Emergency and Critical Care Pharmacology: Commonly Used Drugs

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General Nursing Considerations

- Indications
- Medication dilution
- Administration
  - Constant rate infusions (CRI)
- Medication compatibility
  - The Kings Guide to Parenteral Admixtures
    (www.kingguide.com)
  - Handbook of Injectable Drugs
  - Knowledge of potential side effects or adverse reactions
  - Plumb’s Veterinary Drug Handbook
**Constant Rate Infusions (CRI)**

- Used in drugs that have rapid onset and short duration of action
- Reduces amount of drug used over time
- Avoids peaks and valleys

**Quick CRI Formula #1**

45 kg patient to receive 5 µg/kg/min dopamine CRI

\[
\text{BW}_{\text{kg}} \times \text{Dose (µg/kg/min)} = \text{mg drug qs to 250 ml of NaCl} \\
\text{Administer at 15 ml/hr}
\]

\[
45 \times 5 = 225 \text{ mg}
\]

5.6 ml of 40 mg/ml dopamine is placed in 244 ml NaCl and given at 15 ml/hr

**CRI Formula # 2 (Mg Drug to Add to a Solution)**

45 kg patient to receive 5 µg/kg/min dopamine CRI

\[
M = \frac{(D)(W)(V)}{(R)(16.67)}
\]

\[
M = \frac{(5)(45)(250)}{(15)(16.67)}
\]

\[
M = 56.250 / 250 = 225 \text{ mg}
\]
CRI Formula #2 (Change in Rate)

45 kg patient to receive 10 µg/kg/min dopamine CRI

\[ R = \frac{(D \text{ adjusted})(W)(V)}{M}(16.67) \]

\[ R = \frac{(10)(45)(250)}{225}(16.67) \]

\[ R = 112.500 \div 3,750.75 \]

\[ R = 30 \text{ mL/hr} \]

- \( M \) = milligrams of drug to add to base solution
- \( D \) = dosage of drug in mcg per kg per min
- \( D \text{ adjusted} \) = new dose rate of drug
- \( W \) = body weight in kg
- \( V \) = volume in ml of base solution
- \( R \) = fluid rate in mL/hr
- \( 16.67 \) = conversion factor

Oxygen Therapy

- **Indications**
  - Hypoxemia
  - \( \text{PaO}_2 \) < 80 mmHg
  - \( \text{SpO}_2 \) < 95%
  - Respiratory distress
- **Objective**
  - Correct hypoxemia using the lowest possible \( \text{FIO}_2 \)
- **Administration techniques**
- **Pros**
- **Cons**
Oxygen Therapy

- Contraindications
- Potential complications
  - Diminished or lost the hypercapnic respiratory stimulus to breath
  - Oxygen toxicity
    - P:F > 100% - 24 – 72 hrs
    - P:F > 60% not more than 24 – 72 hrs.
  - Airway inflammation, increased tissue permeability resulting in pulmonary edema, and finally interstitial fibrosis and permanent lung damage

Crystalloids

- Composition
  - Sodium, chloride, potassium, magnesium or calcium, buffer
  - Sodium distribution
    - Sodium major solute in extracellular space, majority extracellular space is extravascular, therefore sodium will reside outside the vascular space

Classification
- Extracellular fluid (ECF) replacement (Isotonic)
- Maintenance (Hypotonic)
- Hypertonic
Electrolyte Composition of Fluids

<table>
<thead>
<tr>
<th>Solution</th>
<th>Na⁺ (mEq/L)</th>
<th>K⁺ (mEq/L)</th>
<th>Cl⁻ (mEq/L)</th>
<th>Ca²⁺ (mEq/L)</th>
<th>Mg²⁺ (mEq/L)</th>
<th>HCO₃⁻ (mEq/L)</th>
<th>Osmolarity (mOsm/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECF (Plasma)</td>
<td>145</td>
<td>4</td>
<td>110</td>
<td>5</td>
<td>3</td>
<td>24</td>
<td>290</td>
</tr>
<tr>
<td>Lactated Ringers</td>
<td>130</td>
<td>5</td>
<td>109</td>
<td>3</td>
<td>0</td>
<td>28</td>
<td>274</td>
</tr>
<tr>
<td>Hartmann’s</td>
<td>151</td>
<td>5</td>
<td>111</td>
<td>2</td>
<td>0</td>
<td>27</td>
<td>294</td>
</tr>
<tr>
<td>Normosol - R</td>
<td>140</td>
<td>5</td>
<td>98</td>
<td>0</td>
<td>3</td>
<td>27</td>
<td>294</td>
</tr>
<tr>
<td>Plasma 154</td>
<td>150</td>
<td>5</td>
<td>108</td>
<td>3</td>
<td>0</td>
<td>28</td>
<td>278</td>
</tr>
<tr>
<td>3% NaCl</td>
<td>126</td>
<td>0</td>
<td>154</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>158</td>
</tr>
<tr>
<td>5% NaCl</td>
<td>1283</td>
<td>0</td>
<td>1283</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2068</td>
</tr>
<tr>
<td>Normosol - R in 5% Dextrose</td>
<td>16</td>
<td>12</td>
<td>98</td>
<td>0</td>
<td>3</td>
<td>16</td>
<td>294</td>
</tr>
<tr>
<td>Plasma 58</td>
<td>16</td>
<td>13</td>
<td>92</td>
<td>0</td>
<td>3</td>
<td>16</td>
<td>311</td>
</tr>
<tr>
<td>3% Dextrose in 1/2 strength Lactated Ringers</td>
<td>80.5</td>
<td>3</td>
<td>58</td>
<td>1.6</td>
<td>0</td>
<td>16</td>
<td>292</td>
</tr>
</tbody>
</table>

