vascular access.

Drug Algorithms

Sedation and Analgesia

- 1. Consult Attending physician
- 2. Options:
 - a. Versed and Fentanyl
 - i. Versed .05mg/kg and Fentanyl 1mcg/kg IV over 5-10 minutes, may repeat both once each.
 - ii. Consider EMLA or local lidocaine as appropriate as adjunct analgesia.
 - b. Versed and Ketamine
 - i. Consider Glycopyrollate IV 5 minutes before Ketamine as antisialogogue (0.004-0.01mg/kg Max dose .1mg)
 - ii. Versed .05mg/kg and Ketamine 0.5-1mg/kg IV over 3-5 minutes, may repeat each once
 - iii. Consider EMLA or local lidocaine as appropriate as adjunct analgesia
 - c. Pentobarbital and Fentanyl
 - i. Pentobarbital 3mg/kg IV (Max dose 100 at one time).
 - ii. Fentanyl 1mcg/kg IV over 3-5 minutes
 - iii. May repeat each drug once at 1mg/kg and 1 mcg/kg doses respectively

**Consider EMLA or local lidocaine as appropriate as adjunct analgesia

Teaching points:

- 1. Drug combinations may be useful but increase the risk of side effects.
- 2. Consult attending physician before venturing into uncharted waters.
- 3. Some sedation plans have low success rates or are contraindicated for some studies, ex. Pentobarbital may hide or create abnormalities on a EEG, and Peds radiology experience suggests that Versed alone is insufficient for sedation for most studies.
- 4. Only Narcotics (narcan 10-100mcg/kg max 2mg) and benzodiazepines (flumazenil 10mcg/kg repeating up to max 1mg) have reversal agents.
- 5. Think Hypoventilation (Ý PCO₂) and respiratory depression, when there are changes in respiratory rate or hypoxemia on pulse oximeter.
- 6. Most sedation drugs are metabolized in the liver and excreted through the kidneys, so use caution with hepatic or renal insufficiency.
- 7. Think!!!!!!

Sedation only:

Child< 2 years old

1. <u>Chloral hydrate*</u>:(works best in patients less than 12 kg) 75 mg/kg PO (max. 1gm/dose , daily 2gm)

2. After 20 minute and not sufficiently sedate then add an additional 25mg/kg (100mg/kg total max)

 Consider 1mg/kg of Benadryl** or Atarax** 0.5mg/kg as adjunct (May give with initial dose if history of difficult sedation in past) * Consider lower dosing (50mg/kg) for newborns and former preemies. **Use caution in infants less than 6 months.

- 4. After 20 minutes more consider Versed if IV access available. Use .05mg/kg IV and may
 - repeat at 3-5 minute intervals up to a max of 0.2mg/kg. Child>18 months old
 - 1. <u>**Pentobarbital**</u>: 3mg/kg IV (Max dose 100 at one time). May repeat in 1mg/kg aliquots every 3-5 minutes up to a total dose of 6mg/kg
 - 2. Consider drawing up max 6mg/kg dose in 10cc syringe and dilute to total volume of 10cc with normal saline. This eliminate discomfort with infusion and allows titering in dose without going over the 6mg/kg maximum recommendation.
 - 3. Consider supplementing with low dose Versed .05 mg/kg.
 - 4. Alternatively may use Versed .05 -.1mg/kg IV, may repeat in .05mg/kg doses at 3-5 minute intervals to a max of .2mg/kg and supplement with Pentobarbital 2mg/kg etc.

Pediatric NPO Guidelines

Child's age	Milk and Solids	Clear liquids
< 6 months	4 hours	2 hours
6 mo to 3 years	6 hours	3 hours
> 3 years	8 hours	3 hours

Inpatient & Postoperative Analgesia

Analgesia

Morphine starting dose 0.05-0.1 mg/kg IV, repeat dosing every 5-10 minutes until effective analgesia established. Use this as basis for IV q2-4hr dosing schedule

Fentanyl starting dose 0.5-1 mcg/kg IV, repeat dosing every 5-10 minutes until effective analgesia established . Use this as basis for IV q1-2hr dosing schedule. If patient is old enough to cooperate consider PCA If effective intermittent regimen cannot be easily established call pain service and consider continuous drip in ICU (Fentanyl 1mcg/kg/hr starting dose) Watch for respiratory depression and consider using Tylenol 15mg/kg(po/pr) as adjunct

Tylenol with Codiene dosed q4hr based on 10mg/kg of tylenol is useful when patient is taking PO well

Sedation

Versed starting dose 0.05-0.1mg/kg IV, may repeat every 5-10 minutes X 2 until effective sedation reached. Use this as basis for IV q1-2hr dosing schedule.

Ativan starting dose 0.05-0.1 mg/kg IV may repeat in 5-10 minutes until effective sedation reached. Use this as basis for IV q2-4hr dosing schedule.

