Fluids, Electrolytes and Common Post Operative Problems

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Overview

- Fluids, electrolytes and trace elements
- Blood products
- Case presentations of common post operative complications
IV Fluid
Fluid Replacement

- **Hourly requirements**
  - 1st 10 kg  4 ml/kg/ hour
  - 2nd 10 kg  2 ml/kg/ hour
  - After 20 kg  1 ml/kg/hour
- Example 90 kg female would require
  - 40 ml
  - 20 ml
  - 70 ml
  - Equals 130 ml/hour
  - Or 3120 ml/day

- **Daily requirements**
  - 1st 10 kg  100 ml/kg/day
  - 2nd 10 kg  50 ml/kg/day
  - After 20 kg  20 ml/kg/day
- Example 90 kg female would require
  - 1000 ml
  - 500 ml
  - 1400 ml
  - Equals 2900 ml/day
Electrolyte Replacement

- Daily requirements of major electrolytes
  - Sodium 1 mEq /kg/ day
  - Potassium 1 mEq /kg/ day
  - Chloride 1 mEq /kg/ day
  - Calcium 2 g/ day
  - Magnesium 20 mEq / day
- Example of a 90 kg woman
  - 90 mEq needed for Na, K, Cl
  - Rational that 1 liter of ½ NS would cover daily requirements
  - 1 liter of ½ NS has 77 mEq of Na and Cl
## Types of Fluid

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Na</th>
<th>Cl</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Buffers</th>
<th>pH</th>
<th>Osmolality</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45% NaCl</td>
<td>77</td>
<td>77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.7</td>
<td>154</td>
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<tr>
<td>0.9% NaCl</td>
<td>154</td>
<td>154</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.7</td>
<td>308</td>
</tr>
<tr>
<td>3.0% NaCl</td>
<td>516</td>
<td>516</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.7</td>
<td>1032</td>
</tr>
<tr>
<td>Lactated Ringers</td>
<td>130</td>
<td>109</td>
<td>4</td>
<td>3</td>
<td></td>
<td>Lactate (28)</td>
<td>6.4</td>
<td>273</td>
</tr>
<tr>
<td>Normosol</td>
<td>140</td>
<td>98</td>
<td>5</td>
<td>3</td>
<td></td>
<td>Acetate (27)</td>
<td>7.4</td>
<td>295</td>
</tr>
</tbody>
</table>
IV Fluids

- 75-85% of a patient's Na is in the extracellular space
- Exogenous fluid administration follows that same distribution
- If 1 liter of NS is given: 275 ml will remain within the intravascular system
- 500 ml bolus of NS only places 125 ml in the intravascular space
Lactated Ringers Solution

- Calcium binds to anticoagulant factors in packed red blood cells thereby causing clotting of donor blood.
- Calcium also decreases the efficacy of certain drugs:
  - Thiopental
  - Amicar
  - Amphotericin
  - Amoxicillin
  - Doxycycline
Dextrose

- 5% dextrose is commonly added to IVF
- Provides 170 kcal per liter (50g)
- Increases the osmolality by 278
- D5NS now has osmolality 560
- D5LR osmolality 525
- This increased osmolality dehydrates cells and can worsen intracellular dehydration in elderly or insulin resistant women
- If nutrition needed recommend parenteral or enteral feedings
Question #1

- Which body fluid has the highest concentration of sodium?
  - Sweat
  - Lasix induced diuresis
  - Diarrhea
  - Gastric secretions
  - Small bowel secretions
Hyponatremia

- $\text{Na}^+ < 136 \text{ mmol/L}$, serious symptoms $< 125 \text{ mmol/L}$
- Symptoms
  - Weakness
  - Confusion
  - Fatigue
  - Muscle cramps
  - Headache
  - Seizures
  - Coma
  - Cerebral edema
Hyponatremia

