Rhode Island Department of Health - Center for Emergency Medical Services

EMS Pharmacology Reference Guide

A companion to the 2017 Statewide Emergency Medical Services Protocols

Preface

This reference guide is released as companion to the 2017 Rhode Island Statewide Emergency Medical Services Protocols. It is intended to serve as a resource for EMS providers and training officers. EMS providers should acquire a fundamental understanding of pharmacology related to their respective level of licensure/practice. Please provide any suggestions for future revisions of this document directly to John_Pliakas@brown.edu.

John N. Pliakas, MSN, NP, NRP, TP-C

Table of Contents

Acetaminophen (Tylenol, APAP)

Classification: Analgesic, antipyretic

General:

Acetaminophen has analgesic and antipyretic properties with effects equivalent to those of aspirin. Its analgesic and antipyretics effects are likely the result from the inhibition of prostaglandin E2 (PGE_2). It does not fall into the non-steroidal anti-inflammatory class of medications as it has no anti-inflammatory effects. Acetaminophen acts on a variant of cycloxygenase (COX3) that is only expressed in the central nervous system. Unlike aspirin, it has no effect on COX1 or COX2 and therefore, it has no effect on platelets. Acetaminophen elevates the pain threshold and readjusts the hypothalamic temperature regulatory center.

Protocol Indication(s):

1. Mild to moderate pain
2. Fever

Contraindications:

1. Known hypersensitivity
2. Environmental hyperthermia

Precautions:

1. Acetaminophen should be used with caution in patients with liver disease/failure.
2. The maximum adult daily dose of acetaminophen is 4,000 mg.

Significant adverse/side effects:

1. Nausea/vomiting
2. Stevens-Johnson Syndrome (rare)
3. Toxic epidermal necrolysis (rare)

Dosage per protocol(s):

2.07	Patient Comfort - Adult
2.07	Patient Comfort - Pediatric
2.15	Fever - Adult
2.15	Fever - Adult

Activated Charcoal

Classification: Gastric decontaminant

General:

Activated charcoal (AC) is charcoal which has been treated with oxygen, which results in the opening up of millions of pores between the charcoal's carbon atoms. These pores directly absorb (bind) the molecules of a multitude of substances. In the EMS setting, AC is utilized as a single dose gastrointestinal decontaminant following the oral ingestion of a toxin (in the hospital, multiple doses are sometimes administered to enhance elimination of a toxin). There are a number of substances that are not chemically attracted to AC and are absorbed poorly if at all by AC. These include electrolytes, iron, lithium, heavy metals, acids or bases, alcohols, cyanide, most common solvents, and most water insoluble compounds such as hydrocarbons (petroleum distillates).

Protocol Indication(s):

1. Oral toxic ingestion within 1 hour of EMS contact

Contraindications:

1. Known hypersensitivity
2. Patient with altered mental status without a protected airway (i.e. not intubated)
3. Due to the increased risk of aspiration without out benefit, AC should not be administered following the ingestion of a substance known not to be absorbed by AC
4. Corrosive ingestion (AC obscures endoscopy, which is performed in such ingestions) unless there are life threatening co-ingestants which are adsorbed by AC

Precautions:

1. Administration of AC increases the risk for aspiration.

Significant adverse/side effects:

1. Nausea/vomiting
2. Intestinal obstruction (associated with the administration of multiple doses)

Dosage per protocol(s): 4.18 Toxicological Emergencies - Adult
4.18 Toxicological Emergencies - Pediatric

Adenosine (Adenocard)

Classification: Antiarrhythmic

General:

Adenosine is a naturally occurring nucleoside found in all cells of the body. Adenosine is byproduct of the breakdown of adenosine triphosphate (ATP). Adenosine specific receptors are located in the lungs and cardiomyocytes. Stimulation of these receptors results in decreased electrical conduction. As a result, SA node automaticity is decreased and conduction velocity is slowed and AV nodal refractoriness is increased. Adenosine terminates reentrant pathways that include the AV node as part of the circuit resulting in restoration of sinus rhythm in supraventricular tachycardia. In atrial fibrillation and flutter, adenosine may transiently increase AV block and unmask fibrillation or flutter waves. Adenosine does not convert atrial fibrillation, atrial flutter, or most forms of ventricular tachycardia and is not indicated in irregular tachycardias. The administration of adenosine to a patient with atrial fibrillation and Wolff-Parkinson-White (WPW) Syndrome may result in ventricular fibrillation. Following IV administration, adenosine is rapidly taken up by erythrocytes and the vascular endothelium. Due to its rapid uptake, adenosine has a half-life of <2 seconds. The side effects of adenosine can be dramatic (sinus pause, asystole), but due to the very short half-life of the drug, they are usually transient in nature. The uptake of adenosine may be inhibited by some medications, such as dipyridamole (Persantine). If a patient is on dipyridamole, the dose of adenosine should be reduced. Some medications, such as theophylline and related methylxanthines (caffeine) act as antagonist at adenosine receptors. The dose of adenosine may need to be increased if a patient is on one of these medications. Patients that are status post cardiac transplant may demonstrate increased sensitivity to adenosine.

Protocol Indication(s):

1. Narrow complex tachycardia
2. Wide complex tachycardia (regular, monomorphic)

Contraindications:

1. Known hypersensitivity
2. Atrial fibrillation associated with WPW Syndrome

Precautions:

1. The administration of adenosine to a patient with atrial fibrillation and Wolff-Parkinson-White (WPW) Syndrome may result in ventricular fibrillation.
2. Adenosine may induce airway hyperresponsiveness and should be used with caution in patients with a history of reactive airway disease (asthma).

Precautions:

3. Patients that are status post cardiac transplant may demonstrate increased sensitivity to adenosine.
4. Patients who receive adenosine via central line should receive half the normal dose.

Significant adverse/side effects:

1. Headache
2. Chest pain
3. Flushing
4. Dyspnea/bronchoconstriction
5. Bradycardia
6. AV block
7. Sinus pause/asystole

Dosage per protocol(s):

3.06 Narrow Complex Tachycardia - Adult
3.06 Narrow Complex Tachycardia - Pediatric
3.07 Wide Complex Tachycardia - Adult

Albuterol (Ventolin, Proventil)

Classification: Beta adrenergic agonist (β2 selective)

General:

Albuterol is a short acting β2 selective adrenergic receptor agonist used in the management of bronchospasm. Albuterol stimulates β2 receptors resulting in an increase in cyclic adenosine monophosphate (cAMP), which leads to the activation of protein kinase A inhibiting phosphorylation of myosin and lowering intracellular ionic calcium concentrations, resulting in relaxation of bronchial smooth muscle (bronchodilation) and relaxation of uterine and vascular smooth muscle. Increasing cAMP concentrations also inhibits the release of mediators from mast cells in the airway. Because it relaxes vascular smooth muscle, some peripheral vasodilation may also occur, which may be reflected by a decrease in the diastolic blood pressure. As a result of sympathomimetic stimulation, an intracellular shift of potassium may occur. This may result in a small (approximately 0.5 mEq/L) decrease in the serum potassium concentration. This is generally not of clinical concern, unless large doses of beta agonist are being administered. However, this effect may be useful in the management of hyperkalemia. Due to its effect on uterine smooth muscle, it may be used to arrest premature labor. When administered via inhalation, significant bronchodilation occurs within 15 minutes, and this effect is demonstrated for 3-4 hours.

Protocol Indication(s):

1. Bronchospasm (asthma/reactive airway)
2. Premature labor
3. Hyperkalemia

Contraindications:

1. Known hypersensitivity

Precautions:

1. Use with caution in patients with myocardial ischemia.
2. Paradoxical bronchospasm may occur in a small percentage of patients who receive albuterol. A proposed etiology is attributed to other compounds in the albuterol preparation. If paradoxical bronchospasm (evidenced by significantly increased and severe bronchospasm following administration) is suspected, discontinue use (avoid levalbuterol as well).

Significant adverse/side effects:

1. Tachycardia
2. Palpitations/cardiac ectopy
3. Tremor
4. Headache
5. Nausea/vomiting

Dosage per protocol(s):

2.04	Allergic Reaction - Anaphylaxis - Adult
2.05	Allergic Reaction - Anaphylaxis - Pediatric
2.18	Obstetrical Complications
4.09	Crush Injury

Amiodarone (Cordarone, Nexterone)

Classification: Antiarrhythmic

General:

Amiodarone is primarily a class III antiarrhythmic, but it also demonstrates electrophysiological effects of class I, II, and IV antiarrythmics. As a class III antiarrhythmic, it binds to and blocks the potassium channels that are responsible for phase 3 repolarization. By blocking potassium channels, it delays repolarization, which leads to an increase in action potential duration and an increase in the effective refractory period (ERP) of all cardiac fibers. This prolongs the period of time that the cell is unexcitable (refractory) and therefore makes the cell less excitable. Amiodarone depresses the slope of phase 0 by inhibiting the transmembrane influx of extracellular sodium ions (class 1 effect), antagonizes beta receptors (class II effect) and displays weak calcium channel blocking effects (class IV). Amiodarone also has α adrenergic blocking properties, which in combination with its beta antagonistic properties, are likely to be partly responsible for its hypotensive effects. Amiodarone decreases the rate of SA node firing, suppresses automaticity, and interrupts reentrant pathways. On the ECG, it prolongs the PR, QRS and QT intervals. Amiodarone is useful in the management of atrial (atrial fibrillation) and ventricular tachyarrhythmias, particularly those resulting from a reentrant mechanism. In ventricular fibrillation or ventricular fibrillation, evidence demonstrating the superiority of amiodarone over lidocaine is lacking.

Protocol Indication(s):

1. Ventricular tachycardia
2. Ventricular fibrillation
3. Wide complex tachycardia
4. Pediatric narrow complex tachycardia

Contraindications:

1. Known hypersensitivity
2. Iodine hypersensitivity
3. Bradycardia
4. AV block >1 degree in the absence of a pacemaker
5. Hypotension (SBP <100 mmHg)

Precautions:

1. Due to its vasodilatory properties, the administration of amiodarone in cardiac arrest should be preceded by the administration of a vasopressor (i.e. epinephrine).

Precautions:

2. Amiodarone should not be used in individuals with polymorphic VT associated with a prolonged QT interval.
3. Amiodarone for infusion should only be diluted with D5W and given with an in-line filter.
4. Use with beta or calcium blocking agents may increase risk of hypotension and bradycardia.

Significant adverse/side effects:

1. Hypotension
2. Bradycardia
3. AV block
4. Torsades de pointes
5. Congestive heart failure
6. Phlebitis

Dosage per protocol(s):

3.03	Cardiac Arrest - Adult
3.03	Cardiac Arrest - Pediatric
3.06	Narrow Complex Tachycardia - Pediatric
3.07	Wide Complex Tachycardia - Adult
3.07	Wide Complex Tachycardia - Pediatric

Notes:

1. The conventional IV preparation of IV amiodarone contains polysorbate 80 and benzyl alcohol. These preservatives are believed to be partly responsible for bradycardia and hypotension associated with the administration of amiodarone. A newer formulation (Nexterone) that does not contain polysorbate 80 or benzyl alcohol is available.
2. Infusions of amiodarone should be mixed in D5W. In cardiac arrest, the bolus dose may be diluted in 20-50 ml normal saline or D5W.
3. The total maximum cumulative 24 hour dose of amiodarone is 2.2 gm.

Aspirin (acetylsalicylic acid, ASA)

Classification: Non-steroidal Anti-inflammatory (NSAID)

General:

Aspirin (ASA) has analgesic, antipyretic, anti-inflammatory and antithrombotic effects. ASA is metabolized to salicylic acid, which is the active agent. Salicylic acid irreversibly inhibits the cycloxygenase (COX) enzyme and results in the decreased production of COX enzyme mediated end products such as thromboxane A2 (TXA_2) and prostaglandin E2 (PGE_2). TXA_2 stimulates the activation of new platelets and also increases platelet aggregation (clumping). By decreasing levels of TXA_2, ASA decreases platelet activation and aggregation. Antiplatelet activity is present within 30-60 minutes of oral ASA administration and lasts the lifetime of the platelet (7-10 days) since the effects of ASA are irreversible. PGE_2 production. PGE_2 is thought to act as a mediator of inflammation and to sensitize nerve endings to chemical mediators that are released locally by the inflammatory response. By decreasing levels of PGE_2, ASA decreases pain and inflammation. ASA also reduces fever, which occurs when the set point of the anterior hypothalamic thermoregulatory center is elevated. Elevation of the hypothalamic thermoregulatory center can be caused by increased PGE_2 synthesis, stimulated by pyrogens released from white blood cells that are activated by infection, hypersensitivity, malignancy, or inflammation. ASA decreases the body temperature in febrile patients by impeding the synthesis and release of PGE_2.

Protocol Indication(s):

1. Chest pain/discomfort believed to be of cardiac etiology
2. Acute coronary syndrome/STEMI
3. Acute decompensated heart failure/pulmonary edema
4. Mild to moderate pain in an adult patient

Contraindications:

1. Known hypersensitivity
2. Environmental hyperthermia
3. Peptic ulcer disease (relative for cardiac indications)
4. Pediatric or adolescent patient

Precautions:

1. ASA is contraindicated in pediatric or adolescents due to concern for Reye's syndrome (Reye's syndrome is characterized by CNS damage, liver injury, and hypoglycemia).

Significant adverse/side effects:

1. Gastritis
2. Nausea
3. Vomiting
4. Upper GI bleeding
5. Increased bleeding

Dosage per protocol(s):

2.07 Patient Comfort - Adult
3.01 Acute Decompensated Heart Failure - Pulmonary Edema
3.02 Chest Pain - Acute Coronary Syndrome - STEMI

Atropine Sulfate

Classification: Anticholinergic (more specifically, antimuscarinic)

General:

Atropine sulfate competitively antagonizes acetylcholine (Ach) at muscarinic cholinergic receptors found predominantly in the heart, lungs, GI tract, GU tract, and glands. Atropine sulfate does not antagonize Ach at nicotinic cholinergic receptors (nicotinic receptors are cholinergic receptors found at the neuromuscular junction). Ach is constantly released from parasympathetic nerve endings and stimulates muscarinic receptors. In the heart (SA/AV nodes) stimulation of muscarinic receptors by Ach decreases heart rate and conduction velocity. Atropine sulfate increases heart rate and conduction velocity by removing the influence of Ach. As noted above, muscarinic receptors are located in other areas of the body and are affected by the antagonism of Ach. In the respiratory tract, antagonism of Ach results in decreased airway secretions and bronchodilation (this is the mechanism of action of ipratropium bromide). This includes the effect of decreased salivation (antisialagogue effect) and this is why atropine is sometimes administered to manage increased salivation associated with ketamine administration. In the GI tract it decreases secretions and motility. Ocular effects include mydriasis (pupillary dilation), unresponsiveness to light, and cycloplegia (inability to focus for near vision). In the genitourinary tract, it results in decreased bladder motility and urinary retention. While not an actual antidote for organophosphate toxicity, atropine is used in its management by antagonizing the action of acetylcholine at muscarinic receptors. Organophosphates inhibit acetylcholinesterase (the enzyme responsible for the breakdown of Ach) resulting in increased levels of Ach at the muscarinic receptor sites.

Protocol Indication(s):

1. Bradycardia associated with inadequate perfusion
2. Organophosphate/nerve agent toxicity
3. Hypersalivation associated with ketamine administration

Contraindications:

1. Known hypersensitivity
2. Glaucoma (relative contraindication to atropine administration in the setting of life threatening bradycardia)

Precautions:

1. Atropine should be used cautiously in the presence of myocardial ischemia and hypoxia since it increases oxygen demand of heart and can worsen ischemia.

Precautions:

2. Atropine administration should not delay implementation of external pacing for patients with poor perfusion.
3. Atropine sulfate may not be effective for infranodal (type II) AV block and new third-degree block with wide QRS complexes where the location of block is likely to be in non-nodal tissue (bundle of His or more distal conduction system).
4. Transplanted (donor) hearts are denervated and are not responsive to atropine.

Significant adverse/side effects:

1. Tachycardia (may worsen myocardial ischemia)
2. Blurred vision (high doses)
3. Urinary retention
4. Dry skin
5. Confusion (high doses)
6. Acute angle closure glaucoma

Dosage per protocol(s):

2.25	Excited Delirium
3.05	Bradycardia - Adult
3.05	Bradycardia - Pediatric
4.10	Organophosphate or Nerve Agent Toxicity

Calcium Chloride

Classification: Electrolyte

General:

Calcium is a positively charged ion involved in multiple physiologic functions. Calcium is required for muscle contraction, nerve impulse transmission, hormone secretion, blood coagulation, cell division, cell motility and wound healing. In vascular smooth muscle, calcium is involved in the maintenance of vascular tone. Calcium is also required for cardiac muscle contraction. The entry of calcium into cardiac cells during depolarization triggers additional intracellular calcium release from the sarcoplasmic reticulum, leading to myocardial contraction. The cardiac pacemaker cells of the SA and AV nodes depend on an inward calcium current for depolarization. Calcium antagonizes the effects of both potassium and magnesium at the cell membrane. Calcium chloride contains three times more elemental calcium than calcium gluconate (1 gm of calcium chloride is equivalent to 3 gm of calcium gluconate).

Protocol Indication(s):

1. Hyperkalemia
2. Hydrofluoric acid (HF) exposure
3. Calcium channel blocker toxicity
4. Beta blocker toxicity
5. Muscle spasm following marine envenomation
6. Pretreatment prior to the administration of a calcium channel blockers in a patient with a tenuous blood pressure

Contraindications:

1. Known hypersensitivity
2. Digitalis toxicity

Precautions:

1. Administer slowly if not in cardiac arrest.

Significant adverse/side effects:

1. Bradycardia
2. Ventricular fibrillation
3. Extravasation necrosis
4. Abdominal pain
5. Nausea/vomiting

Dosage per protocol(s):

3.06	Narrow Complex Tachycardia
4.18	Toxicological Emergencies - Adult
4.18	Toxicological Emergencies - Pediatric
4.09	Crush Injury
2.11	Dialysis Emergencies and Renal Failure
4.08	Chemical and Electrical Burn Injury
4.16	Marine Envenomation

Notes:

- Calcium was routinely administered in cardiac arrest (asystole, PEA). It is now known that calcium is a prime mediator in ischemic neuronal damage and should be reserved for cardiac arrest related to hyperkalemia, calcium channel or beta blocker overdose.
- Fluoride ions bind calcium and magnesium and may result in hypocalcemia following exposure to HF.
- In hyperkalemia, calcium antagonizes cardiac membrane excitability. It has no effect on the serum potassium level. The effect of cardiac membrane stabilization is temporary (20-40 min) and some patients may require a repeat dose.
- Calcium chloride and calcium gluconate are two commonly used parenteral formations of calcium. In the EMS setting, the two preparation may be used interchangeably, but it should be noted that calcium chloride contains three time more elemental calcium than does calcium gluconate (1 gm of calcium chloride is equivalent to 3 gm of calcium gluconate).
- Calcium chloride has greater bioavailability, but is more likely to cause tissue damage if extravasation occurs.
- Sodium bicarbonate and calcium preparations are not compatible and should be given through separate IV lines if possible. If they must be administered via the same IV line, the line should be flushed in between the administration of each.
- Calcium channel blockers of the dihydropyridine class [nifedipine, nicardipine] reduce vascular tone by blocking calcium entry through voltage gated channels.

Calcium Gluconate

Classification: Electrolyte

General:

Calcium is a positively charged ion involved in multiple physiologic functions. Calcium is required for muscle contraction, nerve impulse transmission, hormone secretion, blood coagulation, cell division, cell motility and wound healing. In vascular smooth muscle, calcium is involved in the maintenance of vascular tone. Calcium is also required for cardiac muscle contraction. The entry of calcium into cardiac cells during depolarization triggers additional intracellular calcium release from the sarcoplasmic reticulum, leading to myocardial contraction. The cardiac pacemaker cells of the SA and AV nodes depend on an inward calcium current for depolarization. Calcium antagonizes the effects of both potassium and magnesium at the cell membrane. Calcium chloride contains three times more elemental calcium than calcium gluconate (1 gm of calcium chloride is equivalent to 3 gm of calcium gluconate).