Hemodynamic Exam and Monitoring

Cardiac Output: can be assessed by HR and capillary refill time, mentation, and UOP, (falling BP is a late ominous sign)

Preload: can be assessed accurately by changes in Liver span or by CXR heart size **SVR:** can be assessed by capillary refill time, pulse pressure, and differential temperatures peripheral to central

Shock State	Physical Exam				Monitoring		
	Work of Breathing	Capillary Refill Time(sec)	Liver Size	Skin Temperature	CVP	SVR	CI
Hypovolemic	nl	>2	nl	Cool	-	-	-
Cardiogenic	+++	>2	+++	Cool	-	-	-
Distributive	+/++	+/-	nl	+/-	-		

Pediatric Vasoactive Support

Indication	Drug of Choice	Dosing	Action	
Septic Shock	Dopamine	5-20 μg/kg/min	Inotrope, vasopressor	
Cardiogenic Shock	Dobutamine	2-20 μg/kg/min	Inotrope	
Post-arrest Shock	Epinephrine	.05 to ? μg/kg/min	Inotrope, vasopressor	
Refractory SepticEpinephrineShockorNorepinephrine		.05 to ? μg/kg/min	Vasopressor	
Spinal Shock	Spinal Shock Phenylephrine		Vasopressor	
Cardiogenic Shock Milrinone Second Line Agents Milrinone		0.2-1 μg/kg/min load 50μg/kg	Inotrope, vasodilator	
	Nipride	0.5-5 μg/kg/min	Vasodilator	

Mechanical Ventilation

Initial Settings:

- 1. FIO₂ 50%, if sick 100%
- 2. I time minimum .5 sec, ranging up to 1 sec in older children
- 3. Rate age appropriate 15 -30 to start
- 4. V_T 10ml/kg rounding down then look at chest rise, listen for breath sounds and check Peak pressure. If PP > 35 consider decreasing V_T or switching to pressure ventilation
- 5. PEEP 4cm, higher if FRC compromised by atelectasis, abd distension or severe lung disease

Follow compliance and Oxygenation

Dead Space = 1 - (EtCO₂/PaCO₂) Static Comp. = V_T / (P_{plat}- PEEP) A-a gradient =(P_b-P_{H2O}) x FIO₂ - (PCO₂/.8) - PaO₂

Hypoxemia? - ↑ PEEP to ↑ FRC, to allow FIO₂ wean to < 50%
 Elevated peak pressures? - suction, check tube position with CXR, consider adopting permissive hypercapnia strategy and changing to a pressure control mode.

When things go wrong don't be a DOPE

Dislodged Obstructed Pneumothorax Equipment failure

Extubation

 $\label{eq:section} \begin{array}{l} \mbox{S ecretions / Sedation / Spontaneous V}_T (>5ml/kg) \\ \mbox{O xygenation } FiO_2 <35\% \\ \mbox{A irway - Maintainable?, Leak?, Consider steroids 12 hours prior if intubated >48° or after multiple airway instrumentations? \\ \mbox{P ressures - PP <25, PEEP < 5} \end{array}$

Predictors of Success

Variable	Low risk of Reintubation <10%	High Risk of Reintubation >25%
V _T spont	>6.5 ml/kg	<3.5 ml/kg
FIO ₂	<.30	>.40
OI	<1.4	>4.5
PIP	<25	>30

PediatricTransfusion Medicine

Special preparations

Irradiated Blood is used to to eliminate possibility of Graft Vs. Host disease. Donor-derived T cells can engraft in an immuno-incompetent recipient. Indication for irradiated blood are neonates and children with severe known or suspected congenital or acquired immunodeficiency states.

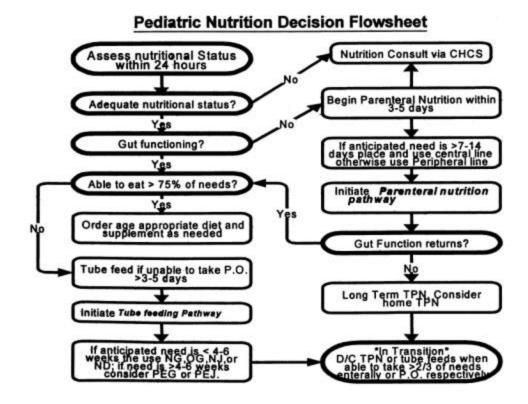
Leukocyte reduced blood products are used to prevent febrile, nonhemolytic transfusion reactions. Microaggregate Filters are suitable to prevent febrile transfusion reactions and are useful in patients who have received blood frequently in the past. However, Leukopore Filters are needed to decrease risk of CMV transmission and HLA alloimmunization

Transfusion rules of thumb

PRBCs - 4cc/kg will increase Hb 1gm/dl

Platelets - 1unit/5kg will increase count by 50,000, (Don't volume reduce unless fluid restriction dictates)

Fresh Frozen Plasma - 10 ml/kg round up/down to closest unit Cryoprecipitate - 1bag / every 5-10kg (Source of fibrinogen and factor VIII)



Pediatric Equipment

Equipment	Infant (4-8kg)	Small Child (8- 11kg)	Child (11-14kg)	Child (14-18kg)	Child (18-24kg)
Oral Airway (mm)	40	40-50	50-60	60-70	70-80
Laryngoscope Blade Type and (Size)	Straight (0 or 1)	Straight (1)	Straight or Curved (1 or 2)	Straight or Curved (2)	Straight or Curved(2)
ET Tube (mm) All uncuffed	Preterm (2.5)Term (3.0 or 3.5)	4.0	4.5	5.0	5.5
ETT Stylet (F)	6	6	6	6	14
ETT length (cm at the lip)	10-10.5	11-12	12.5-13.5	14-15	15.5-16.5
Suction Catheter (F)	6	8	8	10	10
BP Cuff	Newborn-Infant	Infant-Child	Child	Child	Child
NG/OG Tube (F)	5-8	8-10	10	10-12	12-14
Urinary Catheter (F)	5-8	8-10	10	10-12	10-12
Chest Tube (F)	10-12	16-20	20-24	20-24	24-32
Defib. Paddle Size	Infant paddles until1 y.o. or 10kg	Adult paddles when>1 y.o. or >10kg	Adult paddles	Adult paddles	Adult paddles