Colloids

- Large molecular weight solutions
- Colloid fluids contain a suspension of particles that exert an oncotic pressure that attracts water
- Better blood volume expanders than isotonic crystalloids, 50 - 80% of the infused volume remains in the intravascular space
- Colloid types
  - Naturally occurring
  - Synthetic

Colloid Indications

- Crystalloids not effectively improving or maintaining blood volume restoration
- Administered when the total protein or albumin are decreased below 3.5 g/dL (35 g/L) or 1.5 g/dL (15 g/L) respectively
- To support colloid oncotic pressure when the COP is measured in the low teens
- If edema develops prior to adequate blood volume restoration
- Capillary permeability problems or capillary leak syndrome.
- Clotting factor replacement (Plasma)
Physical Properties of Isotonic Crystalloids and HES

<table>
<thead>
<tr>
<th>Isotonic crystalloid</th>
<th>Hesaplast 6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average MW - kD</td>
<td>0</td>
</tr>
<tr>
<td>Number Av MW - kD</td>
<td>0</td>
</tr>
<tr>
<td>Osmolality - mOsm/L</td>
<td>250-308</td>
</tr>
<tr>
<td>CPP - mmHg</td>
<td>0</td>
</tr>
<tr>
<td>Maximum volume expand - %</td>
<td>20-25</td>
</tr>
<tr>
<td>Duration of volume expand - hrs</td>
<td>1.4</td>
</tr>
<tr>
<td>Plasma half-life - hrs</td>
<td>0.5</td>
</tr>
</tbody>
</table>

General Concerns

- Calculation of fluid volume are based on subjective data, potential inaccuracies occur. Necessary to reassess the patient often.
- The patient may require more or less of the original calculated fluid volume.
- You are looking for a resolution in the signs that indicated that the patient needed fluids.
- It is necessary to reassess the patient’s condition frequently (i.e. about every 10 - 15 minutes) during large or rapid volume fluid administration.
- Colloids and crystalloids can negatively affect coagulation factors.
- HES solutions impairs coagulation.
- Decreasing von Willebrand factor and factor VIII up to 80%
- Platelet function is also inhibited.

Anticholinergics - Atropine & Glycopyrrolate

- **Action**
  - Parasympatholytic
  - Blocks muscarinic stimulatory effects
  - Salivation, lacrimation, vomiting diarrhea, miosis and bradycardia

- **Indications**
  - Treat vagally mediated bradycardia
  - Treat organophosphate carbamate toxicity
  - Pre-anesthetic medication

- **Atropine vs Glycopyrolate**
  - Longer duration of action
  - Does not cross the placenta or blood-brain barrier

- **Administration**
  - IM, IV
**Sympathomimetics**

- **Indications**
  - When patient is unresponsive to vigorous fluid therapy
  - When arterial blood pressure (BP), vasomotor tone, and tissue perfusion have not returned to acceptable levels
  - Support myocardial contractility
- **Examples**: Dopamine, Dobutamine, Epinephrine, Norepinephrine

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**Components of O₂ Delivery**

- MAP
- SVR
- SV
- Preload
- Contractility
- Afterload
- DO
- HR
- Hgb
- O₂ Context
- PaO₂
- DO₂

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**Dopamine**

- **Action**
  - Dose dependent effects
  - Dopaminergic
    - Beta 1
    - Alpha
- **Administration**
  - Given as CRI – dilute D5W or 0.9% NaCl
  - Starting in midrange dose, titrate (0.5 – 3µg/kg/min) to effect
**Dobutamine**

- **Action**
  - Primarily beta 1
  - Increase contractility
- **Administration**
  - Given as CRI – dilute D5W or 0.9% NaCl
  - Titrate to effect