Protocol Indication(s):

1. Hyperkalemia
2. Hydrofluoric acid (HF) exposure
3. Calcium channel blocker toxicity
4. Beta blocker toxicity
5. Muscle spasm following marine envenomation.
6. Pretreatment prior to the administration of a calcium channel blockers in a patient with a tenuous blood pressure

Contraindications:

1. Known hypersensitivity
2. Digitalis toxicity

Precautions:

1. Administer slowly if not in cardiac arrest.

Significant adverse/side effects:

1. Bradycardia
2. Ventricular fibrillation
3. Extravasation necrosis
4. Abdominal pain
5. Nausea/vomiting

Dosage per protocol(s):

3.06	Narrow Complex Tachycardia
4.18	Toxicological Emergencies - Adult
4.18	Toxicological Emergencies - Pediatric
4.09	Crush Injury
2.11	Dialysis Emergencies and Renal Failure
4.08	Chemical and Electrical Burn Injury
4.16	Marine Envenomation

Notes:

- Calcium was routinely administered in cardiac arrest (asystole, PEA). It is now known that calcium is a prime mediator in ischemic neuronal damage and should be reserved for cardiac arrest related to hyperkalemia, calcium channel or beta blocker overdose.
- Fluoride ions bind calcium and magnesium and may result in hypocalcemia following exposure to HF.
- In hyperkalemia, calcium antagonizes cardiac membrane excitability. It has no effect on the serum potassium level. The effect of cardiac membrane stabilization is temporary (20-40 min), some patients may require a repeat dose.
- Calcium chloride and calcium gluconate are two commonly used parenteral formations of calcium. In the EMS setting, the two preparation may be used interchangeably, but it should be noted that calcium chloride contains three time more elemental calcium than does calcium gluconate (1gm of calcium chloride is equivalent to 3gm of calcium gluconate).
- Sodium bicarbonate and calcium preparations are not compatible and should be given through separate IV lines if possible. If they must be administered via the same IV line, the line should be flushed in between the administration of each.
- Calcium channel blockers of the dihydropyridine class [nifedipine, nicardipine] reduce vascular tone by blocking calcium entry through voltage gated channels.

Cefazolin (Ancef)

Classification: Cephalosporin antibiotic

General:

Cefazolin is a first generation cephalosporin antibiotic. It inhibits cell wall synthesis. First generation cephalosporins are most active against aerobic gram-positive cocci and are often used for skin infections caused by *S. aureus* and *Streptococcus*. Cephalosporins also have activity against E. coli and some activity against *H. influezae* and *Klebsiella* species, but because of limited gram negative coverage, they are not first line agents for infections that are likely to be caused by gram negative bacteria.

Protocol Indication(s):

1. Open fractures
2. Amputations
3. Grossly contaminated soft tissue wounds

Contraindications:

1. History of allergy to any cephalosporin class antibiotic
2. Penicillin allergy

Precautions:

1. There is believed to be some cross-allergy between penicillin and cephalosporin antibiotics. Providers should inquire to determine if there is a history of allergy to penicillin or cephalosporin antibiotics prior to administering cefazolin, however the inability to determine such should not preclude the administration of cefazolin.

Significant adverse/side effects:

1. Pain, swelling, rash at the injection site

Dosage per protocol(s): 4.05 Extremity Trauma and Musculoskeletal Trauma

Dexamethasone

Classification: Steroid (glucocorticoid)

General:

Dexamethasone is a glucocorticoid steroid. Glucocorticoid receptors are found in virtually every cell in the body and exert a powerful physiologic effect on every body system. Glucocorticoids stimulate the formation of glucose (gluconeogenesis) and cause the breakdown of protein into amino acids (catabolism). Because dexamethasone inhibits the inflammatory and immunologic response, it is useful in the management of allergic and anaphylactic reactions and in the management of disease processes that involve airway inflammation or edema (i.e. reactive airway disease, asthma). In reversing asthmatic obstruction, glucocorticoids probably have multiple actions including the reduction of inflammatory mucosal edema, bronchial smooth muscle reaction, bronchial vasoconstriction, and decreasing capillary permeability. They may also restore the responsiveness of asthmatic patients to beta agonist. Dexamethasone tends to be the preferred agent for reducing cerebral edema associated with tumors and is used in the management of high altitude cerebral edema (HACE). Dexamethasone has an elimination half-life of 3.5-5 hours and a duration of action of 36-54 hours**.** Dexamethasone may also be used for replacement therapy in patients with adrenal insufficiency.

Protocol Indication(s):

1. Adrenal insufficiency
2. Laryngotracheal bronchitis (croup)

Contraindications:

1. Known hypersensitivity to any steroid
2. Systemic fungal infections

Precautions:

None

Significant adverse/side effects:

1. Hyperglycemia
2. Immunosuppression
3. Nausea/vomiting
4. Edema

Dosage per protocol(s): 2.03 Adrenal Insufficiency
2.08 Respiratory Distress (Asthma/RAD/Croup) - Pediatric

Dextrose (D5W, D10%, D25%, D50%)

Classification: Carbohydrate

General:

For the purposes of this discussion, the terms glucose and dextrose are interchangeable. Glucose is the primary carbohydrate used by cells for the production of adenosine triphosphate (ATP), the main source of energy in the body. Glucose is taken into cells by glucose-transporter proteins. These proteins are activated or stimulated by insulin, which is released by pancreatic beta cells. While insulin stimulates the rapid uptake of glucose by all tissues, it is not required for uptake by the brain and some other tissues. Once in the cell, through the process of glycolysis, glucose is converted to pyruvate, giving off a small amount of chemical energy (ATP). Pyruvate is then converted to Acetyl CoA. Through the citric acid cycle (Krebs cycle), Acetyl CoA is processed in the mitochondria to produce energy precursors. Then through oxidative phosphorylation of ADP, ATP is produced. In states of low blood glucose or when glucose is unable to enter the cell, ATP production is decreased, leading to enzymatic and organ dysfunction. Glucose is rapidly absorbed after IV administration, with a clinical response observable within minutes. Distribution is widespread, and it reaches the CNS very quickly. The brain is one of the organs most sensitive to hypoglycemia, but it is unable to store glucose, making it susceptible to hypoglycemia. Dextrose is administered to treat known or suspected hypoglycemia from a variety of causes. Dextrose 5% and water (D5W) is sometimes used as a diluent for IV admixtures and is sometimes used as a primary IV fluid for "keep vein open" purposes. Dextrose is also combined with sodium chloride (D5NS, D5½NS) or Lactated Ringers Solution (D5LR) to alter the osmolality of the solution or to add nutrient value. In some cases (e.g. TPN, insulin therapy for hyperkalemia or calcium-channel blocker toxicity) dextrose may be administered to prevent development of hypoglycemia. Due to the dangers of hyperglycemia in patients with acute cerebral pathology (traumatic brain injury, stroke, and post cardiac arrest), confirmation of hypoglycemia is preferred before the administration of dextrose. However, in the event that the ability to measure the plasma glucose is not available and there is a high index of suspicion for hypoglycemia, dextrose should be administered.

Protocol Indication(s):

1. Hypoglycemia

Contraindications:

1. D5W should be avoided in the setting of increased ICP.

Precautions:

1. IV dextrose preparations for the management of hypoglycemia include D10%, D25%, and D50%. Because higher concentration solutions are hypertonic and their extravasation my lead to tissue injury, D10% is the preferred preparation for the management of hypoglycemia in the field.
2. The patency and function of the IV line should be verified prior to administration. D50% should be administered slow IV push.
3. The blood glucose should be checked following the administration of glucose for the management of hypoglycemia.
4. When glucose is administered to patients with a known or suspected history of alcohol abuse or malnutrition, thiamine should also be administered (see thiamine for more information).
5. Only D10% should be utilized in neonates.

Significant adverse/side effects:

1. Local skin irritation
2. Thrombophlebitis
3. Extravasation with subsequent tissue necrosis
4. Hyperglycemia
5. Osmotic diuresis

Dosage per protocol(s): 2.10 Diabetic Emergencies - Adult
2.10 Diabetic Emergencies - Pediatric

Notes:

1. One study found that the administration of 25 gm (50 ml of D50%) raised the blood glucose by an average of 166 mg/dl, but the response was variable among patients from an increase of 37 mg/dl to 370 mg/dl.
2. Another study comparing the administration of D10% or D50% to patients with hypoglycemia and altered mental status, both groups had a median recovery time of 8 minutes. Patients who were treated with D10% received 15 gm less glucose and where less likely to have high glucose levels after treatment. Patients who were treated with D50% group were more likely to have hyperglycemia and difficulty in bringing their blood glucose levels back into a normal range.

Diazepam (Valium)

Classification: Benzodiazepine

General:

Diazepam binds to the gamma-aminobutryic acid receptor complex A (GABA-A), increasing the affinity of the receptor for GABA, enhancing the effects of GABA. GABA is the primary inhibitory neurotransmitter in the CNS which counterbalances the action of the excitatory neurotransmitter glutamate. Enhancing the effects of GABA results in anxiolysis, sedation, amnesia, increased seizure threshold and muscle relaxation. Like other benzodiazepines, the effects of diazepam are dose dependent (e.g. anxiolysis occurs at doses that do not result in sedation). Diazepam can be administered via the oral, IV/IO and rectal routes (the IV preparation may be used "as is" for rectal administration). Due to slow and erratic abortion following IM administration, diazepam should not be administered via the IM route if possible. Following IV administration, the onset of action is 1-5 minutes with a duration of action of 30-60 minutes. Compared to other benzodiazepines, diazepam has the strongest muscle relaxant effects.

Protocol Indication(s):

1. Seizures
2. Sedation

Contraindications:

1. Known hypersensitivity
2. Hypotension (SBP <100 mmHg)
3. Acute angle glaucoma (relative)
4. Pregnancy (relative for active seizures, all benzodiazepines are pregnancy safety category D)

Precautions:

1. Diazepam can cause respiratory depression, particularly when it is administered with opioids or to patients at extremes of age or those with respiratory conditions. Dosing should be reduced in these patients.
2. When administered to a non-intubated patient, close monitoring of the airway and ventilation is necessary (the use of waveform capnography is highly recommended).

Precautions:

3. Hypotension is less of a concern than respiratory depression, but may occur if it is administered quickly, to volume depleted patients, or to patients with hemodynamic instability.
4. Diazepam tends to precipitate when mixed and should be given undiluted
5. Diazepam should be administered into as large a vein as available (in order to reduce risks of thrombosis).
6. Do not administer diazepam emulsified injection through filters with pore size <5 microns.

Significant adverse/side effects:

1. Respiratory depression
2. Hypotension
3. Confusion

Dosage per protocol(s):

2.07 Patient Comfort - Adult
2.19 Seizures - Adult
2.19 Seizures - Pediatric
3.06 Narrow Complex Tachycardia - Adult
3.07 Wide Complex Tachycardia - Adult

Diltiazem (Cardizem)

Classification: Calcium channel blocker (non-dihydropyridine)

General:

Diltiazem antagonizes the influx of calcium through L-type voltage gated calcium channels in cardiac and vascular smooth muscle cells. In cardiac pacemaker cells, it also delays the recovery of calcium channels to their preactivated state. Diltiazem decreases myocardial contractility, reduces the rate of SA node firing, and decreases AV conduction. Diltiazem is used for the control of rapid, narrow-complex ventricular response rate in the presence of atrial tachyarrhythmias (e.g. atrial fibrillation, atrial flutter). In the setting of PSVT, diltiazem administration may be associated with reversion to normal sinus rhythm. Non-acutely (i.e. not in the EMS or ED setting), diltiazem may be used in the management of angina (especially when due to coronary vasospasm) and hypertension. It is metabolized by the liver primarily and excreted by the kidneys. The onset of action is 2-5 minutes.

Protocol Indication(s):

1. Narrow complex tachycardia
2. Atrial fibrillation with rapid ventricular response

Contraindications:

1. Know hypersensitivity
2. Pregnancy
3. AV block >1 degree in the absence of a pacemaker
3. Sick sinus syndrome in the absence of a pacemaker
4. Hypotension (SBP <100 mmHg)
5. Evidence of heart failure/pulmonary edema/cardiogenic shock
6. Wolff-Parkinson-White syndrome or short PR syndrome
7. Ventricular tachycardia

Precautions:

1. Administration in combination with other nodal agents (e.g. beta antagonist) may result in increased effect and unintended consequences (e.g. increased block).
2. Sustained hypotension after administration may be treated with IV fluid (unless there is evidence of heart failure/pulmonary edema) and some patients may respond to the administration of calcium.
3. Diltiazem is incompatible with furosemide, flush IV tubing well before administering diltiazem in the same IV line.

Significant adverse/side effects:

1. Hypotension
2. Bradycardia
3. AV block
4. Peripheral edema
5. Itching/burning at injection site

Dosage per protocol(s): 3.06 Narrow Complex Tachycardia - Adult

Diphenhydramine (Benadryl)

Classification: Antihistamine (H_1)

General:

Diphenhydramine is a histamine 1 (H_1) receptor antagonist used in the management of allergic reactions and anaphylaxis. Histamine is a chemical messenger that modulates a multitude of cellular responses, including allergic and inflammatory reactions, gastric acid secretion, and possibly neurotransmission in parts of the brain. Histamine is located in most tissues in the human body, with high amounts found in the lung, skin, and gastrointestinal tract. Histamine is found in high concentrations in mast cells and basophils. During allergic reactions, histamine is released and exerts its effects by binding to histamine receptors (H_1 and H_2) located on cellular surfaces (H_3 receptors are found in the nervous system and not relevant to discussion related to allergic and anaphylactic reactions). Histamine receptors exert their effects by distinctly different second messenger pathways. Some of the effects of histamine are mediated by stimulation of one or both receptors. H_1 receptors mediate increased mucous production, bronchoconstriction, constriction of intestinal smooth muscle (cramping, diarrhea), and pruritus. H_1 and H_2 receptors mediate vasodilation resulting in decreased peripheral vascular resistance and hypotension. Both also mediate increased capillary permeability and dilation resulting in urticaria (hives). Diphenhydramine reverses histamine induced bronchoconstriction, vasodilation, and capillary permeability. Diphenhydramine has antiemetic properties and is also useful in the prevention of motion sickness. It is also effective in preventing or diminishing nausea and vomiting mediated by the vestibular pathway (vertigo). Diphenhydramine exerts some anticholinergic properties and may be used for the management of dystonic reactions. Diphenhydramine has sodium channel blocking properties and is sometimes used as local anesthetic.

Protocol Indication(s):

1. Allergic or anaphylactic reaction
2. Dystonic reaction

Contraindications:

1. Known hypersensitivity
2. Narrow angle glaucoma
3. Prostatic hypertrophy or bladder neck obstruction (relative)

Precautions:

1. The drug of choice for <u>anaphylaxis</u> is epinephrine, not diphenhydramine.

Significant adverse/side effects:

1. Sedation
2. Hypotension (rare)
3. May cause paradoxical excitation in young children

Dosage per protocol(s):

2.04	Allergic Reaction - Anaphylaxis - Adult
2.04	Allergic Reaction - Anaphylaxis - Pediatric
4.18	Toxicological Emergencies - Adult
4.18	Toxicological Emergencies - Pediatric

Dopamine Hydrochloride

Classification: Mixed adrenergic receptor agonist (α1, β1, β2, D_1)

General:

Dopamine is the immediate precursor of norepinephrine. It demonstrates mixed adrenergic receptor agonistic effects with a dose dependent receptor response. At low doses (<5 mcg/kg/min), dopamine stimulates dopamine D_1 receptors resulting in increased splanchnic blood flow and renal vasodilation. At intermediate doses (5-10 mcg/kg/min), dopamine stimulates β1 receptors resulting in increased heart rate and contractility. In this dosage range it also has very minimal stimulating effects on vascular β2 receptors, but hypotension secondary to vasodilation is uncommon. At high doses (>15 mcg/kg/min), dopamine stimulates α1 receptors resulting in vasoconstriction. At doses above 20 mcg/kg/min, the α1 response predominates. Dopamine is used primarily for its effect on β1 and α1 receptors. Dopamine increases blood pressure through increases in both myocardial contractility (β1 effect) and vasoconstriction (α1 effect). Because at low "dopaminergic" doses, dopamine may facilitate urine output and natriuresis, it was used in the management of acute kidney injury (AKI). However, the overall benefit of this effect in renal protection is not established and this practice is not recommended. Dopamine was considered the first line vasoactive drug in the management of septic shock, however it has been replaced by norepinephrine for this purpose.

Protocol Indication(s):

1. Cardiogenic shock
2. Bradycardia

Contraindications:

1. Known hypersensitivity
2. Sulfite allergy
3. Pheochromocytoma

Precautions:

1. The dosage should be reduced in patients taking monoamine oxidase inhibitors (MOAIs).
2. The cardiac effects of dopamine are antagonized by beta blocking agents.
3. Dopamine is inactivated by alkaline solutions.
4. Vasopressors are only to be utilized in hemorrhagic shock as a bridge to blood products and/or surgical intervention and only after fluid resuscitation as appropriate for the etiology.

Significant adverse/side effects:

1. Tachycardia
2. Arrhythmias
3. Tissue necrosis secondary to extravasation
4. Mesenteric or peripheral ischemia at high doses

Dosage per protocol(s):

2.20	General Shock and Hypotension - Adult
2.20	General Shock and Hypotension - Pediatric
2.22	Septic Shock - Adult
3.05	Bradycardia - Adult
3.05	Bradycardia - Pediatric
4.18	Toxicological Emergencies - Adult
4.18	Toxicological Emergencies - Pediatric

Droperidol (Inapsine)

Classification: Antipsychotic

General:

Haloperidol is a typical antipsychotic agent which blocks dopamine (D_2), muscarinic cholinergic, alpha adrenergic, and histamine (H_1) receptors. Haloperidol's antipsychotic effects are thought to be a result of its selective blockade of postsynaptic dopamine receptors. Haloperidol reduces the hallucinations and agitation associated with schizophrenia. Droperidol can cause extrapyramidal side effects, including dystonia (continuous spasms and contraction of muscle groups, often of the neck) Parkinsonism (rigidity, tremor, and shuffling gait), akathisia (motor restlessness), and tardive dyskinesia (stereotyped involuntary movements, such as lip smacking, jaw movements, darting of the tongue, or purposeless movement of the limbs). Dystonic reactions may be managed with diphenhydramine. A rare, potentially life threatening neurologic side effect associated with antipsychotics is neuroleptic malignant syndrome (NMS). NMS resembles a very severe form of Parkinsonism, with catatonia, fever, autonomic instability, and altered mental status. NMS is has occurred with all antipsychotics and is more commonly seen when higher doses of the more potent agents are used. Droperidol also has a central antiemetic action and is utilized as an antiemetic in adults using doses as low as 0.625 mg. In the ED, droperidol is also used in the management headache and as an adjunct to analgesia. In 2001 the US Food and Drug Administration issued a black box warning for droperidol over concerns of QT prolongation and the potential for torsades de pointes. The FDA recommended continuous ECG monitoring for patients receiving droperidol and withholding droperidol if the QTI was prolonged (>440 ms in males, >450 ms in females). In 2013 the American Academy of Emergency Physicians (AAEM) conducted a review of the safety of droperidol and issued a clinical practice statement. The AAEM concluded that the black box warning was not supported by the literature for doses <2.5 mg and recommends against ECG monitoring for doses <2.5 mg and that IM doses up to 10 mg appear to be safe and effective as other medications used for sedation of agitated patients.