- Hypovolemic hyponatremia
  - N/V/D
  - Burn victims
  - Diuretics

- Normovolemic hyponatremia
  - SIADH

- Hypervolemic hyponatremia
  - CHF
  - Hepatic failure
  - CRF
## Hyponatremia

<table>
<thead>
<tr>
<th>Fluids Commonly Lost</th>
<th>Sodium Concentration mEq/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>40</td>
</tr>
<tr>
<td>Gastric secretions</td>
<td>55</td>
</tr>
<tr>
<td>Furosemide diuresis</td>
<td>75</td>
</tr>
<tr>
<td>Sweat</td>
<td>80</td>
</tr>
<tr>
<td>Small bowel secretions</td>
<td>145</td>
</tr>
</tbody>
</table>
Hyponatremia

- Correction done with NS infusion
- Can use hypertonic saline (3% NS), rapid correction can lead to central pontine myelinolysis
- Aim for 0.5 mEq/L/hour
- Formula Na needed equals (target Na minus actual Na) × 0.6 (patients weight in kg)
- Example 90 kg women with a coma and Na of 120
  
  \[(140-120) \times 0.6 \times 90 = 1080 \text{ mEq Na needed}\]
- Roughly 7 liters of NS
Hypernatremia

- \( \text{Na}^+ > 143 \, \text{mmol/L} \)

- Symptoms
  - Confusion
  - Seizures
  - Ataxia

- Hypovolemic hypernatremia
  - N/V/D

- Normovolemic hypernatremia
  - Diabetes insipidus

- Hypervolemic hypernatremia
  - Hypertonic fluids

- Treatment for hypernatremia
  - Aim for 0.5 mEq/L/hour correction
  - \( \frac{1}{2} \) NS works well
Hypokalemia

- $K^+ < 3.5$ mmol/L
- Symptoms
  - Arrhythmias
  - Increased QT, flattened T waves
- Causes
  - N/V/D
  - Diuretics
- Treatment
  - Potassium replacement
  - Rule of thumb: 10 mEq IV replaces 0.1 mmol/L in serum
Question #2

- A 35 year old female is admitted for cervical cancer. She is found to have a serum creatinine of 9.6 and a serum potassium of 7.9 mmol/L. All the following are acceptable management solutions except.
  - Calcium gluconate
  - Sucralfate
  - Lasix
  - Insulin
  - Sodium bicarbonate
Hyperkalemia

- $K^+ > 5.0$ mmol/L
- Symptoms
  - Weakness
  - Lethargy
  - Peaked T waves, widened QRS complex, prolonged PR interval
  - Leads to V fib or asystole
- Causes
  - Renal failure
  - Crush injuries, tumor lysis
  - Adrenal insufficiency
Hyperkalemia

- **Treatment**
  - 1 amp of calcium gluconate to protect the membrane potential of cardiac cells
  - Insulin 10-20 units transiently drives K into the cell
  - Sodium bicarbonate increases pH and preferentially drives H\(^+\) out of the cell in exchange for K\(^+\)
  - Kayexalate (PO or PR) will bind to K\(^+\) and be eliminated
  - Dialysis if overwhelming hyperkalemia
Hypocalcemia

- Ca$^{++} < 8.8$ mg/dl

**Symptoms**
- Neuromuscular spasms
- Tetany – Chvostek’s or Trousseau’s sign
- Increased QT interval
- Depression

**Causes**
- CRF
- decreased Vitamin D
- hypoparathyroidism
- Sepsis

**Treatment**
- Calcium and Vitamin D replacement
Question #3

- A 40 year old women treated 8 months ago for a MMT of the uterus presents to the ED for confusion. She is audibly moaning and complaining of pain. Her family states she cannot get enough to drink. What electrolyte disturbance is happening?
  - Hyponatremia
  - Hyperkalemia
  - Hypercalcemia
  - Hypomagnesemia
  - Hyperphosphatemia
Question #4

- A serum calcium is 14 mg/dl. A CT scan confirms multiple lytic lesions of her vertebral bodies. All of the following are correct except.
  - IV hydration with NS
  - Glucocorticoids
  - Lasix
  - Biphosphonate
  - Calcitonin
Hypercalcemia