**Epinephrine**

- **Action**
  - Alpha 1
  - Vasoconstriction
  - Beta 1
  - Increase heart rate
  - Beta 2
  - Dilates bronchioles
- **Administration**
  - Bolus or CRI
  - Bolus in CPR

**Norepinephrine**

- **Action**
  - Alpha 1
  - Beta 1
- **Administration**
  - Given as CRI – dilute D5W or 0.9% NaCl
  - Titrate to effect
Smooth Muscle Vasoconstrictor - Vasopressin

- **Action**
  - Vasopressin acts as a direct peripheral smooth muscle vasoconstrictor

- **Uses**
  - CPR - alternative to epinephrine
  - Septic shock

Vasodilators

- **Venodilators**
  - Expands vascular capacity by dilating veins, which reduces preload and venous pressure.
  - Reduce congestion but not improve cardiac output
  - Example: Nitroglycerin

- **Arterial vasodilators**
  - Decrease systemic vascular resistance, which reduces afterload and improves cardiac output
  - Decreases the work of the heart
  - Example: Clevidipine

Venodilator - Nitroglycerin

- **Administration**
  - Applied transdermally, usually on the pinna of the ear or some other hairless spot
  - Dose measured in inches by application of a strip of ointment to a measuring paper
  - Gloves should be worn when applying the ointment
  - Should not be touch application site with bare hands
  - Application site should be rotated.
Arterial Vasodilator - Clevidipine

- **Action**
  - Dihydropyridine calcium channel blocker
  - And is a smooth muscle vasodilator

- **Uses**
  - Goal: reduce blood pressure
  - Treat transient heart failure
  - Severe hypertenion

- **Administration**
  - Aseptic technique used when handling this medication
  - Not diluted
  - Dedicated IV line
  - Should be used within 12 hours

- **Administration**
  - Titrated to effect by doubling the dose every 90 seconds.
  - As the blood pressure approaches goal, the infusion rate should be increased in smaller increments and titrated less frequently
  - Primary concern is hypotension
  - Heart rate and blood pressure should be measured continuously
  - Assess perfusion parameters until the patient is stable
  - If hypotension, the drug is reduced or turned off; effects will dissipate within a few minutes.

General Concerns - Vasoactive Drugs

- Most if not all drugs are titrated to effect
- **Monitor**
  - Direct BP monitoring is desirable but indirect methods are also acceptable
  - Regardless, it is recommended that BP is monitored
  - Perfusion parameters
  - Mentation, mucous membrane color, capillary refill time, heart rate, and pulse quality
  - Sympathomimetics should not be a substitute for adequate volume restoration
Antiarrhythmic – Lidocaine (Class 1B)

- **Action**
  - Sodium channel blocker, blocks fast sodium channels responsible for rapid depolarization
- **Indications**
  - Used to treat ventricular arrhythmias if cardiovascularylly unstable
- **Administration**
  - Initial bolus (undiluted), if responsive then CRI
  - **CRI**
    - Diluted in either D5W or 0.9% NaCl compatible with LRS
    - Usually titrated to effect
    - Titrated in 5 µg/kg/min increments every 10 to 15 min until:
      - Desired effect is seen
      - Maximum dose has been reached
      - Adverse signs are seen

**Potential adverse effect:**
- Nausea
- Vomiting
- Tremors
- Seizures
- Hypotension
- Bradycardia

**General**
- Cats more sensitive than dogs
  - Usual in much lower doses
  - May exhibit central nervous system signs

**Weaning**
- Slow or stop infusion, notify clinician

Diuretic - Furosemide

- **Action**
  - Loop diuretic, meaning it acts primarily in the ascending loop of Henle
  - Natriuretic
  - Renal vasodilator
- **Administration – Anuria / Oliguria**
  - Used in high doses for anuria
  - If no effect another diuretic or combination of diuretics
  - Used in low doses for oliguria
  - Given as an IV bolus or CRI
Diuretic - Furosemide

▪ Action
  ▪ In heart failure decreases blood volume and reduces capillary pressure
▪ Administration – Heart Failure
  ▪ IV bolus, IM, CRI
    ▪ Administration by IV bolus is not often done due to its effect on urine output
    ▪ CRI – loading dose first
  ▪ Potential adverse effects
    ▪ Excessive diuresis and dehydration,
    ▪ Hypokalemia
    ▪ Hypotension,
    ▪ Hyperkalemia, hypernatremia, metabolic alkalosis
    ▪ Vomiting and diarrhea
    ▪ Potentially potentiating nephrotoxic effects of action drugs

Mannitol

▪ Actions
  ▪ Osmotic diuretic
  ▪ Free radical scavenger
  ▪ Rheologic properties
▪ Indications
  ▪ Increased intracranial pressure, cerebral edema
  ▪ Cushing’s triad
  ▪ Deterioration level of consciousness
  ▪ Changes in resting pupil size and/or loss of pupillary light response
  ▪ Acute kidney injury
  ▪ Acute / oliguria