Protocol Indication(s):

1. Aggressive or agitated behavior with suspected substance abuse (alcohol).
2. Alternative to haloperidol or ketamine for the management of excited delirium syndrome.

Contraindications:

1. Depressed mental status
2. Parkinson's disease
3. Prolonged QTI (>440 ms in males, >450 ms in females)

Precautions:

1. Elderly patients with dementia related psychosis.
2. Utilize caution if combined with other medications that may prolong the QTI (ondansetron).

Significant adverse/side effects:

1. Extrapyramidal symptoms (dystonia)
2. QT prolongation

Dosage per protocol(s): 2.07 Patient Comfort - Adult
2.09 Behavioral Emergencies
2.13 Excited Delirium

Recommended reading:

American Academy of Emergency Physicians, Clinical Practice Statement, Safety of Droperidol Use in the Emergency Department, 09/07/2013.

Enalalprilat (Vasotec)

Classification: Angiotensin enzyme inhibitor (ACE-I)

General:

Enalalprilat inhibits angiotensin, an enzyme that converts angiotensin I to angiotensin II. Angiotensin II is a potent vasoconstrictor and stimulator of aldosterone secretion. Inhibition of angiotensin II synthesis results in decreased blood circulating levels of this potent vasoconstrictor and decreased secretion of aldosterone, which results in a net water loss (aldosterone promotes water and sodium retention and potassium secretion). The net result is a reduction in afterload, making enalalprilat a useful drug in the management of acute decompensated heart failure with hypertension.

Protocol Indication(s):

1. Acute decompensated heart failure (cardiogenic pulmonary edema) with hypertension (SBP>140mmHg) refractory to nitrates

Contraindications:

1. Known hypersensitivity
2. Hypotension (SBP <100 mmHg)
3. Pregnancy
4. History of ACE-E induced angioedema
5. Hereditary angioedema

Precautions:

1. Excretion may be prolonged in patients with impaired renal function.

Significant adverse/side effects:

1. Hypotension

Dosage per protocol(s): 3.01 Acute Decompensated Heart Failure - Pulmonary Edema

Epinephrine (Adrenaline)

Classification: Endogenous Catecholamine

General:

Epinephrine is the synthetic formulation of the endogenous hormone adrenaline. Adrenaline is synthesized in the adrenal medulla and released, with small quantities of norepinephrine, into the systemic circulation. It is a potent stimulator of both α and β receptors and it affects multiple organs. Its effects are dose dependent and its net effect depends on the dose administered. At low doses, peripheral β2 effects predominate, resulting in vascular smooth muscle relaxation (vasodilation). Stimulation of cardiac β1 receptors results in increased contractility, heart rate, and conduction velocity. As a result, cardiac output and myocardial oxygen demand are increased. Stimulation of bronchial β2 receptors results in bronchial smooth muscle relaxation, reversal of bronchospasm and decreased release of histamine, tryptase, and other mediators of inflammation from mast cells and basophils. Stimulation of α1 receptors results in vasoconstriction and increased afterload. At higher doses, as used in cardiac arrest, α effects (vasoconstriction) predominate. Aerosolized epinephrine may act on subglottic mucosal α receptors to reverse edema in some situations (croup).

Protocol Indication(s):

1. Cardiac arrest
2. Bradycardia
3. Anaphylaxis (drug of choice)
4. Asthma
5. Laryngotracheobronchitis (croup)
6. Shock (pediatric)

Contraindications:

1. Known hypersensitivity
2. Age ≥50 years of age (asthma)
3. Pheochromocytoma

Precautions:

1. The use of an auto-injector is strongly recommended for the administration of IM epinephrine at all provider levels if available.

Precautions:

2. In the setting of allergic reaction/anaphylaxis, patients ≥50 years of age, with a history of cardiac disease, or a heart rate >150 are at risk for cardiac ischemia following the administration of epinephrine (these patients should have ongoing cardiac monitoring and a multi-lead ECG following the administration of epinephrine).
3. In the setting of asthma and allergic reactions of mild or moderate severity and no respiratory symptoms (wheezing, dyspnea, hypoxia), epinephrine administration should be avoided in patients ≥50 years of age due to the risk for adverse cardiovascular events. Epinephrine should never be withheld in cases of allergic reaction/anaphylaxis with severe symptoms.
4. Use of nebulized epinephrine for croup should be limited to those patients with significant respiratory distress or stridor at rest.
5. In shock situations, assessment of volume status and volume administration should precede epinephrine administration.

Significant adverse/side effects:

1. Tachycardia and arrhythmias
2. Myocardial ischemia/infarction
3. Hypertension
4. Tremor
5. Anxiety
6. Headache
7. Nausea/vomiting

Dosage per protocol(s):

2.04	Allergic Reaction - Anaphylaxis - Adult
2.04	Allergic Reaction - Anaphylaxis - Pediatric
2.08	Respiratory Distress (Asthma-RAD-COPD) - Adult
2.08	Respiratory Distress (Asthma-RAD-Croup) - Pediatric
2.20	General Shock and Hypotension - Pediatric
3.03	Cardiac Arrest - Adult
3.03	Cardiac Arrest - Pediatric
3.05	Bradycardia - Adult
3.05	Bradycardia - Pediatric

Notes:

1. 1:1000 preparation contains 1mg epinephrine per mL of solution (10 mg in 10 mL).
2. 1:10000 preparation contains 0.1mg (100 mcg) epinephrine per mL of solution (1 mg in 10 mL).
3. 1:100000 preparation contains 0.01mg (10 mcg) epinephrine per mL of solution (0.1 mg in 10 mL).

Etomidate (Amidate) RESTRICTED USE MEDICATION

Classification: Sedative-hypnotic

General:

Etomidate is a sedative-hypnotic agent frequently used in rapid sequence intubation (RSI)/medication assisted intubation (MAI). The exact mechanism of action is unknown, but it is believed that etomidate enhances the effect of gamma-aminobutryic acid (GABA) at the GABA receptor complex. GABA is the primary inhibitory neurotransmitter in the CNS which counterbalances the action of the excitatory neurotransmitter glutamate. Enhancing the effects of GABA results sedation. It has an onset of action of 15-45 seconds and a duration of action of 3-12 minutes. When used within the recommended dosage range, etomidate has minimal effect on hemodynamics. It decreases intracranial pressure by decreasing cerebral blood flow and cerebral metabolic demand ($CMRO_2$). Etomidate has no analgesic properties. The administration of etomidate may result in adrenal suppression. While this is only likely to be of significance when it is administered by infusion over a period of time, this effect is seen following single bolus of the drug. There has been considerable discussion in the medical literature regarding etomidate related adrenal suppression and the safety of etomidate in the setting of sepsis. To date there have been no randomized controlled studies examining outcomes following the administration of etomidate as a single bolus for RSI/MAI in the setting of sepsis. Due to its rapid onset of action and hemodynamic profile, etomidate has become the induction agent of choice for most situations requiring RSI/MAI.

Protocol Indication(s):

1. Induction agent for RSI/MAI

Contraindications:

None

Precautions:

1. Use of etomidate is restricted to paramedics participating in a CEMS approved medication assisted intubation program.
2. Dose should be adjusted in patients with hemodynamic instability.

Significant adverse/side effects:

1. Pain on injection (secondary to propylene glycol diluent, may be reduced by administering through a rapidly flowing IV placed in a large vein).

Significant adverse/side effects:

2. Myoclonus (not of clinical significance), can be reduced or mitigated by the co-administration of an opioid or benzodiazepine.

Dosage per protocol(s): 5.04 Rapid Sequence Intubation/Medication Assisted Intubation

Famotidine (Pepcid)

Classification: Antihistamine (H_2)

General:

Famotidine is a H_2 antagonist useful in the management of allergic and anaphylactic reactions. Histamine is a chemical messenger that modulates a multitude of cellular responses, including allergic and inflammatory reactions, gastric acid secretion, and possibly neurotransmission in parts of the brain. Histamine is located in most tissues in the human body, with high amounts found in the lung, skin, and gastrointestinal tract. Histamine is found in high concentrations in mast cells and basophils. During allergic reactions, histamine is released and exerts its effects by binding to H_1 and H_2 receptors located on cellular surfaces (H_3 receptors are found in the nervous system and not relevant to discussion related to allergic and anaphylactic reactions). Histamine receptors exert their effects by distinctly different second messenger pathways. Some of the effects of histamine are mediated by stimulation of one or both receptors. H_1 receptors mediate increased mucous production, bronchoconstriction, constriction of intestinal smooth muscle (cramping, diarrhea), and pruritus. H_1 and H_2 receptors mediate vasodilation resulting in decreased peripheral vascular resistance and hypotension. Both mediate increased capillary permeability and dilation resulting in urticaria (hives). H_2 receptors mediate gastric acid secretion (hence the use of H_2 antagonist in gastroesophageal reflux disease). Famotidine reverses some of effects that are secondary to stimulation of the H_2 receptors. Additionally, it is believed that famotidine may enhance the effects of H_1 antagonist (diphenhydramine).

Protocol Indication(s):

1. Allergic or anaphylactic reaction

Contraindications:

1. Known hypersensitivity

Precautions:

1. The dosage should be adjusted in the setting of decreased renal function, but this is not an issue when used acutely for allergic or anaphylactic reactions.

Significant adverse/side effects:

None

Dosage per protocol(s): 2.04 Allergic Reaction - Anaphylaxis - Adult
2.04 Allergic Reaction - Anaphylaxis - Pediatric

Fentanyl (Sublimaze)

Classification: Synthetic opioid

General:

Fentanyl is a synthetic opioid with a potency 100 times greater than that of morphine sulfate. Fentanyl provides analgesia by primarily stimulating mu (μ) receptors in the central nervous system (CNS). In addition to analgesia, stimulation of μ receptors may also result in respiratory depression, sedation (as a secondary effect), euphoria, decreased gastrointestinal motility and bradycardia. Respiratory depression associated with fentanyl is enhanced when it is co-administered with benzodiazepines or administered to patients who have consumed alcohol. Fentanyl's onset of action is almost immediate and it's analgesic effects last 30-60 minutes. Its ultra-short onset of action and short duration of action make fentanyl an ideal agent for us by EMS as an analgesic. Unlike morphine sulfate, fentanyl does not result in a significant histamine release and therefore is associated with a lesser risk of bronchoconstriction, tachycardia, or hypotension.

Protocol Indication(s):

1. Moderate to severe pain

Contraindications:

1. Known hypersensitivity
2. Hypotension (SBP <100 mmHg)

Precautions:

1. Fentanyl should be administered slowly.
2. Careful monitoring (including the use of waveform capnography) is warranted when co-administering with benzodiazepines or to patients who have consumed alcohol as these patients are at risk for ventilatory depression.

Significant adverse/side effects:

1. Respiratory depression
2. Hypotension
3. Chest rigidity (this is an extremely rare adverse effect associated with the rapid administration of high doses (>5 mcg/kg)

Dosage per protocol(s): 2.07 Patient Comfort - Adult
2.07 Patient Comfort - Pediatric

Notes:

- Fentanyl and morphine sulfate belong two different drug classes (phenylpiperidine and phenanthrene classes respectively). There is no cross reaction between these two classes so fentanyl can be administered to patients with an allergy to morphine sulfate.

Furosemide (Lasix)

Classification: Diuretic

General:

As a loop diuretic, furosemide decreases the reabsorption of sodium, chloride and potassium in the loop of Henle causing the excretion of these electrolytes in the urine. In an effort to maintain osmolarity, water follows sodium and diuresis occurs.

Protocol Indication(s):

1. Acute decompensated heart failure

Contraindications:

1. Hypotension (SBP <100 mmHg)

Precautions:

1. There's minimal or no role for the administration of furosemide early in the management of acute decompensated heart failure (ADHF). The majority of patients with ADHF aren't volume overloaded. Use only
2. The immediate management of the patient with ADHF should focus on the application of CPAP and the administration of nitroglycerin.
3. The administration of furosemide may lead to a decrease in cardiac output in patients with left ventricular failure. This is a result of decreased venous return and increased systemic afterload. Increased systemic afterload may occur due to stimulation of the renin angiotensin system (RAS) resulting in the release of renin, raising circulating levels of angiotensin, a powerful vasoconstrictor.

Significant adverse/side effects:

1. Hypotension
2. Hypovolemia
3. Hypokalemia
4. Hyponatremia
5. Hypochloremia
6. Hypomagasemia
7. Ototoxicity/hearing loss (usually associated with rapid administration or administration with aminoglycoside antibiotics).

Dosage per protocol(s): 3.01 Acute Decompensated Heart Failure

Glucagon

Classification: Hormone

General:

Glucagon is a polypeptide hormone that is produced by the alpha islet cells of the pancreas. It enhances gluconeogenesis (generation of glucose from certain non-carbohydrate carbon substrates) and glycogenolysis (breakdown of glycogen to glucose). The net effect is a transient (short term) increase in the blood glucose level. This effect is dependent on adequate glycogen stores and may be inadequate if glycogen stores are depleted. Because its effect on blood glucose is transient, hypoglycemic patients treated with glucagon must be administered glucose or be feed to prevent recurrent hypoglycemia. Glucagon also relaxes gastrointestinal smooth muscle and is sometimes used in the management of esophageal obstruction and to facilitate radiological examination of the gastrointestinal tract. Glucagon is also used in beta blocker toxicity because it activates adenyl cyclase and exerts inotropic and chronotropic effects via an alternate pathway that bypasses blocked beta receptors. It is also sometimes used in calcium blocker toxicity for its inotropic and chronotropic properties. It should be noted that the use of glucagon in the setting of beta blocker and calcium channel blocker toxicity is based primarily on theoretic evidence and its efficacy for this use has been recently questioned.

Protocol Indication(s):

1. Hypoglycemia
2. Anaphylaxis in patients on beta-blockers
3. Beta blocker toxicity

Contraindications:

1. Known hypersensitivity

Precautions:

None

Significant adverse/side effects:

1. Nausea and vomiting
2. Hypokalemia
3. Hyperglycemia

Dosage per protocol(s):

2.08 Allergic Reaction - Anaphylaxis - Adult
2.08 Allergic Reaction - Anaphylaxis - Pediatric
2.10 Diabetic Emergencies - Adult
2.10 Diabetic Emergencies - Pediatric
4.18 Toxicological Emergencies - Adult
4.18 Toxicological Emergencies - Pediatric

Glucose (oral)

Classification: Carbohydrate

General:

Glucose is the primary carbohydrate used by cells for the production of adenosine triphosphate (ATP), the main source of energy in the body. Glucose is taken into cells by glucose-transporter proteins. These proteins are activated or stimulated by insulin, which is released by pancreatic beta cells. While insulin stimulates the rapid uptake of glucose by all tissues, it is not required for uptake by the brain and some other tissues. Once in the cell, through the process of glycolysis, glucose is converted to pyruvate, giving off a small amount of chemical energy (ATP). Pyruvate is then converted to Acetyl CoA. Through the citric acid cycle (Krebs cycle), Acetyl CoA is processed in the mitochondria to produce energy precursors. Then through oxidative phosphorylation of ADP, ATP is produced. In states of low blood glucose or when glucose is unable to enter the cell, ATP production is decreased, leading to enzymatic and organ dysfunction. The brain is one of the organs most sensitive to hypoglycemia, but it is unable to store glucose, making it susceptible to hypoglycemia. Due to the dangers of hyperglycemia in patients with acute cerebral pathology (traumatic brain injury, stroke, and post cardiac arrest), confirmation of hypoglycemia is preferred before the administration of glucose. However, in the event that the ability to measure the plasma glucose is not available and there is a high index of suspicion for hypoglycemia, glucose should be administered. Oral glucose should only be administered to patients with intact airway protective reflexes (ability to swallow and cough). For patients with a decreased level of consciousness or who are at risk for aspiration, the administration of IV glucose or IM glucagon is indicated.

Protocol Indication(s):

1. Hypoglycemia
2. Beta antagonist toxicity

Contraindications:

1. Loss of airway protective reflexes or other risk for aspiration.
2. Patient <2 years of age.

Precautions:

1. The blood glucose should be checked following the administration of glucose for the management of hypoglycemia.

Significant adverse/side effects:

1. Aspiration
2. Vomiting

Dosage per protocol(s): 2.10 Diabetic Emergencies - Adult
2.10 Diabetic Emergencies - Pediatric

Haloperidol (Haldol)

Classification: Antipsychotic

General:

Haloperidol is a typical antipsychotic agent which blocks dopamine (D_2), muscarinic cholinergic, alpha adrenergic, and histamine (H_1) receptors. Haloperidol's antipsychotic effects are thought to be a result of its selective blockade of postsynaptic dopamine receptors. Haloperidol reduces the hallucinations and agitation associated with schizophrenia. Haloperidol can cause extrapyramidal side effects, including dystonia (continuous spasms and contraction of muscle groups, often of the neck) Parkinsonism (rigidity, tremor, and shuffling gait), akathisia (motor restlessness), and tardive dyskinesia (stereotyped involuntary movements, such as lip smacking, jaw movements, darting of the tongue, or purposeless movement of the limbs). Dystonic reactions may be managed with diphenhydramine. An elevated risk of acute dystonia is observed in males and younger age groups. A rare, potentially life threatening neurologic side effect associated with antipsychotics is neuroleptic malignant syndrome (NMS). NMS resembles a very severe form of Parkinsonism, with catatonia, fever, autonomic instability, and altered mental status. NMS is has occurred with all antipsychotics and is more commonly seen when higher doses of the more potent agents are used. Haloperidol also has antiemetic properties, but is not commonly used as an antiemetic agent. Haloperidol is used to manage aggressive or agitated behavior and is an alternative to ketamine for the management of excited delirium syndrome (ExDS).

Protocol Indication(s):

1. Aggressive or agitated behavior with suspected substance abuse (alcohol)
2. Alternative to ketamine for the management of excited delirium syndrome

Contraindications:

1. Depressed mental status
2. Parkinson's disease
3. Prolonged QTI (>440 ms in males, >450 ms in females)

Precautions:

1. Elderly patients with dementia related psychosis.

Significant adverse/side effects:

1. Extrapyramidal symptoms (dystonia)
2. QT prolongation

Dosage per protocol(s): 2.09 Behavioral Emergencies
2.13 Excited Delirium

Hydrocortisone (Solu-Cortef)

Classification: Steroid (synthetic glucocorticoid)

General:

Hydrocortisone is synthetically produced cortisol, the primary glucocorticoid in humans. Hydrocortisone exerts its effects in a similar fashion to cortisol. Glucocorticoid receptors are found in virtually every cell in the body and exert a powerful physiologic effect on every body system. Glucocorticoids stimulate the formation of glucose (gluconeogenesis) and cause the breakdown of protein into amino acids (catabolism). Because hydrocortisone inhibits the inflammatory and immunologic response, it is useful in the management of allergic and anaphylactic reactions and in the management of disease processes that involve airway inflammation or edema (i.e. reactive airway disease, asthma). In reversing asthmatic obstruction, glucocorticoids probably have multiple actions including the reduction of inflammatory mucosal edema, bronchial smooth muscle reaction, bronchial vasoconstriction, and decreasing capillary permeability. They may also restore the responsiveness of asthmatic patients to beta agonist. Hydrocortisone may be used for replacement therapy in patients with adrenal insufficiency.