- “Stones, bones, groans and mental overtones”
  - N/V common, ileus, constipation
  - Hypovolemia, hypotension
  - Shortened QT interval
  - Polyuria and nephrolithiasis
  - Confusion, coma

- Total serum calcium > 10 mg/dl

- Causes:
  - Hyperparathyroidism
  - Cancer- bony metastases
  - Above 2 reasons account for 90% of hypercalcemia
Hypercalcemia

- **Treatment**
  - NS diuresis with or without lasix
  - Calcitonin
    - Given as 4 U/kg q 12
    - Mild effect (decreases Ca$^{++}$ by 0.5 mmol/L)
  - Biphosphonates
    - Etidronate 7.5 mg/kg in 250 ml NS over 2 hours for 3 days
    - Zometa 4 mg IV infusion over 15 minutes, repeat in 7 days
  - Hemodialysis
Hypophosphatemia

- $\text{PO}_4 < 2.6 \text{ mg/dl}$

**Symptoms**
- Often silent; however
- Exacerbate CHF
- Anemia
- Decreases 2,3-diphosphoglycerate (shifts the oxyhemoglobin dissociation curve to the left)
- Weakness

**Causes**
- Glucose loading
- Respiratory Alkalosis
- Sepsis
- Diabetic ketoacidosis
- Decreased absorption
Hypophosphatemia

- **Treatment**
  - Oral replacement for values less than 2 mg/dl
  - Neutra-Phos or K-Phos recommend 1200-1500 mg/day (each tab is 250mg)
  - IV replacement for values less than 1 mg/dl
  - 0.08-0.16 mmol/kg IV over 6 hours
Hyperphosphatemia

- $\text{PO}_4 > 4.8 \text{ mg/dl}$
- Symptoms
  - ?
- Causes
  - Renal insufficiency
  - Tumor necrosis
- Treatment
  - Sucralfate
  - Hemodialysis
Question #5

- What is the most common laboratory finding of hypomagnesemia?
  - Hypokalemia
  - Hypophosphatemia
  - Hyponatremia
  - Hypocalcemia
Hypomagnesemia

- Mg++ < 1.5 mg/dl

Symptoms

- Decreased K⁺ (40%)
- Decreased PO4 (30%)
- Decreased Na⁺ (27%)
- Decreased Ca++ (22%)
- Arrhythmias
- Seizures

Causes

- Drugs- Lasix, aminoglycosides, cisplatin
- Diarrhea
- Diabetes
- Alcoholism
Hypomagnesemia

- Treatment
  - Oral replacement
    - Magnesium oxide 400 mg
    - Magnesium gluconate 500 mg
  - IV replacement
    - 1-2 g over 1 hour infusion
Question #6

- Hyporeflexia from hypermagnesemia commonly occurs above what serum level?
  - 2 mg/dl
  - 3 mg/dl
  - 4 mg/dl
  - 5 mg/dl
Hypermagnesemia

- Mg > 2.5 mg/dl

Symptoms
- Hyporeflexia 4 mg/dl
- Complete heart block 10 mg/dl
- Cardiac arrest 13 mg/dl

Causes
- Hemolysis
- Renal insufficiency

Treatment
- Calcium gluconate 1 g IV over 2-3 minutes
- Volume replacement and lasix
- hemodialysis
Question #7

- What trace element deficiency causes hair loss and dry skin?
  - Zinc
  - Copper
  - Manganese
  - Selenium
  - Molybdenum
Trace Elements

- **Zinc** (10-15 mg/day)
  - Alopecia, decreased immune system, dermatitis

- **Copper** (2-6 mg/day)
  - Anemia, decreased hair pigmentation, hypothermia

- **Manganese** (2.5 mg/day)
  - Bleeding disorder, decreased MMP’s

- **Selenium** (0.05-0.2 mg/day)
  - CHF, cardiomyopathy, decreased glutathione
Blood Products
Blood products