▪ Administration
  ▪ May be given as an intermittent bolus or as a CRI. 20% and 25% mannitol
  ▪ May be diluted with D5W for peripheral vein
  ▪ Use a 18 – micron Hemo-Nate filter
▪ General
  ▪ Response may be seen within 10 minutes, maximal effects are noted at 20 – 40 minutes
  ▪ Mannitol may be continued in patients with volume overload and intracranial hemorrhage
  ▪ Can be piggybacked with other crystalloids
  ▪ May crystallize when exposed to low temperatures; solutions less than 15% are less likely to crystallize
Regular Crystalline Insulin

**Action**
- Promotes entry of glucose and potassium into the cell
- Inhibits the release of glucagon (prevents gluconeogenesis / glycogenolysis)
- Inhibits ketone production

**Indications**
- Treatment of hyperglycemia secondary to DKA
- Treatment option for hyperkalemia

Regular Crystalline Insulin - DKA

**Insulin Administration**
- **Intramuscular technique**
  - Insulin is administered every 2 hours based upon the blood glucose level while adjusting the dose up or down depending on the rate of declining glucose levels.
  - As blood glucose approaches 250 mg/dL, the q2 hour IM insulin dose can be changed to the subcutaneous route and administered every four to six hours.
  - When the patient is eating and drinking, no longer ketotic and is not vomiting the regular insulin may be switched to a long-acting form.

Regular Crystalline Insulin - DKA

**Insulin Administration**
- **CRI technique**
  - With the regular insulin CRI, the regular insulin dose is diluted in 250 mL of 0.9 % saline.
  - Insulin binds to glass and plastic, so the first 50 mL of the infusion should be discarded.
  - Insulin infusion is piggybacked on to the primary fluid line and administered with a fluid infusion pump.
  - Insulin rate is adjusted according to a dosing table.
  - The goal is essentially the same as the IM technique.
### Regular Crystalline Insulin - Hyperkalemia

- **Insulin Administration**
  - Insulin is given with dextrose to minimize the risk of the patient becoming hypoglycemic.

- **General Concerns**
  - Regular insulin is considered a fast-acting insulin with a duration of 1 – 4 hours.
  - Blood glucose is monitored at the appropriate frequency.

- **Potential for adverse effects**
  - Signs seen related to overdose, at risk for hypoglycemia:
    - Weakness
    - Ataxia
    - Seizures
    - Cerebral edema secondary to rapid glucose reduction (> 75 mg/dL/hr)

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### Prokinetic - Metoclopramide

- **Action**
  - Antiemetic action due to its antagonist activity at Dopamine D₂ receptors in the chemoreceptor trigger zone.
  - Mixed serotonin 5-HT3 receptor antagonist/5-HT4 receptor agonist.

- **Indication**
  - Enhance gastrointestinal motility and promote gastric emptying.

- **Administration**
  - Can be given IV, subcutaneously, and orally.
  - CRI
    - Dilute the drug to a concentration of 1 mg/mL in 0.9% saline.
  - Dose is divided over 24 hrs.
**Prokinetic - Metoclopramide**

- **Contraindications**
  - Contraindicated in cases of gastric outflow or gastrointestinal obstruction due to foreign body or intussusception

- **Potential adverse effects**
  - Increase in seizure activity in epileptics
  - Sedation
  - Hyperactivity
  - Changes in behavior
  - Diarrhea
  - Abdominal pain

**Serotonin 5HT₃ Antagonist - Ondansetron**

- **Indications**
  - Antiemetic and nausea

- **Administration**
  - Administered intravenously over 2 to 5 mins but no less than 30 seconds
  - Compatibilities: PlasmaPlex A, 0.9% NaCl, D₅W
  - Incompatibilities: Ampicillin, Timentin, Faneomycin, and Enrofloxacin

- **Potential adverse effect (Rare People)**
  - Hypotension, tachycardia, rash, neurologic signs and hypokalemia

**Protein pump inhibitor - Pantoprazole**

- **Indication**
  - Acid reducer – GI protectant

- **Administration**
  - Standard dilution
  - Administered over 3 – 5 minutes
  - Dilute for CRI: dilute to 0.4 mg/mL in 0.9% NaCl
  - Over 30 minutes
  - Compatibilities: Lactated Ringer's solution and D₅W
  - Incompatibilities: Midazolam, magnesium sulfate and zinc containing solutions

- **Adverse effects reported in people**
  - Headache, diarrhea, constipation and abdominal pain
Summary

- Medication administration is not a benign procedure. Medication administration requires
  - Forethought
  - Attention to detail
  - Vigilance