Protocol Indication(s):

1. Adrenal insufficiency
2. Asthma
3. COPD exacerbation
4. Allergic and anaphylactic reactions

Contraindications:

1. Known hypersensitivity to any steroid
2. Systemic fungal infections

Precautions:

None

Significant adverse/side effects:

1. Hyperglycemia
2. Immunosuppression
3. Nausea/vomiting
4. Edema

Dosage per protocol(s):

2.03 Adrenal Insufficiency
2.04 Allergic Reaction - Anaphylaxis - Adult
2.04 Allergic Reaction - Anaphylaxis - Pediatric
2.08 Respiratory Distress (Asthma/RAD/COPD) - Adult
2.08 Respiratory Distress (Asthma/RAD/Croup) - Pediatric

Hydroxocobalamin (vitamin B12a)

Classification: Antidote

General:

Hydroxcobalamin is a natural precursor for cyanocobalamin (vitamin B12). Hydroxocobalamin is utilized as an antidote for cyanide toxicity. Cyanide is a cellular asphyxiant which disrupts metabolism dependent on metal-containing enzymes. In particular, it binds to ferric iron present in the cytochrome oxidase system disrupting oxidative phosphorylation (oxidative phosphorylation is the final metabolic pathway of cellular respiration). Cells then shift to anaerobic metabolism which results in the production of lactic acid, which is manifested clinically as metabolic acidosis. Each hydroxocobalamin molecule deactivates one cyanide ion when its hydroxo portion is replaced by the cyanide ion creating cyanocobalamin. Cyanocobalamin is excreted in the urine.

Protocol Indication(s):

1. Known or suspected cyanide toxicity

Contraindications:

1. Known anaphylactic reaction to hydroxocobalamin or cyanocobalamin

Precautions:

1. If other cyanide antidotes are to be administered, they should not be administered concurrently in the same intravenous line.

Significant adverse/side effects:

1. Hypertension
2. Chromaturia (abnormal coloration of the urine)
3. Nausea
4. Headache
5. Erythema
6. Rash

Dosage per protocol(s): 4.18 Toxicological Emergencies - Adult
4.18 Toxicological Emergencies - Pediatric

Ibuprofen (Advil, Motrin)

Classification: Non-steroidal anti-inflammatory

General:

Ibuprofen is a non-steroidal anti-inflammatory agent (NSAID) with analgesic effects, anti-inflammatory, and antipyretic effects. NSAIDs are thought to exert their effects by inhibiting prostaglandin synthesis by inhibiting the cyclooxygenase (COX) enzyme, which catalyzes the conversion of arachidonic acid to prostaglandin and endoperoxide. Prostaglandins are a modulator of inflammation and are also involved in thermoregulation, pain transmission, and platelet aggregation. Ibuprofen should be avoided in patients with chronic kidney disease due to the risk of renal injury. NSAID related renal injury occurs secondary to changes in renal hemodynamics (renal blood flow), which is mediated by prostaglandins, particularly in the presence of circulating vasoconstrictors (angiotensin II). Prostaglandins modulate vasodilation of the afferent arterioles which supply blood to the glomerulus maintaining glomerular perfusion and glomerular filtration. Inhibition of prostaglandins results in unopposed constriction of the afferent arterioles and decreased renal perfusion.

Protocol Indication(s):

1. Mild to moderate pain
2. Fever

Contraindications:

1. Known hypersensitivity
2. Allergy to any NSAID (including aspirin)
3. Asthma
4. Renal insufficiency
5. Peptic ulcer disease or GI bleeding
6. Pregnancy
7. Hypovolemia
8. Trauma other than isolated extremity trauma
9. Anticipated major surgery (within 7 days)

Precautions:

1. Ibuprofen is not indicated for the treatment of abdominal pain.

Significant adverse/side effects:

1. GI bleeding
2. Nausea/vomiting
3. Headache
4. Drowsiness
5. Abdominal pain
6. Dyspepsia
7. Diarrhea

Dosage per protocol(s):

2.07	Patient Comfort - Adult
2.07	Patient Comfort - Pediatric
2.15	Fever - Adult
2.15	Fever - Adult

Intravenous Fat Emulsion (IFE) 20% (Intralipid)

Classification: Soy based long chain fatty acid emulsion

General:

Intravenous fat emulsion (IFE) is a soy based long change fatty acid emulsion used as a component of total parenteral nutrition as a source of fatty acids and calories. Over the last decade, IFE has emerged as a novel antidote for agents that have an affinity for or a tendency to bind with lipids (e.g. lipophilic agents). There are several theories as to the mechanism of action for IFE as an antidote, but the exact mechanism is not completely understood. The most common theory is the known as the "lipid sink" theory. The lipid sink theory postulates that administering IFE creates a "lipid sink" providing an alternative binding site for the lipophilic toxic agent. It is likely that mechanisms other than the "lipid sink" may also contribute to IFE role as an antidote. The first reported use of IFE as an antidote was for local anesthetic toxicity. Since this time, there have been multiple case reports involving the use of IFE to reverse cardiotoxicity and cardiac arrest secondary to multiple lipophilic agents, including beta blockers, calcium channel blockers, tricyclic antidepressants, and selective serotonin uptake inhibitors.

Protocol Indication(s):

1. Profound hemodynamic compromise or cardiac arrest associated with a highly lipophilic agent

Contraindications:

1. Known hypersensitivity to any component of the formulation, or severe egg or legume (soybean) allergies

Precautions:

1. Do not use in infants <30 days.

Significant adverse/side effects:

1. Fat embolism
2. Fat overload syndrome (not of concern in acute setting)
3. Hypertriglyceridemia (longer term use)
4. Acute pancreatitis (longer term use)
5. Cholestasis (longer term use)
6. Increased risk of infection (longer term use)

Dosage per protocol(s): 4.18 Toxicological Emergencies - General - Adult
4.18 Toxicological Emergencies - General - Pediatric

Notes:

- There is currently ongoing research into the use of IFE in the management of refractory ventricular fibrillation.
- The IFE bolus dose (1.5 ml/kg) should be drawn up into a syringe and administered IVP over two minutes. This dose may be repeated twice. An infusion of 15 ml/kg may be started at the time of the first bolus dose and administered over 60 minutes.

Suggested reading:

Bania TC. Antidotes in Depth: Intravenous Fat Emulsions. In: Flomenbaum NE, Goldfrank LR, Hoffman RS et al, eds: Goldfrank's Toxicologic Emergencies. New York NY, 2011; 976-981.

Mirtallo, JM, et al. State of the Art Review: Intravenous Fat Emulsions: Current Applications, Safety Profile, and Clinical Implications. Ann Pharmacother 2010; 44:688- 700.

Cave, G, Harvey, M. Intravenous Lipid Emulsion as Antidote Beyond Local Anesth Toxicity: A Systematic Review. Acad Emerg Med 2009; 16:815-824.

Website: www.lipidrescue.org

Ipratropium Bromide (Atrovent)

Classification: Anticholinergic

General:

Ipratropium bromide is an anticholinergic agent used in the management of bronchospasm. Ipratropium competes with acetylcholine for binding at the cholinergic muscarinic receptors in the lung (M1, M2, M3). Antagonism of the cholinergic muscarinic receptors results in a decrease in the formation of cyclic guanosine monophosphate (cGMP), which leads to decreased contractility of bronchial smooth muscle resulting bronchodilation. When administered via inhalation, the effects of ipratropium are almost exclusively limited to the airway. Inhaled ipratropium has minimal effect on heart rate or intraocular pressure. Ipratropium may be administered by inhalation alone or in combination with albuterol (Combivent).

Protocol Indication(s):

1. Bronchospasm

Contraindications:

1. Known hypersensitivity
2. Benign prostatic hypertrophy (relative)
3. Bladder neck obstruction (relative)

Precautions:

1. Due to the risk of inadvertent topical administration (of the nebulization preparation), ipratropium should be used with caution in patients with narrow-angle glaucoma.
2. Metered-dose-inhaler ipratropium preparations may include allergens contraindicating use in patients with soy or nut allergies.
3. Paradoxical bronchospasm may occur in a small percentage of patients who receive ipratropium. A proposed etiology is attributed to other compounds in the ipratropium preparation. If paradoxical bronchospasm (evidenced by significantly increased and severe bronchospasm following administration) is suspected, discontinue use.

Significant adverse/side effects:

1. Cough
2. Throat irritation
3. Headache

Significant adverse/side effects:

4. Dry mouth
5. Urinary retention

Dosage per protocol(s):

2.04	Allergic Reaction - Anaphylaxis - Adult
2.04	Allergic Reaction - Anaphylaxis - Pediatric
2.08	Respiratory Distress (Asthma/COPD/RAD) - Adult
2.08	Respiratory Distress (Asthma/RAD/Croup) - Pediatric
2.18	Obstetrical Complications
4.09	Crush Injury

Ketamine (Ketalar)

Classification: Dissociative general anesthetic

General:

Ketamine is a dissociative anesthetic agent, structurally similar to phencyclidine (PCP), which interrupts the connection between the cortex and the limbic system. This results in profound sedation in a "dissociative" state of anesthesia. In this state, the patient appears awake, but is unaware of their surroundings. The patient's eyes remain open with corneal and light reflexes maintained and nystagmus may develop. Airway protective reflexes are maintained and unless administered rapidly or in conjunction with opioids, ketamine's effect on ventilation is minimal. Ketamine also stimulates opioid receptors and is thus a unique sedative agent in that it also provides analgesia as well. Ketamine stimulates the sympathetic nervous system and releases catecholamines resulting in augmentation of the blood pressure and heart rate and increased mean arterial pressure (MAP). Ketamine directly and indirectly stimulates pulmonary bronchodilation. The onset of action for IV ketamine is 1-2 minutes and 3-8 minutes for IM administration. As the dose related effect of ketamine transitions from analgesia to anesthesia, nystagmus emerges as a side effect. Nystagmus may be used as an endpoint indicator for ketamine dosing. Ketamine is often the induction agent of choice for rapid sequence intubation of patients with reactive airway disease and in certain shock states.

Protocol Indication(s):

1. Moderate to severe pain
2. Pre-cardioversion sedation when IV access is unavailable
3. Excited delirium
4. Combative behavior unresponsive to other interventions

Contraindications:

1. Cardiac ischemia/infarction or history of coronary artery disease (relative)
2. Penetrating ocular injury
3. Patient ≤ 3 months of age
4. Schizophrenia

Precautions:

1. Intravenous ketamine should be administered over 60 seconds.
2. When not used in conjunction with a neuromuscular blocking agent, the most common respiratory side effect associated with ketamine is laryngeal spasm. It is usually transitory and easily managed with positive pressure ventilation.

Precautions:

3. Excessive salivation may occur in some patients. This can be managed with atropine 0.5 mg IV/IM.
4. Emergence reactions may occur following the administration of ketamine. These reactions occur more commonly in adult patients. Emergence reactions may be treated with low does benzodiazepines.

Significant adverse/side effects:

1. Emergence reaction
2. Tachycardia
3. Hypotension/hypertension
4. Hypersalivation
5. Laryngospasm
6. Increased intraocular pressure
7. Vomiting
8. Transient apnea (if given rapidly via IV route)

Dosage per protocol(s):

2.07	Patient Comfort - Adult
2.07	Patient Comfort - Pediatric
2.13	Excited Delirium
2.09	Behavioral Emergencies

Notes:

- Ketamine is often the induction agent of choice for rapid sequence intubation of patients with reactive airway disease and in certain shock states.
- Ketamine has been used extensively in military tactical combat care and its use in US civilian EMS for analgesia, sedation, and rapid sequence intubation.
- Historically ketamine was avoided in cases of increased intracranial pressure (ICP) due to its potential to increase ICP, however it is now believed that any increase in ICP is offset by an in increase in the MAP resulting in an increase in cerebral perfusion pressure.

Ketorolac tromethamine (Toradol)

Classification: Non-steroidal anti-inflammatory

General:

Ketorolac is a non-steroidal anti-inflammatory agent (NSAID) with potent analgesic effects and moderate anti-inflammatory effects. NSAIDs are thought to exert their effects by inhibiting prostaglandin synthesis by inhibiting the cyclooxygenase (COX) enzyme, which catalyzes the conversion of arachidonic acid to prostaglandin and endoperoxide. Prostaglandins are a modulator of inflammation and are also involved in thermoregulation, pain transmission, and platelet aggregation. Ketorolac also has antipyretic properties, but is not used primarily to treat fever. Ketorolac should be avoided in patients with chronic kidney disease due to the risk of renal injury. NSAID related renal injury occurs secondary to changes in renal hemodynamics (renal blood flow), which is mediated by prostaglandins, particularly in the presence of circulating vasoconstrictors (angiotensin II). Prostaglandins modulate vasodilation of the afferent arterioles which supply blood to the glomerulus maintaining glomerular perfusion and glomerular filtration. Inhibition of prostaglandins results in unopposed constriction of the afferent arterioles and decreased renal perfusion. Ketorolac is frequently used in the management of pain associated with renal colic.

Protocol Indication(s):

1. Mild to moderate pain

Contraindications:

1. Known hypersensitivity
2. Allergy to any NSAID (including aspirin)
3. Asthma
4. Renal insufficiency
5. Peptic ulcer disease or GI bleeding
6. Pregnancy
7. Hypovolemia
8. Trauma other than isolated extremity trauma
9. Anticipated major surgery (within 7 days)

Precautions:

1. Ketorolac is not indicated for the treatment of abdominal or chest pain.
2. The dose of ketorolac should be reduced by 50% in patients >65 yo due to concern for age related reduction of renal function.

Significant adverse/side effects:

1. GI bleeding
2. Nausea/vomiting
3. Headache
4. Drowsiness
5. Abdominal pain
6. Dyspepsia
7. Diarrhea

Dosage per protocol(s): 2.07 Patient Comfort - Adult
2.07 Patient Comfort - Pediatric

Labetalol (Trandate)

Classification: Combined alpha and beta antagonist

General:

Labetalol is a combined alpha and beta antagonist. Labetalol blocks α1, ß1, and ß2 receptors. Labetalol's antagonistic effects are greater on beta receptors than on alpha receptors (1:7 for IV administration). It is rapidly absorbed and widely distributed to relevant target tissues after an IV dose. The onset of action for a given dose occurs within about 5-10 minutes after administration. The half-life of labetalol is about 8 hours. Labetalol is administered by bolus or infusion. The maximum cumulative dose of labetalol is 300 mg.

Protocol Indication(s):

1. Blood pressure reduction in patients with ischemic stroke who are candidates to receive or are receiving tPA.

Contraindications:

1. Known hypersensitivity
2. Heart rate <60
3. AV block >1 degree in the absence of a pacemaker
4. Hypotension (SBP <100 mmHg)
5. Acute decompensated heart failure

Precautions:

1. Patients receiving labetalol for acute BP reduction should have frequent monitoring of their BP (generally every 5-10 minutes in the EMS/transport setting).

Significant adverse/side effects:

1. Hypotension
2. Bradycardia
3. Dizziness

Dosage per protocol(s): 2.13 tPA for Acute Ischemic Stroke

Lactated Ringers Solution

Classification: Crystalloid

General:

Lactated Ringers (LR) is a balanced resuscitation fluid. Balanced resuscitation fluids have an electrolyte composition similar to human blood plasma. In contrast to sodium chloride 0.9% (NaCl 0.9%), LR has less chloride, a small amount of additional electrolytes, and an anion buffer (lactate). LR has a strong ion difference (SID) of +28. The SID is the difference between the concentrations of strong cations and strong anions. While a detailed explanation of the SID is beyond the scope of this guide, it is useful to know that the administration of a resuscitation fluid with a SID less than the serum bicarbonate level (normal range 22–26 mmol/L) will lead to a more acidotic state (↓pH) and the administration of a resuscitation fluid with a SID greater than the serum bicarbonate level leads to a more alkalotic state (↑pH). The table below compares the electrolyte composition and SID of LR and NaCl 0.9% to human blood plasma (concentrations are in mEq/L):

	Sodium (Na^+)	**Chloride (Cl^-)**	**Potassium (K^+)**	**Calcium (Ca^{++})**	**Lactate**	**SID**
Plasma	140	100	4	5	1-2	+40
LR	130	109	4	3	28	+28
NaCl 0.9%	154	154	0	0	0	0

Compared to NaCl 0.9%, LR is more physiologically similar to human plasma. There is some recent data that suggests that outcomes may be worse in patients who receive fluid resuscitation with NaCl 0.9% v. those who receive fluid resuscitation with LR or other buffered resuscitation fluids. Specifically, resuscitation with NaCl 0.9% was associated with an increase in acute kidney injury, hyperchloremic metabolic acidosis, and increased mortality. For this reason, LR was chosen as the fluid of choice for patients requiring large volume fluid resuscitation.

Protocol Indication(s):

1. Dehydration
2. Hypovolemia
3. Shock
4. Burns
5. Ocular irrigation

Contraindications:

1. Profound liver failure (LR may increase the lactate level, but it should be noted that the lactate in LR is in the form of sodium lactate, not lactic acid and it will not make the patient more acidotic)

Precautions:

1. Fluids should be administered judiciously to patients with evidence of or a history of heart failure.
2. Because LR is slightly hypotonic, large volumes may increase intracranial pressure.
3. The calcium in LR can bind to the citrated anticoagulant in blood products and lead to inactivation of anticoagulant and promote the formation of clots in donor blood. For this reason, LR is contraindicated as a diluent for red blood cell transfusions.

Significant adverse/side effects:

1. Fluid overload
2. Metabolic alkalosis
3. Increased intracranial pressure (large volumes, primarily of concern in patients with already increased intracranial pressure).

Dosage per protocol(s):

1.01	Routine Patient Care
2.20	General Shock and Hypotension - Adult
2.20	General Shock and Hypotension - Pediatric
2.21	Hemorrhagic Shock - Adult
2.21	Hemorrhagic Shock - Pediatric
2.22	Septic Shock - Adult
2.22	Septic Shock - Pediatric
3.03	Cardiac Arrest - Adult
3.03	Cardiac Arrest - Pediatric
4.06	Traumatic Cardiac Arrest - Adult
4.06	Traumatic Cardiac Arrest - Pediatric
4.07	Thermal Burns - Adult
4.07	Thermal Burns - Pediatric
4.11	Ocular Trauma and Emergencies
4.22	Radiation Incident
7.44	Ocular Irrigation - Morgan Lens©

Notes:

- Because only 25% of crystalloid fluids remain in the vascular compartment, the infusion of LR should not be expected to have a significant impact on serum lactate levels.
- Contrary to popular belief, LR is safe to use as a resuscitation fluid in the patient with hyperkalemia.

Levalbuterol (Xopenex)

Classification: Beta adrenergic agonist (β2 selective)

General:

Levalbuterol is a β2 selective adrenergic receptor agonist used in the management of bronchospasm. Stimulation of β2 receptors results in an increase in cyclic adenosine monophosphate (cAMP), which leads to the activation of protein kinase A inhibiting phosphorylation of myosin and lowering intracellular ionic calcium concentrations, resulting in relaxation of bronchial smooth muscle (bronchodilation). Increasing cAMP concentrations is also inhibits the release of mediators from mast cells in the airway. As a result of sympathomimetic stimulation, an intracellular shift of potassium may occur. This may result in a small (approximately 0.5 mEq/L) decrease in the serum potassium concentration. This is generally not of clinical concern, unless large doses of beta agonist are being administered. However, this effect may be useful in the management of hyperkalemia. Albuterol is a 50/50 racemic mixture of two isomers. The R- isomer which causes bronchodilation and the S-isomer is devoid of any clinical utility, but is believed to increase airway reactivity and may contribute to paradoxical bronchospasm. Because of its slow metabolism, the S-isomer exists in higher and prolonged plasma concentrations. Some clinical trials comparing racemic albuterol and levalbuterol in patients with asthma have demonstrated lower mean heart rates in patients using levalbuterol, while other trials demonstrated no difference in heart rate. Levalbuterol may be considered in patients with a history of arrhythmias, structural heart disease, or cardiac conditions that could worsen with an episode of tachycardia (e.g., decompensated heart failure).

Protocol Indication(s):

1. Bronchospasm associated with asthma or COPD

Contraindications:

1. Known hypersensitivity to levalbuterol or albuterol

Precautions:

1. Use with caution in patients with coronary artery disease.
2. Administered with to patients being treated with monoamine oxidase inhibitors or tricyclic antidepressants, or within 2 weeks of discontinuation of such agents, because the cardiovascular effects of levalbuterol may be potentiated.

Significant adverse/side effects:

1. Tachycardia
2. Palpitations
3. Nervousness, tremor, anxiety
4. Headache
5. Nausea
6. Hypokalemia

Dosage per protocol(s): 2.08 Respiratory Distress (asthma, COPD, RAD) - Adult

Lidocaine (Xylocaine)

Classification: Antiarrhythmic

General:

Lidocaine is a class IB antiarrhythmic that suppresses ventricular arrhythmias. Lidocaine acts selectively on diseased or ischemic non-nodal tissue, where it blocks sodium entry into sodium fast channels, resulting in a decrease in the rate and magnitude of depolarization. Conduction velocity is decreased and arrhythmias originating from a reentrant mechanism may be interrupted. Lidocaine reduces automaticity by decreasing the slope of phase 4 depolarization. It also decreases the effective refractory period (ERP). It has no direct effect on nodal tissue via sodium channel blockade and has no effect on QRS duration at non-toxic levels and has limited effects on the action potential duration (APD) and the QT interval. Lidocaine is not useful in the management of atrial arrhythmias. Lidocaine may be useful in the management of arrhythmias associated with digitalis toxicity. The plasma half-life (t½) is short (approximately 20 minutes). It is metabolized by the liver and its t½ may be prolonged when hepatic function or blood flow is decreased (states of decreased cardiac output, congestive heart failure, liver disease). Lidocaine also has local anesthetic properties and for this purpose, it may be administered by topical administration, infiltration, or inhalation.

Protocol Indication(s):

1. Ventricular tachycardia
2. Ventricular fibrillation

Contraindications:

1. Known hypersensitivity or allergy to any local anesthetic in the amide class
2. AV block > 1st degree in the absence of a pacemaker
3. Idioventricular escape rhythm in the absence of a pacemaker
4. Stokes-Adams syndrome
5. Wolff-Parkinson-White (WPW) syndrome

Precautions:

1. Plasma half-life may be prolonged in the setting of congestive heart failure, advanced age, liver disease or any condition resulting in decreased hepatic blood flow. The maintenance infusion should be reduced in patients >70 yo, congestive heart failure, or hepatic failure.
2. Lidocaine should not be administered in the setting of an idioventricular escape rhythm in the absence of a pacemaker.

Significant adverse/side effects:

1. Drowsiness
2. Paresthesia
3. Slurred speech
4. Nystagmus (early sign of toxicity)
5. Seizures (severe toxicity)

Dosage per protocol(s):

3.03	Cardiac Arrest - Adult
3.03	Cardiac Arrest - Pediatric
3.04	Post Cardiac Arrest Care - Adult
3.07	Wide Complex Tachycardia - Adult
3.07	Wide Complex Tachycardia - Pediatric
7.44	Ocular Irrigation - Morgan Lens©
7.45	Gastric Tube Placement
7.61	Vascular Access - Intraosseous

Lorazepam (Ativan)

Classification: Benzodiazepine

General:

Lorazepam binds to the gamma-aminobutryic acid receptor complex A (GABA-A), increasing the affinity of the receptor for GABA, enhancing the effects of GABA. GABA is the primary inhibitory neurotransmitter in the CNS which counterbalances the action of the excitatory neurotransmitter glutamate. Enhancing the effects of GABA results in anxiolysis, sedation, amnesia, increased seizure threshold and muscle relaxation. The effects of benzodiazepines are dose dependent (e.g. anxiolysis occurs at doses that do not result in sedation). Lorazepam can be administered via the PO, IV/IO, PR and IM routes. Following IV administration, the onset of action is within 5 minutes with peak effects occurring at 5-10 minutes. The duration of action may be 4-6 hours. Due to its long half-life**,** lorazepam provides longer seizure protection than midazolam or diazepam. Unlike midazolam and diazepam, there are no active metabolites.

Protocol Indication(s):

1. Seizures
2. Sedation
3. Sympathetic agent toxicity
4. Muscular spasm associated with a sting or envenomation

Contraindications:

1. Known hypersensitivity
2. Hypotension (SBP <100 mmHg)
3. Acute angle glaucoma (relative)
4. Pregnancy (relative for active seizures, all benzodiazepines are pregnancy safety category D)

Precautions:

1. Lorazepam can cause respiratory depression, particularly when it is administered with opioids or to patients at extremes of age or those with respiratory conditions. Dosing should be reduced in these patients.

Precautions:

2. When administered to a non-intubated patient, close monitoring of the airway and ventilation is necessary (the use of waveform capnography is highly recommended).
3. Hypotension is less of a concern than respiratory depression, but may occur if it is administered quickly, to volume depleted patients, or to patients with hemodynamic instability.
4. Due to the viscosity of the lorazepam drug formulation, the dose is usually diluted with and equal amount of saline.

Significant adverse/side effects:

1. Respiratory depression
2. Hypotension
3. Confusion

Dosage per protocol(s):

2.07 Patient Comfort - Adult
2.07 Patient Comfort - Pediatric
2.19 Seizures - Adult
2.19 Seizures - Pediatric
4.18 Toxicological Emergencies

Magnesium Sulfate

Classification: Electrolyte

General:

Magnesium sulfate is the common formulation of magnesium used for IV administration. Magnesium is a positively charged electrolyte (cation). Magnesium is a cofactor in a multitude of enzymatic reactions and is required for all biologic activities involving adenosine triphosphate (ATP). It is also required for the proper function of the Na^+ - K^+ exchange pump, which transfers Na^+ out of the cell in exchange for K^+ providing electrical stability of the cellular membrane. Magnesium demonstrates antiarrhythmic effects which are possibly mediated by blockade of sodium currents. It is useful in the management of torsades de pointes associated with a prolonged QTI. These antiarrhythmic effects are demonstrated in the presence of normal serum magnesium levels. Magnesium is also a nonselective calcium antagonist and blocks a number of calcium dependent processes. By inhibiting calcium uptake by smooth muscle, administration results in bronchial, vascular, and uterine relaxation (tocolysis), making it useful in the management of bronchospasm and premature labor. Magnesium decreases neuronal and neuromuscular excitability. Magnesium is the anticonvulsant of choice in eclampsia. Its anticonvulsant activity is likely multifactorial and may include antagonism of the excitatory neurotransmitter N-methyl-d-aspartate (NMDA). Clinical manifestations of hypomagnesaemia include cardiovascular abnormalities (QTI prolongation, arrhythmias, vasospasm, and myocardial ischemia) and neuromuscular abnormalities (weakness, tremor, seizures, tetany, and altered mental status). Patients who are malnourished, chronic alcohol users, and those taking diuretics are at particular risk for hypomagnesaemia.

Protocol Indication(s):

1. Polymorphic ventricular tachycardia associated with a prolonged QTI (Torsade's de pointes)
2. Cardiac arrest with suspected hypomagnesaemia
3. Asthma
4. Preterm labor

Contraindications:

1. Known hypersensitivity

Precautions:

1. Hypotension, bradycardia, and conduction disturbances may occur if administered too rapidly. Administer with caution in patients with bradycardia.
2. Toxicity is associated with CNS and neuromuscular depression. A decrease in deep tendon reflexes (DTRs) is an early sign of toxicity and may indicate impending respiratory depression.
3. The administration of calcium reverses respiratory depression associated with magnesium toxicity.
4. Repeat doses should be administered cautiously in patients with decreased renal function.

Significant adverse/side effects:

1. Hypotension
2. Bradycardia/conduction disturbance (administer with caution in patients with bradycardia)
3. Respiratory depression
4. Flushing

Dosage per protocol(s):

2.08	Asthma - Reactive Airway Disease - COPD - Adult
2.08	Asthma - Reactive Airway Disease - Croup - Pediatric
2.18	Obstetrical Complications
3.03	Cardiac Arrest - Adult
3.03	Cardiac Arrest - Pediatric
3.07	Wide Complex Tachycardia - Adult
3.07	Wide Complex Tachycardia - Pediatric

Methylprednisolone (Solu-Medrol)

Classification: Steroid (synthetic glucocorticoid)

General:

Methylprednisolone is a synthetic glucocorticoid. Glucocorticoid receptors are found in virtually every cell in the body and exert a powerful physiologic effect on every body system. Glucocorticoids stimulate the formation of glucose (gluconeogenesis) and cause the breakdown of protein into amino acids (catabolism). Because methylprednisolone inhibits the inflammatory and immunologic response, it is useful in the management of allergic and anaphylactic reactions and in the management of disease processes that involve airway inflammation or edema (i.e. reactive airway disease, asthma). In reversing asthmatic obstruction, glucocorticoids probably have multiple actions including the reduction of inflammatory mucosal edema, bronchial smooth muscle reaction, bronchial vasoconstriction, and decreasing capillary permeability. They may also restore the responsiveness of asthmatic patients to beta agonist. Methylprednisolone may also be used for replacement therapy in patients with adrenal insufficiency.

Protocol Indication(s):

1. Adrenal insufficiency
2. Asthma
3. COPD exacerbation
4. Allergic and anaphylactic reactions

Contraindications:

1. Known hypersensitivity to any steroid.
2. Systemic fungal infections.

Precautions:

None

Significant adverse/side effects:

1. Hyperglycemia
2. Immunosuppression
3. Nausea/vomiting
4. Edema

Dosage per protocol(s):

2.03 Adrenal Insufficiency
2.04 Allergic Reaction - Anaphylaxis - Adult
2.04 Allergic Reaction - Anaphylaxis - Pediatric
2.08 Respiratory Distress (Asthma/RAD/COPD) - Adult
2.08 Respiratory Distress (Asthma/RAD/Croup) - Pediatric

Metoprolol (Lopressor)

Classification: Beta antagonist (β1 selective)

General:

Metoprolol is a β1 (cardiac) selective beta antagonist and thereby reduces sympathetic stimulation of the heart resulting in decreases in the heart rate, cardiac output, and AV conduction. Metoprolol reduces myocardial oxygen consumption. Metoprolol is classified as a Class 2 antiarrhythmic agent. Like other cardioselective beta antagonist, metoprolol loses its cardioselectivity at higher doses and will inhibit β2 receptors. Metoprolol is used in the chronic management of angina, hypertension, tachyarrhythmias, and heart failure. Acutely, metoprolol is used for ventricular rate control (supraventricular tachycardia, atrial fibrillation/flutter), hypertension and thyrotoxicosis. It may also be used in the management of recurrent and refractory ventricular fibrillation or tachycardia. The onset of action following IV administration is within 5 minutes with a peak effect in less than 1 hour and a duration of action of 5 to 8 hours.

Protocol Indication(s):

1. Refractory and recurrent ventricular fibrillation/tachycardia
2. Narrow complex tachycardia

Contraindications:

1. Known hypersensitivity
2. Heart rate <60
3. AV block >1 degree in the absence of a pacemaker
4. Hypotension (SBP <100 mmHg)
5. Acute decompensated heart failure

Precautions:

1. Metoprolol should be used cautiously in combination with other nodal agents (diltiazem) and this combination should be avoided whenever possible.
2. In response to hypoglycemia the sympathetic nervous system stimulates an increase in blood glucose via β receptors. Antagonism of β receptors will result in the blood glucose remaining low. Antagonism of the β receptors will also suppress the sympathetic signs associated with hypoglycemia.
3. The hypotensive effects of metoprolol may be enhanced in patients receiving amiodarone or antihypertensive agents.
4. Metoprolol may enhance the CNS depressive effects of benzodiazepines.

Significant adverse/side effects:

1. Hypotension
2. Bradycardia
3. AV block
4. Dizziness
5. Bronchospasm
6. Heart failure

Dosage per protocol(s): 3.03 Cardiac Arrest - Adult
3.06 Narrow Complex Tachycardia - Adult

Midazolam (Versed)

Classification: Benzodiazepine

General:

Midazolam binds to the gamma-aminobutryic acid receptor complex A (GABA-A), increasing the affinity of the receptor for GABA, enhancing the effects of GABA. GABA is the primary inhibitory neurotransmitter in the CNS which counterbalances the action of the excitatory neurotransmitter glutamate. Enhancing the effects of GABA results in anxiolysis, sedation, amnesia, increased seizure threshold and muscle relaxation. The effects of midazolam are dose dependent (e.g. anxiolysis occurs at doses that do not result in sedation). As compared to other benzodiazepines, midazolam has the most profound anterograde amnestic effects and it is therefore the generally preferred agent when a benzodiazepine is being used for this effect (e.g. pre cardioversion). Midazolam can be administered via the oral, IV/IO, IM, PR and IN routes. Following IV administration, the onset of action is 1-5 minutes with peak effects occurring at 2-3 minutes. The duration of action is 20-30 minutes. Midazolam is metabolized in the liver and has an active metabolite. Compared to diazepam, midazolam is 3-4 times more potent and has a more rapid onset and recovery.

Protocol Indication(s):

1. Seizures
2. Sedation
3. Sympathetic agent toxicity
4. Muscle spasm associated with a sting or envenomation

Contraindications:

1. Known hypersensitivity
2. Hypotension (SBP <100 mmHg)
3. Acute angle glaucoma (relative)
4. Pregnancy (relative for active seizures, all benzodiazepines are pregnancy safety category D)

Precautions:

1. Midazolam can cause respiratory depression, particularly when it is administered with opioids or to patients at extremes of age or those with respiratory conditions. Dosing should be reduced in these patients.

Precautions:

2. When administered to a non-intubated patient, close monitoring of the airway and ventilation is necessary (the use of waveform capnography is highly recommended).
3. Hypotension is less of a concern than respiratory depression, but may occur if it is administered quickly, to volume depleted patients, or to patients with hemodynamic instability.

Significant adverse/side effects:

1. Respiratory depression
2. Hypotension
3. Confusion

Dosage per protocol(s):

2.07	Patient Comfort - Adult
2.07	Patient Comfort - Pediatric
2.09	Behavioral Emergencies
2.19	Seizures - Adult
2.19	Seizures - Pediatric
2.25	Excited Delirium
3.01	Acute Decompensated Heart Failure - Pulmonary Edema
3.06	Narrow Complex Tachycardia - Adult
3.06	Narrow Complex Tachycardia - Pediatric
3.07	Wide Complex Tachycardia - Adult
3.07	Wide Complex Tachycardia – Pediatric
4.17	Bites - Stings - Envenomation
4.18	Toxicological Emergencies

Naloxone (Narcan)

Classification: Opioid antagonist

General:

Naloxone is an opioid antagonist which binds with high affinity to opioid receptors (μ, k, δ) but does not activate a receptor mediated response. It rapidly displaces bound opioid molecules and reverses the effects of opioids. While naloxone it a competitive antagonist at all of the opioid receptors, its effects on the μ (mu) receptor are ten times greater on other opioid receptors. Following IV administration, it rapidly (within 30 seconds) reverses opioid related respiratory depression and coma. Naloxone has a ½ life of about 20 minutes. Naloxone has a lesser effect on the analgesic effect of opioids mediated by the k (kappa) receptors. The primary goal of naloxone administration is to reverse respiratory depression associated with opioid use or ingestion and its administration should be titrated to this effect. Naloxone is not indicated in cardiac arrest, even if the etiology of the arrest is opioid related. Naloxone may be administered via the IV/IM/SC/IN routes. Patients that have taken/ingested very high amounts of opioids, any doses of propoxyphene, or potent (usually synthetic) agents, may require high doses of naloxone (up to 10 mg) before a clinical response is achieved.

Protocol Indication(s):

1. Opioid related respiratory depression.

Contraindications:

1. Known hypersensitivity

Precautions:

1. Administration of naloxone to chronic opioid users may precipitate symptoms of withdrawal.
2. Naloxone's short serum t ½ life should be considered when administered to patients who have taken/received longer duration opioids. Rebound opioid intoxication may occur.
3. Patients that have taken/ingested very high amounts of opioids, any doses of propoxyphene, or potent (usually synthetic) agents, may require high doses of naloxone (up to 10mg) before a clinical response is achieved.

Significant adverse/side effects:

1. Acute withdrawal syndrome
2. Vomiting
3. Pulmonary edema (rare)

Dosage per protocol(s): 4.18 Toxicological Emergencies - General - Adult
4.18 Toxicological Emergencies - Pediatric - Pediatric

Notes:

- If naloxone is administered to a patient with no opioid on board, miossis (pupillary constriction) may occur.

Nicardipine (Cardene)

Classification: Calcium channel blocker (dihydropyridine class)

General:

Nicardipine is a dihydropyridine class calcium channel blocker (CCB). Nicardipine antagonizes the influx of calcium through L-type voltage gated calcium channels in vascular smooth muscle cells, resulting in arteriolar dilation and decreased systemic vascular resistance (afterload).
The effects of nicardipne are dose dependent and when used within the recommended dosing range, nicardipine has no significant effect on cardiac conduction or contractility. Unlike sodium nitroprusside, an older drug used for acute blood pressure reduction, nicardipine does not increase intracranial pressure. The onset of action for nicardipine is 5-10 minutes. Rapid dose-related increases in nicardipine plasma concentrations are seen during the first two hours after administration by IV infusion. Plasma concentrations increase at a much slower rate after the first few hours, and approach a steady state at 24-48 hours. On termination of IV infusion, nicardipine concentrations rapidly decrease, with at least 50% decrease during the first 2 hours post-termination of the infusion.

Protocol Indication(s):

1. Blood pressure reduction in patients with ischemic stroke who are candidates to receive or are receiving tPA

Contraindications:

1. Known hypersensitivity
2. Severe aortic stenosis
3. Hypotension (SBP <100 mmHg)

Precautions:

1. Patients receiving nicardipine for acute reduction of their BP should have frequent monitoring of their BP (generally every 5-10 minutes in the EMS/transport setting).

Significant adverse/side effects:

1. Hypotension
2. Tachycardia
3. Headache

Dosage per protocol(s): 2.13 tPA for Acute Ischemic Stroke

Nitroglycerine (NTG)

Classification: Organic nitrate

General:

Nitroglycerin is an organic nitrate that is metabolized by smooth muscle to its active metabolite, nitric oxide (NO). NO relaxes vascular smooth muscle resulting in marked venous and arterial dilation. The end result is a reduction in cardiac pre and afterload and a reduction in myocardial oxygen demand. In the setting of cardiac ischemia, NTG decreases myocardial oxygen demand and improves myocardial oxygen supply. The reduction of preload decreases heart size and reducing afterload decreases left ventricular (LV) wall tension (the pressure in the wall of the left ventricle during ejection). The effect of decreasing heart size and LV wall tension is decreased oxygen demand. The increase in myocardial oxygen supply occurs secondary to two effects. Decreasing preload decreases the distending pressure of the heart increasing subendocardial blood flow (increased pressure collapses the subendocardial vasculature) and by vasodilating epicardial and collateral coronary arteries, blood flow to ischemic myocardium is increased. In the setting of acute decompensated heart failure (cardiogenic pulmonary edema), NTG reduces pulmonary congestion by reducing venous return (preload), which decreases pulmonary blood flow and by reducing afterload, which results in increased left ventricular stroke volume (the volume of blood ejected out of the left ventricle with one contraction).

Protocol Indication(s):

1. Acute decompensated heart failure (ADHF) [cardiogenic pulmonary edema]
2. Chest pain/discomfort related to cardiac ischemia

Contraindications:

1. Known hypersensitivity
2. Hypotension (SBP <100mmHg)
3. Recent use of a phosphodiesterase type 5 inhibitor (sildenafil [Viagra, Revatio] or vardenafil [Levitra] with 24 hours or tadalafil [Cialis, Adcirca]) within 36 hours.
4. Right ventricular infarction (RVI)
5. Tachycardia (HR>100) in the absence of heart failure
6. Increased intracranial pressure

Precautions:

1. Patients with right ventricular infarction (RVI) are very preload sensitive and can develop severe hypotension in response to nitrates or other preload-reducing agents. If hypotension develops following the administration of NTG, an IV fluid bolus may be necessary. In patients with inferior wall STEMI, also obtain right sided leads to assess for evidence of RVI.
2. Patients with aortic stenosis are very preload dependent to maintain cardiac output. The use of NTG in patients with known aortic stenosis or a suggestive murmur should be judicious and carefully titrated.

Significant adverse/side effects:

1. Hypotension
2. Headache
3. Tachycardia (reflex)
4. Bradycardia
5. Methmemoglobinemia (nitrate ions can oxidize hemoglobin to methmemoglobin [this is a long term effect and unlikely to be seen in the EMS setting).

Dosage per protocol(s): 3.01 Acute Decompensated Heart Failure - Pulmonary Edema
3.02 Chest Pain - Acute Coronary Syndrome - STEMI

Notes:

- At lower doses, venodilation is greater than arteriodilation. At higher doses (those used for the management of ADHF), widespread arteriodilation occurs.
- NO activates guanylate cyclase and increases cGMP (cGMP is a second messenger involved in the regulation of smooth muscle tone). Increasing cGMP results in the dephosphorization of myosin light chains and in the subsequent relaxation of smooth muscle.

Suggested reading:

Claveau D et al. Complications associated with nitrate use in patients presenting with acute pulmonary edema and concomitant moderate or severe aortic stenosis. Ann Emerg Med 2015 Oct; 66:355.

Nitrous Oxide (N_2O)

Classification: Inorganic gas, inhaled anesthetic

General:

N_2O is an inorganic gas with analgesic properties useful in the treatment of mild to moderate pain, or as a bridge to IV analgesia. The exact mechanism of action for N_2O is unknown, but its effects take place within the pain centers of the brain and spinal cord. It is thought to affect the release of endogenous neurotransmitters such as opioid peptides and serotonin. The release of these neurotransmitters is thought to activate descending pain pathways that inhibit pain transmission. Additionally, it is thought to have an effect on the gamma aminobutryic acid (GABA) receptors increasing inhibition of nerve cells causing drowsiness and sleep. The onset of action is 30-60 seconds and the peak effect is seen within 2-5 minutes. N_20 is able to diffuse from the blood in to closed gas spaces (i.e. bowel, middle ear, pneumothorax) causing them to expand. Because N_20 is self-administered by the patient, the patient must be able to understand and follow directions. N_20 is blended with oxygen and in the EMS setting is delivered in a 50/50 concentration.

Protocol Indication(s):

1. Mild to moderate pain

Contraindications:

1. Known hypersensitivity
2. Altered mental status
3. Acute intoxication or drug use
4. Pregnancy (except during delivery)
5. Blunt or penetrating chest trauma/pneumothorax
6. Craniofacial injury/traumatic brain injury/increased intracranial pressure
7. Undifferentiated abdominal pain
8. Diving emergencies (decompression illness)
9. Respiratory distress
10. Maxillofacial abnormalities/facial trauma or burns
11. Status-post retinal surgery

Precautions:

1. The patient must be able to <u>self-administer</u> N_20.
2. Beware that the delivered FiO2 is 50%.

Significant adverse/side effects:

1. Nausea and vomiting (especially if used with a narcotic analgesic)
2. Lightheadedness/dizziness
3. Euphoria
4. Respiratory depression

Dosage per protocol(s): 2.07 Patient Comfort - Adult
2.07 Patient Comfort - Pediatric

Suggested reading:

Procedure Protocol 7.56 Nitrous Oxide Administration

Norepinephrine (Levophed)

Classification: Adrenergic receptor agonist (α1, β1, β2)

General:

Norepinephrine is an adrenergic agonist with activity on α1, β1, and β2 receptors. Norepinephrine's activity is strongest on the α1 receptor and it has moderate agonistic activity on the β receptors, with greater β1 receptor activity than β2. The vasoconstrictive effects of norepinephrine are greater than its inotropic or chronotropic effects. In septic shock, due to an increase risk for death and arrhythmic events associated with the administration of dopamine, norepinephrine is now the vasopressor of choice in patients with septic shock refractory to fluid resuscitation.

Protocol Indication(s):

1. Shock/hypotension

Contraindications:

1. Known hypersensitivity
2. Sulfite allergy

Precautions:

1. Norepinephrine may not be appropriate as a single agent in some case of cardiogenic shock secondary to its effect of increased afterload.
2. Due to concern for oxidation which may occur when norepinephrine is mixed in 0.9% sodium chloride, D5W is the preferred diluent for admixtures containing norepinephrine. However, this is a long term effect and in the EMS setting, it may be mixed in normal saline if D5W is not available.
3. The dosage should be reduced in patients taking monoamine oxidase inhibitors (MOAIs).
4. Norepinephrine and other vasopressors are only to be utilized in hemorrhagic shock as a bridge to blood products and/or surgical intervention and only after fluid resuscitation as appropriate for the etiology.

Significant adverse/side effects:

1. Hypertension
2. Reflex bradycardia
3. Mesenteric or peripheral ischemia at high doses

Dosage per protocol(s):

2.20 General Shock and Hypotension - Adult
2.20 General Shock and Hypotension - Pediatric
2.21 Hemorrhagic Shock - Adult
2.21 Hemorrhagic Shock - Pediatric
2.22 Sepsis and Septic Shock - Adult
2.22 Sepsis and Septic Shock - Pediatric
4.18 Toxicological Emergencies - Adult
4.18 Toxicological Emergencies - Pediatric

Notes:

- Norepinephrine is the preferred vasopressor for the management of hypotension associated with tricyclic antidepressant (TCA) toxicity (endogenous norepinephrine stores become depleted with TCA toxicity).

Ondansetron (Zofran)

Classification: Antiemetic

General:

Ondansetron is a 5-HT_3 (serotonin) receptor antagonist which is used as an antiemetic. 5-HT_3 receptors are expressed in the enteric (intestinal) nervous system, the nerve endings of the vagus nerve, and the central nervous system, particularly in the chemoreceptor trigger zone (CTZ). The CTZ is an area of the vomiting center (area postrema) of the brain. Because ondansetron is not associated with many of the risks associated with other antiemetics (e.g. hypotension, extrapyramidal reactions), it is often the antiemetic of choice. Ondansetron has not been found useful in the treatment of motion induced nausea and vomiting and it has little effect on nausea associated with vertigo.

Protocol Indication(s):

1. Nausea/vomiting
2. Penetrating ocular injury

Contraindications:

1. Known hypersensitivity
2. Prolonged QT interval (male >440 msec, female >450 msec)
3. Pregnancy (1st trimester)

Precautions:

1. Use with caution if administering with other agents that may cause QTI prolongation.

Significant adverse/side effects:

1. Headache (particularly in those prone to migraine headaches)
2. QTI prolongation
3. AV conduction disturbance (associated with rapid administration)
4. Sedation
5. Diarrhea
6. Dry mouth
7. Serotonin syndrome

Dosage per protocol(s):

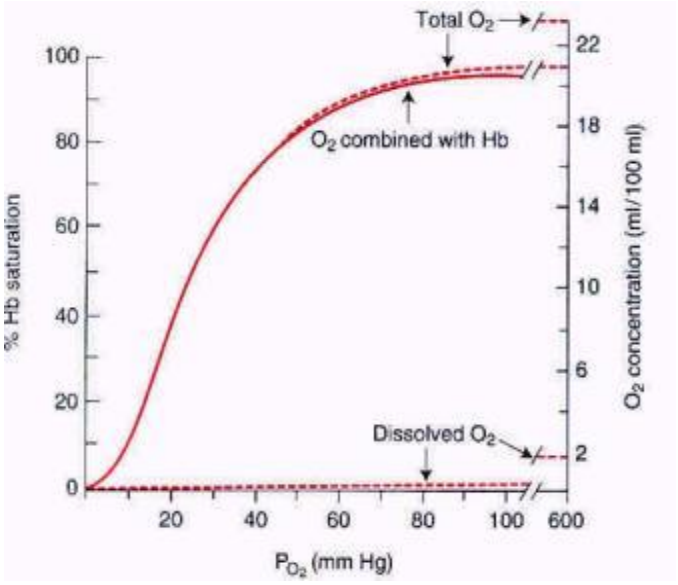
2.07 Patient Comfort - Adult
2.07 Patient Comfort - Pediatric
4.11 Ocular Trauma and Emergencies

Oxygen (O_2)

Classification: Elemental gas

General:

Oxygen is an odorless, tasteless, colorless gas that supports combustion. It is present in ambient air at a concentration of 21%. Oxygen is required by the body to facilitate the breakdown of glucose (aerobic metabolism) into a useable form, without oxygen, the breakdown of glucose is ineffective and incomplete (anaerobic metabolism). All cells require oxygen to survive and function. The majority of oxygen in the body is transported to the cells bound to hemoglobin (Hb), a protein molecule contained in erythrocytes (red blood cells). A small percentage (2-4%) of oxygen is dissolved in blood plasma. The binding of oxygen and Hb is reversible. The oxyhemoglobin dissociation curve (below) demonstrates the ability of Hb to combine with oxygen and relates oxygen saturation (SaO_2/SpO_2) and partial pressure of oxygen in the arterial blood (PaO_2). Because the affinity of Hb for oxygen is affected by many variables, the position of the curve changes. Acidosis (decreased pH), increased CO_2, increased body temperature, and increased levels of DPG (a substance which binds reversibly with Hg and facilitates the release of oxygen) cause the curve to shift to the right. When the curve is shifted to the right, the affinity of Hb for oxygen is decreased and the off-loading of oxygen occurs more easily. Conversely, conditions that are opposite of those which result in a rightward shift of the curve result in a leftward shift of the curve. These conditions include alkalosis (increased pH), decreased CO_2, decreased body temperature, and decreased levels of DPG. When the curve is shifted to the left, the affinity of Hg for oxygen is increased and the off-loading of oxygen is more difficult.



Note that the curve contains a steep slope below a PaO_2 of 60 mmHg, but beyond a PaO_2 of 60 mmHg, the curve is almost flat, indicating that small changes in the PaO_2 in this range will result in little change in saturation above this point. But, at a PaO_2 of less than 60 mmHg the curve is very steep, and small changes in the PaO2 greatly increase or reduce the SaO_2. The time to desaturate from a 90% to 0% is dramatically less than the time to desaturate from 100% to 90%. During the preoxygenation phase of rapid sequence intubation, oxygen is administered to create an oxygen reservoir in the lungs, blood and tissues. During preoxygenation, oxygen replaces the predominantly nitrogenous mixture of room air and oxygen in the functional residual capacity (FRC) with 100% oxygen. The establishment of an oxygen reservoir permits several minutes of apnea to occur prior to arterial oxygen desaturation to less than 90%.

Protocol Indication(s):

1. Patient with dyspnea/shortness of breath, chest pain/discomfort presumed to be of cardiac etiology and/or with a SpO_2 of <94%
2. Pediatric patient with asthma, reactive airway disease, bronchiolitis, croup and a SpO_2 of < 92%
3. Cardiac arrest
4. Preoxygenation prior to suctioning or intubation
5. Sickle cell crisis
6. Obstetrical delivery/complications
7. Carbon monoxide exposure
8. Diving emergencies (pulmonary over pressure syndrome, arterial gas embolism, decompression sickness, nitrogen narcosis)

Contraindications:

1. Paraquat toxicity (may potentiate harmful superoxide formation)
2. Bleomycin use (may increase injury associated with pulmonary toxicity)

Precautions:

1. Oxygen is a drug and should be administered only when an indication for administration is present. The longstanding EMS practice of empiric “high flow/concentration” oxygen in normoxic patients must be abandoned.

Precautions:

2. The use of oxygen in patients with chronic obstructive pulmonary disease (COPD) commonly carries a precautionary warning and is the subject of discussion and debate in the pulmonary medicine literature. Most concerns are related to decreased minute ventilation (depressed ventilation) and increased CO_2 levels associated with the administration of supplemental oxygen to patients with COPD, particularly those with chronic hypercapnia "CO_2 retainers". In such patients, the central chemoreceptors become less sensitive to these changes. The stimulus for ventilation then originates from peripheral chemoreceptors located in the carotid bodies and the aortic arch. These receptors are stimulated by low arterial oxygen levels, transmitting signals to the respiratory center in the medulla. This leads to an increased minute ventilation, with a low arterial oxygen level, and a reduced minute ventilation with a high arterial oxygen level. Oxygen administration may also result in increased CO_2 levels from changes in ventilation and perfusion (V/Q) matching and a phenomenon known as the Haldane effect (the binding of oxygen to Hb displaces CO_2). Both of these topics are beyond the scope of this reference guide. Information regarding these two concepts should easily be found in any physiology textbook. The best approach to the administration of oxygen to patients with COPD is to tolerate lower SpO_2 levels, but never withhold oxygen from a seriously ill hypoxic patient due to fear of cause hypercapnic respiratory failure. Should ventilator depression occur, it should be managed accordingly.
3. There is concern regarding possible hyperoxic injury secondary to supranormal arterial oxygen levels. Hyperoxic injury may affect multiple organ systems (lungs, heart, and brain). Recently published data demonstrated worse outcomes with hyperoxia after resuscitation from cardiac arrest. The exact mechanism of injury is unclear, but hyperoxic injury may be mediated by reactive oxygen species (ROS), hyperoxia-induced vasoconstriction, or amplified reperfusion injury. For this reason, the lowest possible concentration of oxygen should administered. In the post cardiac arrest patient, the FiO_2 should be titrated to the minimum concentration required to maintain the SpO_2 ≥ 94%, but less than 100%. Care should be taken when titrating oxygen concentrations to avoid hypoxia.
4. In patients with suspected or proven acute coronary syndromes and the absence of hypoxia, the benefit of oxygen therapy is uncertain, and in some cases oxygen therapy may be harmful.
5. The routine use of supplemental oxygen is not recommended in acute stroke patients who are not hypoxic.

Significant adverse/side effects:

1. Hyperoxic injury
2. Retinopathy of prematurity

Dosage per protocol(s):

1.01	Routine Patient Care
2.08	Respiratory Distress - Adult
2.08	Respiratory Distress - Pediatric
2.16	Neonatal Resuscitation
2.17	Obstetrical Delivery
2.18	Obstetrical Complications
3.03	Cardiac Arrest - Adult
3.03	Cardiac Arrest - Pediatric
3.04	Post Cardiac Arrest - Adult
3.04	Post Cardiac Arrest - Pediatric
3.05	Bradycardia - Pediatric
4.13	Hypothermia and Localized Cold Injury - Adult
4.13	Hypothermia and Localized Cold Injury - Pediatric
4.15	Diving Emergencies
4.20	Carbon Monoxide Exposure

Notes:

- An arterial saturation (SpO_2) of 90% correlates to a PaO_2 of 60 mmHg.
- An arterial saturation (SpO_2) of 100% may correlate to a PaO2 anywhere between approximately 80-500 mmHg.
- Administering oxygen in the setting of paraquat toxicity may potentiate harmful superoxide formation. Superoxides are thought to be involved in the pathogenesis of pulmonary damage. Oxygen should only be considered in cases associated with profound hypoxia.

Suggested reading:

Abdo WF, Heunks LM. Oxygen-induced hypercapnia in COPD: myths and facts. Crit Care. 2012 Oct 29; 16(5):323.

Aubier M et al. Effects of the administration of O_2 on ventilation and blood gases in patients with chronic obstructive pulmonary disease during acute respiratory failure. Am Rev Respir Dis.1980; 122(5):747–754.

Girardis M et al. Effect of Conservative vs Conventional Oxygen Therapy on Mortality among Patients in an Intensive Care Unit: The Oxygen-ICU Randomized Clinical Trial. JAMA 2016; 316(15): 1583-1589.

Oxymetazoline (Afrin, Zicam)

Classification: Adrenergic receptor agonist (α1 and partial α2)

General:

Oxymetazoline is a α1 adrenergic receptor agonist with partial α2 agonistic properties. It is a vasoconstrictor typically administered intranasal as a decongestant or to treat epistaxis.

Protocol Indication(s):

1. Epistaxis

Contraindications:

1. Known hypersensitivity
1. Hypertension (DBP >100 mmHg)
2. Coronary artery disease
3. Patient taking monoamine oxidase (MAO) inhibitor

Precautions:

None

Significant adverse/side effects:

1. Hypertension
2. Dizziness
3. Headache
4. Cardiac irregularities (palpitations, tachycardia)

Dosage per protocol(s): 2.14 Epistaxis

Phenobarbital

Classification: Barbiturate

General:

Phenobarbital acts on GABAA receptors, increasing synaptic inhibition. This produces sedative hypnotic effects and elevates the seizure threshold, reducing the spread of seizure activity from a seizure focus. Phenobarbital may also inhibit calcium channels, resulting in a decrease in excitatory transmitter release. Phenobarbital is used as a second line agent in the management of seizures. Phenobarbital is also used in the management of delirium tremens associated with alcohol withdrawal.

Protocol Indication(s):

1. Seizures refractory benzodiazepines

Contraindications:

1. Known hypersensitivity
2. Hypotension (SBP <100 mmHg)

Precautions:

1. Barbiturates suppress the hypoxic and chemoreceptor response to CO_2. Consider the use of sidestream waveform capnography in patients receiving phenobarbital. Be aware of possible need for airway management.
2. Phenobarbital should be administered at a rate less than 1 mg/kg/min.

Significant adverse/side effects:

1. Respiratory depression
2. Hypotension
3. Administration may result in hyperactive behavior in pediatric patients

Dosage per protocol(s): 2.19 Seizures - Pediatric

Phenylephrine (Neosynephrine)

Classification: Adrenergic receptor agonist (α1)

General:

Phenylephrine is an adrenergic agonist with activity on the α1 receptor. Phenylephrine's effect is primarily venous and arterial vasoconstriction. The administration of phenylephrine results in the increase of the mean arterial blood pressure (MAP) without any significant effect on heart rate or ventricular contractility. However, significant elevation blood pressure may result it reflex bradycardia. Phenylephrine may be the vasopressor of choice in the patient with atrial fibrillation who is tachycardic with hypotension (unrelated to their heart rate). Phenylephrine may be administered by intravenous infusion or by IV bolus. Administration by IV bolus is reserved for the profoundly hypotensive or periarrest patient. Bolus administration is usually a bridge to the establishment of an IV infusion of phenylephrine or another vasopressor. Phenylephrine is commonly used in patients with neurogenic shock, however secondary to the mechanism of neurogenic shock, these patients may experience bradycardia which may be exacerbated by the administration of phenylephrine. Phenylephrine may also be applied topically to the mucosa as a vasoconstrictor.

Protocol Indication(s):

1. Shock/hypotension

Contraindications:

1. Known hypersensitivity
2. Sulfite allergy
3. Bradycardia

Precautions:

1. Phenylephrine and other vasopressors are only to be utilized in hemorrhagic shock as a bridge to blood products and/or surgical intervention and only after fluid resuscitation as appropriate for the etiology.
2. Any concern for local extravasation of phenylephrine must be communicate to the receiving facility as it may require treatment with phentolamine (an alpha agonist).

Significant adverse/side effects:

1. Hypertension
2. Reflex bradycardia
3. Mesenteric or peripheral ischemia at high doses

Dosage per protocol(s):

2.20 General Shock and Hypotension - Adult
2.20 General Shock and Hypotension - Pediatric
2.21 Hemorrhagic Shock - Adult
2.21 Hemorrhagic Shock - Pediatric
2.22 Sepsis and Septic Shock - Adult
2.22 Sepsis and Septic Shock – Pediatric
7.45 Gastric Tube Insertion

Pitocin (Oxytocin)

Classification: Hormone (synthetic)

General:

Pitocin is a synthetic version of oxytocin, a hormone endogenously produced in the posterior pituitary gland. Binding sites for oxytocin are found on the membranes of uterine smooth muscle. Pitocin lowers the threshold for depolarization in uterine smooth muscle resulting in an increase of the frequency and force of uterine contractions (i.e. increases uterine tone). The most common cause of postpartum hemorrhage (PPH) is uterine atony. Pitocin can also initiate uterine contractions at any time and is frequently used to induce labor. In the EMS setting, pitocin is used for the prevention and management of postpartum hemorrhage.

Protocol Indication(s):

1. Postpartum hemorrhage (prevention and management)

Contraindications:

1. Known hypersensitivity
2. Presence of a second fetus

Precautions:

1. Pitocin should not be administered until after delivery of the placenta.
2. When used for the management of active postpartum hemorrhage, pitocin should be used in conjunction with fundal massage.

Significant adverse/side effects:

1. Hypotension
2. Tachycardia

Dosage per protocol(s): 2.18 Obstetrical Complications

Pralidoxime Chloride (2PAM)

Classification: Cholinesterase reactivator

General:

Pralidoxime chloride is a cholinesterase reactivator used as an antidote for organophosphate based pesticides and nerve agents. As a group, pesticides and nerve agents are referred to cholinesterase inhibitors. Cholinesterase inhibitors phosphorylate and inactivate cholinesterase. Cholinesterase is the enzyme responsible for the breakdown of the neurotransmitter acetylcholine (Ach). When cholinesterase is inhibited, Ach accumulates and activates muscarinic and nicotinic receptors. Activation of muscarinic receptors results in miosis (pupillary constriction), bradycardia, bronchial secretion and increased secretions, increased GI motility, relaxation of the urinary sphincter, contraction of the bladder, and increased secretions (salivation, lacrimation). Activation of nicotinic receptors at the neuromuscular junction results in muscular contraction (fasciculations and weakness). If the offending agent is able to cross the blood brain barrier (BBB), it will affect the cholinergic receptors in the central nervous system (CNS). The effects can be tremor, anxiety, restlessness, seizures, or coma. Due to their lipid solubility, organophosphates rapidly cross the blood brain barrier. Because pralidoxime does not cross the BBB, it is not effective in reversing the CNS effects of cholinesterase inhibitors. Pralidoxime is usually administered with atropine sulfate, which is a muscarinic agonist, because it blocks the effects of excess Ach, but only at muscarinic receptors (it has no effect on nicotinic receptors located at the neuromuscular junction).

Protocol Indication(s):

1. Organophosphate or nerve agent exposure with signs/symptoms

Contraindications:

1. Known hypersensitivity

Precautions:

1. Repeat dosing may be required.
2. Should not be used as prophylaxis

Significant adverse/side effects:

1. Dizziness
2. Headache
3. Nausea

Significant adverse/side effects:

4. Tachycardia
5. Weakness
6. Hypertension
7. Blurred vision

Dosage per protocol(s): 4.19 Nerve Agent or Organophosphate Exposure

Prednisolone (Orapred)

Classification: Steroid (synthetic glucocorticoid)

General:

Prednisolone is a synthetic glucocorticoid steroid. Glucocorticoid receptors are found in virtually every cell in the body and exert a powerful physiologic effect on every body system. Glucocorticoids stimulate the formation of glucose (gluconeogenesis) and cause the breakdown of protein into amino acids (catabolism). Because prednisolone inhibits the inflammatory and immunologic response, it is useful in the management of allergic and anaphylactic reactions and in the management of disease processes that involve airway inflammation or edema (i.e. reactive airway disease, asthma). In reversing asthmatic obstruction, glucocorticoids probably have multiple actions including the reduction of inflammatory mucosal edema, bronchial smooth muscle reaction, bronchial vasoconstriction, and decreasing capillary permeability. They may also restore the responsiveness of asthmatic patients to beta agonist.

Protocol Indication(s):

1. Asthma/reactive airway disease
2. Allergic and anaphylactic reactions

Contraindications:

1. Known hypersensitivity to any steroid
2. Systemic fungal infections

Precautions:

None

Significant adverse/side effects:

1. Hyperglycemia
2. Immunosuppression
3. Nausea/vomiting
4. Edema

Dosage per protocol(s): 2.04 Allergic Reaction - Anaphylaxis - Pediatric
2.08 Respiratory Distress (Asthma/RAD/Croup) - Pediatric

Procainamide (Pronestyl)

Classification: Antiarrhythmic (class 1A)

General:

Procainamide is a class IA antiarrhythmic useful in the management of atrial and ventricular arrhythmias. Class I antiarrhythmic agents block sodium entry into the cell during depolarization. Class I agents are subcategorized into three groups (IA, IB, IC) based on their degree of sodium blockade. IA agents slow the rate of rise of phase 0 and prolong the relative refractory period of the ventricle thus prolonging the repolarization time. Procainamide raises the ventricular fibrillation threshold. Procainamide has mild post ganglionic effects and may cause hypotension secondary to peripheral vasodilation. Procainamide is used in the management of atrial fibrillation and flutter, paroxysmal supraventricular tachycardia, ventricular tachycardia, and refractory ventricular fibrillation. Procainamide may convert atrial fibrillation to a sinus rhythm.

Protocol Indication(s):

1. Refractory ventricular fibrillation/tachycardia
2. Wide complex tachycardia

Contraindications:

1. Known hypersensitivity
2. Hypotension (SBP <100mmHg)
3. Heart rate <60
4. AV block > 1st degree in absence of a pacemaker
5. Preexisting QT prolongation or torsade's de pointes

Precautions:

1. Use with caution in heart failure
2. Administration should be stopped when one of the following occurs: arrhythmia resolves, hypotension ensues, or the QRS widens by >50%, or 17 mg/kg is administered

Significant adverse/side effects:

1. Hypotension
2. AV block
3. Bradycardia
4. QRS/QT prolongation

Dosage per protocol(s): 3.04 Cardiac Arrest - Adult
3.07 Wide Complex Tachycardia - Adult

Notes:

- The 2015 AHA ECC Guidelines recommend procainamide, amiodarone or sotalol for the treatment of stable ventricular tachycardia. However, a higher class of recommendation is given to procainamide compared to amiodarone and sotalol.

Promethazine (Phenergan)

Classification: Phenothiazine

General:

Promethazine is a phenothiazine with antiemetic properties. Promethazine blocks dopaminergic (D1 and D2) receptors in the brain. Promethazine also exerts a strong α adrenergic effect and competes with histamine for the H1 receptor (antihistamine). Promethazine's antiemetic effect is thought to take place in the chemoreceptor trigger zone (CTZ), which is an area of the vomiting center (area postrema) of the brain. Due to its antihistamine effects, promethazine is sometimes used in the management of motion sickness. Promethazine has weak antipsychotic effects as compared to other phenothiazines.

Protocol Indication(s):

1. Nausea and vomiting

Contraindications:

1. Known hypersensitivity
2. Parkinson's disease
3. Narrow angle glaucoma

Precautions:

1. Promethazine is an irritant drug that can lead to serious vascular injury and potential gangrene with the need for tissue grafting and/or amputation if it is inadvertently extravasated or given intra-arterially.
2. Promethazine lowers the seizure threshold and should be used cautiously in patients with a history of seizures.
3. Promethazine for injection contains metabisulfites, which may cause anaphylaxis; this reaction is more likely to occur in patients with a history of asthma.
4. Due to its potential sedating effect, promethazine should not be used when sedation is not desirable.

Significant adverse/side effects:

1. Sedation
2. Extrapyramidal/dystonic reactions
3. Hypotension (particularly in volume depleted patients)

Significant adverse/side effects:

4. Tachycardia
5. Blurred vision
6. Dry mouth
7. Neuroleptic malignant syndrome
8. Paradoxical excitation (particularly in pediatric and geriatric patients)

Dosage per protocol(s): 2.07 Patient Comfort - Adult

Proparacaine Hydrochloride 0.5% Ophthalmic Solution

Classification: Local anesthetic (ester group)

General:

Proparacaine is a local anesthetic belonging to the ester subgroup of local anesthetics. Proparacaine blocks sodium ion channels required for the initiation and conduction of neuronal impulses thereby affecting corneal local anesthesia. Proparacaine is used as a topical ophthalmic anesthetic to facilitate ocular irrigation and to provide analgesia in cases of ultraviolet keratitis (corneal flash burns). Maximal corneal anesthesia is achieved within 20 seconds of installation, with anesthetic effects lasting 15–20 minutes. Like tetracaine, because proparacaine belongs to the ester group of local anesthetics, it can be administered with minimal concern for allergic/anaphylactic reaction in patients with an allergy to any of the local anesthetics belonging to the amide group (lidocaine, bupivacaine, mepivacaine, prilocaine).

Protocol Indication(s):

1. Known hypersensitivity
2. Chemical ocular exposure requiring irrigation
3. Corneal flash burns

Contraindications:

None

Precautions:

1. Patients should be advised that their eyes will be insensitive up to 20 minutes and that care should be taken to avoid ocular contact.

Significant adverse/side effects:

1. Corneal injury due to insensitivity
2. Transient stinging or burning
3. Conjunctival redness
4. Ocular discomfort

Dosage per protocol(s): 4.11 Ocular Trauma and Emergencies

Pseudoephedrine Hydrochloride (Sudafed)

Classification: α adrenergic receptor agonist

General:

Pseudoephedrine is an alpha adrenergic receptor agonist that is used as a nasal decongestant. It produces vasoconstriction by stimulating alpha receptors within the mucosa of the respiratory tract resulting in the temporary reduction of swelling associated with inflammation of the mucous membranes. Systemically, pseudoephedrine may result in a mild increase of the heart rate.

Protocol Indication(s):

1. Ear or sinus squeeze associated with diving

Contraindications:

1. Known hypersensitivity
2. Hypertension
3. Patient taking monoamine oxidase inhibitors (MAOIs)
4. Benign prostatic hyperplasia (BPH)
5. Glaucoma

Precautions:

None

Significant adverse/side effects:

1. Anxiety
2. Restlessness
3. Insomnia
4. Increased heart rate

Dosage per protocol(s): 4.15 Diving Emergencies

Rocuronium (Zemuron)

Classification: Non-depolarizing neuromuscular blocking agent

General:

Rocuronium competes with acetylcholine (Ach) for binding at nicotinic receptors at the neuromuscular junction preventing depolarization of the muscle cell membrane and inhibiting muscular contraction. Because these agents compete with Ach at the receptor, they are called competitive blockers. Rocuronium is used to facilitate endotracheal intubation and to facilitate ventilation in the patient with and advanced airway in place. Rocuronium does not cross the blood brain barrier and have no sedating or analgesic properties and therefore, sedation and analgesia must be administered at the time as it is. Rocuronium has an onset of action of 1-3 minutes and has a 30-40 minute duration of action (dose dependent).

Protocol Indication(s):

1. Facilitation of ventilation in a patient with an advanced airway in place.
2. Alternative for rapid sequence intubation when succinylcholine is contraindicated (restricted use for this purpose)

Contraindications:

1. Known hypersensitivity
2. Lack of ability continuously monitor waveform capnography.

Precautions:

1. Rocuronium should only be administered by providers skilled in advanced airway management, including performing cricothyrotomy.
2. Advanced airway placement must be confirmed by the presence of a capnographic waveform for ≥6 breaths prior to administration and waveform capnography must be continuously monitored following the administration of rocuronium.
3. Providers must be vigilant for signs of unintentional awareness (patient is awake, but under paralysis) or pain perception requiring additional sedation/analgesia. Signs may include tachycardia, hypertension, ocular tearing.
4. Rocuronium should be dosed on ideal body weight.

Significant adverse/side effects:

None of clinical significance.

Dosage per protocol(s): 2.07 Patient Comfort - Adult

Sodium Bicarbonate (NaHCO3)

Classification: Alkalizing (buffering) agent

General:

Sodium bicarbonate is a naturally occurring buffering agent which binds free hydrogen (H+) ions to form carbonic acid, which is a weak acid that dissociates to carbon dioxide (CO_2) and water (H_2O). CO_2 can then be excreted by the lungs and H2O can be excreted by the kidney. Excretion of CO^2 by the lungs requires adequate minute ventilation, if minute ventilation is inadequate, paradoxical acidosis can occur. The brain is especially subject to the effects of paradoxical acidosis because CO^2 diffuses across the blood brain barrier more rapidly than does sodium bicarbonate. Historically, sodium bicarbonate was used to empirically treat presumed metabolic acidosis during cardiac arrest. The routine administration of sodium bicarbonate in cardiac arrest is not recommended, even in the event of a "prolonged downtime". Acidosis associated with cardiac arrest is often a result of a respiratory and metabolic etiology and is best treated by the restoration of ventilation and perfusion. In the rare circumstance of severe preexisting metabolic acidosis, sodium bicarbonate administration may be considered in cardiac arrest. In the EMS setting, sodium bicarbonate is primarily used in the management of suspected hyperkalemia, crush injury/syndrome, sodium channel blocker toxicity, and cardiac arrest associated with excited delirium. When sodium bicarbonate is administered in the setting of hyperkalemia, H+ ions move from the intracellular space to the extracellular space and potassium (K+) shifts from the extracellular space (serum) to the intracellular space to maintain electrical neutrality of the cell. The exact mechanism of sodium bicarbonate as an antidote for sodium channel blocker toxicity is not completely understood. It is believed the mechanism may be twofold: 1. Alkalization (higher pH) promotes dissociation of the drug from sodium channels; 2. The sodium load plays a more important role by helping to drive sodium through both blocked and unblocked channels. In crush injury (CI)/crush syndrome (CS), alkalization with sodium bicarbonate helps prevent acute kidney injury secondary to myoglobin and uric acid deposition in kidneys. It also combats hyperkalemia associated with CI/CS. In excited delirium, sodium bicarbonate may be used to help correct associated acidosis, prevent or minimize acute kidney injury from rhabdomyolysis, and may be beneficial if hyperkalemia is present.

Protocol Indication(s):

1. Hyperkalemia
2. Sodium channel blocker toxicity (tricyclic antidepressants and others)
3. Crush injury/syndrome

Contraindications:

None when the above indications are present

Precautions:

1. Sodium bicarbonate precipitates and interacts with multiple medications. Therefore, it should not be given or mixed with any other medications.
2. Flush IV line prior to and after administration.
3. In neonates and children <2 years of age, a 4.2% solution of sodium bicarbonate should be used and administered slowly.
4. Sodium bicarbonate may cause tissue necrosis, ulceration, and sloughing.

Significant adverse/side effects:

1. Metabolic alkalosis
2. Paradoxical acidosis
3. Exacerbation of heart failure
4. Hypernatremia
5. Hypokalemia
6. Hypocalcemia

Dosage per protocol(s):

2.11	Dialysis Emergencies and Renal Failure
2.25	Excited Delirium
4.09	Crush Injury/Crush Syndrome
4.18	Toxicological Emergencies - Adult
4.18	Toxicological Emergencies - Pediatric

Notes:

- Medications with sodium channel blocking properties include: tricyclic antidepressants (TCA), quinidine, procainamide, flecanide, encanide, bupivicane, propranolol, carbamazepine, quinine, and diphenhydramine.
- Typical ECG findings associated with sodium channel blocker (TCA) toxicity include QRS/QTI prolongation, ventricular dysrhythmias, and a late R wave in lead aVR.

Sodium Chloride 0.9% (NaCl 0.9%)

Classification: Crystalloid

General:

Sodium Chloride 0.9% is an unbalanced crystalloid fluid. While often referred to as "normal saline", it contains a supraphysiologic concentration of chloride (154 mEq/L, 1.5 times that of plasma), 154 mEq/L of sodium, and it has a pH of 5.7 (the pH of plasma is 7.4). Simply stated, "Normal saline is not normal". Unlike Lactated Ringers solution (LR), it does not contain an anion buffer. It has a strong ion difference (SID) of 0. The SID is the difference between the concentrations of strong cations and strong anions. While a detailed explanation of the SID is beyond the scope of this guide, it is useful to know that the administration of a resuscitation fluid with a SID less than the serum bicarbonate level (normal range 22–26 mmol/L) will lead to a more acidotic state (↓pH) and the administration of a resuscitation fluid with a SID greater than the serum bicarbonate level leads to a more alkalotic state (↑pH). The table below compares the electrolyte composition and SID of LR and NaCl 0.9% to human blood plasma (concentrations are in mEq/L):

	Sodium (Na^+)	Chloride (Cl^-)	Potassium (K^+)	Calcium (Ca^{++})	Lactate	SID
Plasma	140	100	4	5	1-2	+40
NaCl 0.9%	154	154	0	0	0	0
LR	130	109	4	3	28	+28

There is some recent data that suggests that outcomes may be worse in patients who receive fluid resuscitation with NaCl 0.9% v. those who receive fluid resuscitation with LR or other buffered resuscitation fluids. Specifically, resuscitation with NaCl 0.9% was associated with an increase in acute kidney injury, hyperchloremic metabolic acidosis, and increased mortality. For this reason, LR was chosen as the fluid of choice for patients requiring large volume fluid resuscitation. NaCl 0.9% should only be used in patients requiring limited fluid administration.

Protocol Indication(s):

1. Dehydration
2. Hypovolemia
3. Shock
4. Ocular irrigation

Contraindications:

1. Profound liver failure (LR may increase the lactate level, but it should be noted that the lactate in LR is in the form of sodium lactate, not lactic acid and it will not make the patient more acidotic).

Precautions:

1. Fluids should be administered judiciously to patients with evidence of or a history of heart failure.
2. Because LR is slightly hypotonic, large volumes may increase intracranial pressure.
3. The calcium in LR can bind to the citrated anticoagulant in blood products and lead to inactivation of anticoagulant and promote the formation of clots in donor blood. For this reason, LR is contraindicated as a diluent for red blood cell transfusions.

Significant adverse/side effects:

1. Fluid overload
2. Metabolic alkalosis
3. Increased intracranial pressure (large volumes, primarily of concern in patients with already increased intracranial pressure).

Dosage per protocol(s):

1.01	Routine Patient Care
2.20	General Shock and Hypotension - Adult
2.20	General Shock and Hypotension - Pediatric
2.21	Hemorrhagic Shock - Adult
2.21	Hemorrhagic Shock - Pediatric
2.22	Septic Shock - Adult
2.22	Septic Shock - Pediatric
3.03	Cardiac Arrest - Adult
3.03	Cardiac Arrest - Pediatric
4.06	Traumatic Cardiac Arrest - Adult
4.06	Traumatic Cardiac Arrest - Pediatric
4.07	Thermal Burns - Adult
4.07	Thermal Burns - Pediatric
4.11	Ocular Trauma and Emergencies
4.22	Radiation Incident
7.44	Ocular Irrigation - Morgan Lens©

Sodium Chloride 3% (Hypertonic Saline)

Classification: Electrolyte solution

General:

Hypertonic (3%) saline (HTS) is a solution of 3% sodium chloride and sterile water. It is hyperosmolar with an osmolality of 1027 mOsml/L. HTS draws water from the extravascular space to the intravascular space. This effect is useful in reducing intracranial volume, thereby reducing intracranial pressure. Secondarily, HTS may also increase the mean arterial pressure (MAP) by increasing intravascular volume, augmenting cerebral perfusion pressure (CPP). HTS is used in the management of increased intracranial pressure with clinical evidence (altered mental status (GCS <8), abnormal motor posturing, unilateral or bilateral dilation of pupils, +/- bradycardia and/or hypertension) suggesting brain herniation. Use of HTS in the setting of increased ICP is usually a bridge to surgical or other interventions as the effect on ICP is transient. In other settings, HTS is utilized for the correction of hypernatremia. Use this purpose requires the ability to measure the serum sodium.

Protocol Indication(s):

1. Acute neurologic event with evidence of increased ICP

Contraindications:

1. Known hypersensitivity

Precautions:

1. HTS should not be administered with blood products.

Significant adverse/side effects:

1. Hypervolemia
2. Irritation at injection site
3. Phlebitis

Dosage per protocol(s): 2.01 Acute Neurologic Event with Evidence of Increased ICP

Sodium Thiosulfate

Classification: Antidote

General:

Sodium thiosulfate is used as an antidote for cyanide toxicity. Cyanide is a cellular asphyxiant which disrupts metabolism dependent on metal-containing enzymes. In particular, it binds to ferric iron present in the cytochrome oxidase system disrupting oxidative phosphorylation (oxidative phosphorylation is the final metabolic pathway of cellular respiration). Cells then shift to anaerobic metabolism which results in the production of lactic acid, which is manifested clinically as metabolic acidosis. Sodium thiosulfate donates a sulfur atom necessary for the transformation of cyanomethemoglobin to thiocyanate, thus increasing the endogenous detoxification of cyanide. Thiocyanate is then excreted in the urine. Sodium thiosulfate is often used in conjunction with sodium nitrite, which binds with cyanide to form cyanomethemoglobin.

Protocol Indication(s):

1. Cyanide toxicity (known or suspected)

Contraindications:

None

Precautions:

1. Sodium thiosulfate should not be administered concurrently in the same intravenous line with hydroxocobalamin.
2. Sodium thiosulfate may contain trace impurities of sodium sulfite, however this should not deter its administration for treatment of life threatening cyanide toxicity, even if the patient is sulfite-sensitive.

Significant adverse/side effects:

1. Nausea
2. Vomiting
3. Headache
4. Hypotension

Dosage per protocol(s): 4.18 Toxicological Emergencies - Adult
4.18 Toxicological Emergencies - Pediatric

Succinylcholine (Anectine) RESTRICTED USE AGENT MEDICATION

Classification: Depolarizing neuromuscular blocking agent

General:

Succinylcholine is a depolarizing neuromuscular blocking agent used for rapid sequence intubation/medication assisted intubation (RSI/MAI). Succinylcholine occupies nicotinic receptors at the neuromuscular junction and mimics the effect of acetylcholine (Ach). This results in depolarization of the receptors leading to transient muscular fasciculations (twitching). The receptors are then rendered incapable of responding to depolarization and flaccid paralysis ensues. Paralysis lasts until the succinylcholine diffuses from the neuromuscular junction back into the vascular compartment where it is hydrolyzed (broken down due to a reaction with water) by psuedocholinesterase, an enzyme produced in the liver and found in blood plasma. The action of succinylcholine is not limited to the receptors located at the neuromuscular junction. It may stimulate cardiac muscarinic receptors, leading to bradycardia. Bradycardia is most commonly observed following repeat dosing. Less commonly, succinylcholine administration may cause histamine release, leading to flushing, hypotension, and tachycardia. Under normal conditions, the administration of succinylcholine results in a 0.5-1.0 mEq/L increase in the serum potassium. Patients with certain pathological conditions are at increased risk for hyperkalemia following the administration of succinylcholine. In most of these conditions, this is thought to be due to an up regulation of junctional and extrajunctional cholinergic receptors. These conditions include spinal cord injury with paralysis, CVA with paralysis, progressive neuromuscular disorders (multiple sclerosis, amyotrophic lateral sclerosis, Guillain-Barre Syndrome), immobility, myopathies, muscular dystrophies, burns, and crush injury. Receptor up regulation does not occur immediately, but occurs over a short period of time. Succinylcholine is considered safe if administered within 24 hours of onset in some of these conditions (see below). The onset of action for succinylcholine is 45 seconds and the duration of action is 8-12 minutes.

Protocol Indication(s):

1. Rapid sequence intubation/medication assisted intubation

Contraindications:

1. Known hypersensitivity
2. Personal or family history of malignant hyperthermia
3. Burns (>24hrs)
4. Crush injury (>24hrs)
5. Spinal cord injury with paralysis (>24hrs)
6. CVA with paralysis (>24hrs)

Contraindications:

7. Hyperkalemia
8. Intra-abdominal infection
9. Rhabdomyolysis
10. Amyotrophic lateral sclerosis
11. Prolonged immobilization
12. Inherited myopathies
13. Muscular dystrophy

Precautions:

1. Succinylcholine should only be administered by providers skilled in advanced airway management, including performing cricothyrotomy. Use of succinylcholine is restricted to paramedics participating in a CEMS approved medication assisted intubation program.
2. When using succinylcholine or any other neuromuscular blocking agent for the facilitation of endotracheal intubation, the airway must be assessed for difficulty and a plan must be developed in the event intubation is unsuccessful and ventilation is not possible. A back-up airway device (i.e. supraglottic airway, etc.) and equipment to perform a cricothyrotomy must be immediately available.
3. Following the IV administration of succinylcholine, the intubating provider should wait a full minute prior to performing direct laryngoscopy to ensure optimal intubating conditions are present.

Significant adverse/side effects:

1. Malignant hyperthermia (see notes section below)
2. Hyperkalemia
3. Fasciculations
4. Increased intraocular pressure (not of clinical significance, airway takes priority)
5. Bradycardia (usually associated with repeat dosing)
6. Increased ICP (see notes section below)

Dosage per protocol(s): 5.04 Rapid Sequence Intubation/Medication Assisted Intubation

Notes:

- When compared to other available neuromuscular blocking agents, succinylcholine has the fastest onset of action and the shortest duration of action.

Notes:

- Malignant hyperthermia (MH) is a rare condition characterized by a genetic skeletal muscle membrane abnormality. In a patient with a susceptibility to MH, an acute event or exposure triggers an abnormal release of calcium from the sarcoplasmic reticulum (a storage site for calcium) in the muscle cells, which results in a sustained muscle contraction and thus an abnormal increase in metabolism and heat production. The muscle cells eventually are depleted of adenosine triphosphate (ATP) the source of cellular energy, and die, releasing large amounts of potassium into the bloodstream, causing hyperkalemia, followed by ventricular (cardiac) arrhythmias. Myoglobin is also released from the muscle cells and may be cause acute kidney injury (AKI). Patients with MH are also at risk for coagulopathies.
- Succinylcholine is known to be a trigger of MH, particularly when administered in conjunction with a halogenated anesthetic. MH is less commonly associated with succinylcholine when it is not used in conjunction with a halogenated anesthetic.
- Clinical manifestations of MH include hypercarbia (increasing $EtCO_2$), acidosis, sinus tachycardia, masseter muscle spasm, muscular rigidity, and hyperthermia.
- The management MH includes discontinuing the triggering agent, rapid cooling, managing acidosis, and administering the antidote medication Dantrolene.
- In animal studies, when succinylcholine is administered in the setting of increased ICP, a transient increase in the ICP is observed. This occurs during the fasciculation phase, but is not believed to be directly related to the fasciculations. The clinical significance of this transient effect is unknown. Due to succinylcholine's rapid onset, consistent and reliable effects, and short duration of action, it is the recommended neuromuscular blocking agent for RSI of the head injured patient.
- Succinylcholine is safe in myasthenia gravis.

Terbutaline (Breathine, Bricanyl)

Classification: Beta adrenergic agonist (β2 selective)

General:

Terbutaline is β2 selective adrenergic receptor agonist used in the management of bronchospasm. Terbutaline stimulates β2 receptors resulting in an increase in cyclic adenosine monophosphate (cAMP), which leads to the activation of protein kinase A inhibiting phosphorylation of myosin and lowering intracellular ionic calcium concentrations, resulting in relaxation of bronchial smooth muscle (bronchodilation) and relaxation of uterine and vascular smooth muscle. Increasing cAMP concentrations also inhibits the release of mediators from mast cells in the airway. Because it relaxes vascular smooth muscle, some peripheral vasodilation may also occur, which may be reflected by a decrease in the diastolic blood pressure. As a result of sympathomimetic stimulation, an intracellular shift of potassium may occur. This may result in a small (approximately 0.5 mEq/L) decrease in the serum potassium concentration. This is generally not of clinical concern, unless large doses of beta agonist are being administered. Terbutaline has little or no effect on alpha adrenergic receptors and may be preferred over epinephrine for the management of reversible bronchospasm in patients with hypertension or a history of cardiovascular disease. The effects of terbutaline are observed within minutes after administration and persist for 4-6 hours.

Protocol Indication(s):

1. Bronchospasm (asthma/RAD/COPD)

Contraindications:

1. Known hypersensitivity

Precautions:

1. Use with caution in patients with myocardial ischemia.

Significant adverse/side effects:

1. Tachycardia
2. Palpitations/cardiac ectopy
3. Tremor
4. Headache
5. Nausea/vomiting

Dosage per protocol(s): 2.08 Respiratory Distress (Asthma/COPD/RAD)

Tetracaine 0.5% Ophthalmic Solution

Classification: Local anesthetic (ester group)

General:

Tetracaine is a local anesthetic belonging to the ester subgroup of local anesthetics. Tetracaine blocks sodium ion channels required for the initiation and conduction of neuronal impulses thereby affecting corneal local anesthesia. Tetracaine is used as a topical ophthalmic anesthetic to facilitate ocular irrigation and to provide analgesia in cases of ultraviolet keratitis (corneal flash burns). Maximal corneal anesthesia is achieved within 10–20 seconds after instillation, with anesthetic effects lasting 10–20 minutes. Because tetracaine belongs to the ester group of local anesthetics, it can be administered with minimal concern for allergic/anaphylactic reaction in patients with an allergy to any of the local anesthetics belonging to the amide group (lidocaine, bupivacaine, mepivacaine, prilocaine).

Protocol Indication(s):

1. Chemical ocular exposure requiring irrigation
2. Corneal flash burns

Contraindications:

None

Precautions:

1. Patients should be advised that their eyes will be insensitive up to 20 minutes and that care should be taken to avoid ocular contact.

Significant adverse/side effects:

1. Corneal injury due to insensitivity
2. Transient stinging or burning
3. Conjunctival redness
4. Ocular discomfort

Dosage per protocol(s): 4.11 Ocular Trauma and Emergencies

Thiamine

Classification: Vitamin (B1)

General:

Thiamine is a component of the B complex. Thiamine exists in the body in the form of thiamine pyrophosphate (TTP). TTP catalyzes several reactions responsible in the glycolytic and Krebs cycle responsible for the metabolism of glucose. Without TTP a significant amount of energy available in glucose cannot be obtained. The brain is very sensitive to thiamine deficiency, which may occur in alcoholics and malnourished patients. The two major syndromes of concern associated with thiamine deficiency are Wernicke's encephalopathy and Korsakoff's syndrome. Wernicke's encephalopathy is characterized by confusion, ataxia (unstable gait), opthalmoplegia (paralysis of the extra ocular muscles), and nystagmus (constant involuntary eye movement). Wernicke's responds rapidly to thiamine administration. If Wernicke's syndrome is left untreated, it can progress to Korsakoff's syndrome, which is characterized by learning and memory impairment out of proportion to other cognitive functions in an otherwise alert and responsive patient. Because the normal metabolism of glucose results in the consumption of TTP, the administration of a glucose load to a patient with marginal TTP stores may precipitate symptoms of thiamine deficiency. Thiamine is administered prior to or with dextrose in patients at high risk for thiamine deficiency (alcoholics and malnourished patients).

Protocol Indication(s):

1. Co-administration with glucose to malnourished patients or patients with a history of alcohol abuse

Contraindications:

1. Known hypersensitivity

Precautions:

1. While very uncommon, allergic reactions have been reported.

Significant adverse/side effects:

None

Dosage per protocol(s): 2.10 Diabetic Emergencies - Adult

Tissue Plasminogen Activator (t-PA)

Classification: Fibrinolytic

General:

Tissue plasminogen activator (t-PA) is a fibrinolytic agent. When tissue injury occurs, platelets respond and adhere to the site of injury. Platelets and injured tissue release chemical mediators that promote aggregation (clumping of platelets) and result in activation of the coagulation cascade. Activation of the coagulation cascade results in the formation of thrombin. Thrombin converts fibrinogen to fibrin. Fibrin strands become cross-linked forming a fibrous mesh which entangles platelets over the wound creating a clot**.** t-PA binds to fibrin in a clot and converts fibrin bound plasminogen to plasmin. Plasmin initiates local fibrinolysis causing the clot to dissolve. While the activity of t-PA is relatively specific to fibrin-bound plasminogen, systemic bleeding complications may occur following the administration of t-PA. t-PA is primarily used in the management of ischemic stroke, myocardial infarction, and pulmonary embolus. It is also used to restore function in central venous lines and other devices that have become occluded by a clot. In patients with ischemic stroke, the window for the administration of systemic IV t-PA is within 3 hours after the time the patient was last seen normal, but in some patients the window may be increased up to 4.5 hours.

Protocol Indication(s):

1. Ischemic stroke

Contraindications:

1. Known hypersensitivity
2. BP >185/110 on repeated measurements at time of treatment (not responsive to anti-hypertensive medications)
3. Significant head trauma or prior stroke in the previous 3 months
4. Presentation suggestive of subarachnoid hemorrhage (even if head CT is negative for hemorrhage)
5. Arterial puncture at a non-compressible site in previous 7 days
6. History of previous intracranial hemorrhage, intracranial neoplasm, AVM, or aneurysm
7. Recent intracranial or intraspinal surgery
8. Active internal bleeding
9. Platelet count <100,000
10. Heparin received within 48 h resulting in abnormally elevated aPTT
11. Current use of an oral anticoagulant with INR >1.7 or PT >15s
12. Current use of a thrombin inhibitor or direct 10a inhibitor with elevated sensitive laboratory tests

Contraindications:

13. Blood glucose concentration <50 mg/dL
14. CT evidence of multilobar infarction (hypodensity >1/3 cerebral hemisphere)
15. Additional exclusionary criteria for the administration beyond 3 hours following the onset of stroke symptoms include: age >80 yo, use of oral anticoagulants (regardless of INR), baseline NIHSS score >25, imaging evidence of ischemic injury involving more than one third of the MCA territory, or a history of both stroke and diabetes mellitus.
16. Minor or rapidly improving stroke symptoms (relative)
17. Pregnancy (relative)
18. Seizure at onset with postictal residual neurological impairments (relative)
19. Major surgery or serious trauma within previous 14 days (relative)
20. Recent (within 21 days) gastrointestinal or urinary tract hemorrhage (relative)
21. Recent (within 3 mo) acute myocardial infarction (relative)

Precautions:

1. For any acute worsening of neurologic condition, or if patient develops severe headache, acute hypertension, nausea, or vomiting (suggestive of ICH), discontinue the t-PA infusion and contact medical control for further instructions including decision to adjust antihypertensive agents and/or diversion to nearest hospital.
2. Patients should have frequent monitoring of their BP (generally every 5 minutes in the EMS/transport setting) while receiving t-PA.
3. The following procedures should not be performed within 24 hours of t-PA administration (unless lifesaving): arterial or central venous punctures/lines, IM injections, nasogastric tubes, or urinary catheter insertion.
4. Do not give any antithrombotic drugs (including heparin, warfarin, aspirin, clopidogrel, dipyridamole, ticlopidine, or NSAIDS) for 24 hrs. following t-PA administration.
5. Mild orolingual angioedema may be seen in a small percentage of patients receiving t-PA. It is typically mild and transient, and affects the contralateral side from the hemisphere of ischemic injury.
6. Severe angioedema is a rare occurrence, but may occur. If the patient develops stridor, immediately discontinue the infusion, provide appropriate airway management and contact medical control.
7. Minor bleeding may occur after t-PA administration. Oozing at IV sites, ecchymosis (particularly under BP cuffs), and gingival bleeding are frequently seen. In these cases, there is no need to stop the infusion, monitor for further or more extensive bleeding.
8. Major systemic bleeding (GI, GU) may require that the infusion be discontinued. If this occurs, contact medical control.
9. If hypotension develops after infusion of t-PA, consider tamponade physiology.

Significant adverse/side effects:

1. Bleeding (minor and major, including intracerebral hemorrhage)
2. Angioedema
3. Arrhythmias (when administered for STEMI, reperfusion related)

Dosage per protocol(s): 2.13 t-PA for Acute Ischemic Stroke

Notes:

- The current use of aspirin, NSAIDs or antiplatelet drugs (dipyridamole, ticlopidine, clopidogrel) are not contraindications to t-PA administration.
- The dose of t-PA for acute ischemic stroke is 0.9 mg/kg (maximum dose =90 mg). 10% of the dose is administered as an IV bolus over 1 minute and the remainder is infused over 1 hour. For dose determination, the patient's actual (measured) body weight should be used.
- Verify with the sending hospital that the excess tPA has been withdrawn from the tPA bottle and wasted, so that the tPA bottle will be empty when the full dose is finished infusing. For example, if the total dose is 70 mg, then there would be an extra 30 cc that has been withdrawn and wasted since a 100 mg bottle of tPA contains 100cc of fluid when reconstituted.
- When pump alarms to signify that the infusion is complete (bottle is empty) there will still be some tPA left in the tubing which must be infused. Remove the IV tubing connector from the t-PA bottle and attach it to a newly spiked bag of 0.9% NS and re-start the infusion at the same rate. The pump will stop automatically when the preset volume has been infused (the total volume must equal or exceed the amount of residual t-PA in the administration set).

Tranexamic Acid (TXA)

Classification: Anti-fibrinolytic

General:

TXA is a synthetic derivative of lysine that inhibits fibrinolysis by blocking the lysine binding sites on plasminogen. Part of the physiologic response to trauma and surgery in any patient is the formation and subsequent breakdown (fibrinolysis) of clots. In some cases, clot breakdown can become excessive (hyper-fibrinolysis) thus causing increased hemorrhage. TXA inhibits both plasminogen activation and plasmin activity thus preventing clot breakdown rather than promoting new clot formation. Other potential mechanisms of action including decreasing the systemic inflammatory response to trauma are being explored.

Protocol Indication(s):

1. Patients with blunt or penetrating trauma (including extremity trauma) with signs of significant hemorrhage (SBP < 90 mm Hg, HR > 110 BPM); or who are considered in paramedic judgment to be at high risk of significant hemorrhage (external or internal)

Contraindications:

1. Known hypersensitivity
2. Time elapsed from injury >3 hours
3. Age <16 years
4. Isolated closed head injury
5. Pregnancy ≥24 weeks
6. Patient who has or will receive prothrombin complex concentrate (PCCs), or factor VIIa complex concentrates

Precautions:

1. TXA should be used cautiously in the setting of urinary tract bleeding as ureteral obstruction due to clotting has been reported.
2. Do not administer in the same IV/IO as blood products or penicillin.
3. A second (maintenance) dose must be given over 8 hours. EMS providers must clearly communicate to the receiving facility staff that a loading does was administered in the field.

Significant adverse/side effects:

1. Hypotension (if given IV push)
2. Nausea/vomiting
3. Diarrhea

Dosage per protocol(s): 2.21 Hemorrhagic Shock - Adult

Vecuronium (Norcuron)

Classification: Non-depolarizing neuromuscular blocking agent

General:

Vecuronium competes with acetylcholine (Ach) for binding at nicotinic receptors at the neuromuscular junction preventing depolarization of the muscle cell membrane and inhibiting muscular contraction. Because these agents compete with Ach at the receptor, they are called competitive blockers. Vecuronium is used to facilitate ventilation in the patient with an advanced airway in place. Vecuronium does not cross the blood brain barrier and has no sedating or analgesic properties and therefore, sedation and analgesia must be administered prior to or at the same time it is administered. Vecuronium has an onset of action of 2-4 minutes and has a 30-40 minute duration of action (dose dependent).

Protocol Indication(s):

1. Facilitation of ventilation in a patient with an advanced airway in place

Contraindications:

1. Known hypersensitivity
2. Lack of ability continuously monitor waveform capnography.

Precautions:

1. Vecuronium should only be administered by providers skilled in advanced airway management, including performing cricothyrotomy.
2. Advanced airway placement must be confirmed by the presence of a capnographic waveform for ≥6 breaths prior to administration and waveform capnography must be continuously monitored following the administration of vecuronium.
3. Providers must be vigilant for signs of unintentional awareness (patient is awake, but under paralysis) or pain perception requiring additional sedation/analgesia. Signs may include tachycardia, hypertension, ocular tearing.
4. Vecuronium should be dosed on ideal body weight.

Significant adverse/side effects:

None of clinical significance.

Dosage per protocol(s): 2.07 Patient Comfort – Adult