- Packed red blood cells pRBC’s
- Platelets
- Fresh frozen plasma (FFP)
- Cryoprecipitate
- Albumen
- Hetastarch
Question #8

- What is the least likely to occur during a blood transfusion?
  - CMV transmission
  - Hepatitis C transmission
  - Hepatitis B transmission
  - HIV transmission
  - Transfusion reaction
Question #9

- What product is least likely to transmit hepatitis?
  - Platelets
  - FFP
  - pRBC
  - Whole blood
  - Albumen
pRBC’s

- Colloid of choice for anemia/hypovolemia
- Raises hematocrit by 2 to 3% per unit
- 250-300 ml
- Comprised of RBC’s, plasma, nonfunctioning WBC’s and platelets
- Adverse effects:
  - Blood borne illnesses (HIV, Hep B, C, D, CMV)
  - Transfusion reactions
Transmission Rates

- Hepatitis B 1/60,000
- Hepatitis C 1/120,000
- HIV 1/500,000
- CMV 1/2 to 3
- Transfusion reaction 1/100 to 1/1000
Platelets

- Administer when platelet count < 10,000 (prophylaxis) or if < 20,000 and clinically hemorrhaging
- Comprised of platelets, nonfunctioning WBC’s, few RBC’s and plasma
- 50-70 ml per unit
- 1 six pack raises count by 36,000 to 48,000
- A single unit increases count by 6,000 to 8,000
- Awareness of antibody exposure (ITP not an indication for platelet transfusion)
FFP

- Acute correction of coagulopathy
- Comprised of II, V, VII, VIII, IX, XII, XIII and 500 mg fibrinogen
- 180 to 250 ml
- Increases factor levels by 3%
- Adequate clotting occurs with factors above 30%
- Short lived, must use 1-2 hours prior to procedure
- Not indicated after multiple units of pRBC’s
Cryoprecipitate

- Treatment of Hemophilia A, von Willebrand’s and hypofibrinogenemia
- Compromised of VIII, XIII, von Willebrand’s factor, fibronectin and 200 mg fibrinogen
- 5 to 15 ml
- Generally give 10 units at a time
- Good for coagulopathic patients who cannot withstand added fluid volume
Albumen

- It composes 75% of the oncotic pressure in plasma
- Available in 5% solution or 25% solution in 100 ml NS
- Molecular weight of 69 kd
- Half life of 16 hours
- 5% albumen has a plasma volume expansion of 0.7 to 1.3
- 25% albumen has a volume expansion of 4 to 5
- Therefore 100 ml of 25% albumen will increase the vascular volume by 400 to 500 ml
- No risk of Hepatitis transmission
Hetastarch

- Synthetic colloid of amylopectins
- Molecular weight of 69 kd
- Half life of 24 hours although excretion can take up to 17 days
- Plasma volume expansion of 1 to 1.3
- 500 mg given over 8 hours
- Anaphylaxis does occur in < 1%
Parasite #1
Case #1 (Mrs. Clonorchis Sinensis)

- This is a delightful 74 year old woman, widowed, with endometrial cancer. She has HTN, DM, COPD and a CVA with minimal deficits two years ago. She smokes 2 ppd and weighs 230 lbs. Her medications include Toprol XL 100 mg BID, Accupril 20 mg QD, Lasix 40 mg BID, Glucophage 500 mg BID, Glyburide 5 mg BID, Plavix 75 mg QD, Advair, Combivent, ASA 325 mg QD and a multivitamin. She is scheduled for a TAH/BSO/LNS. What preoperative testing would you order?

- CBC
- BMP
- CMP
- PT/PTT
- T & H
- T & C 2 units
- T & C 4 units
- ABG
- PFT
- ECHO
- EKG
- Carotid Doppler
- Cardiac Consult
- Exercise stress echo
- Dobutamine stress echo
- Coronary angiography
- Hemoglobin A1c
- TSH
Mrs. Clonorchis Sinensis

- Her surgery went without complications. What maintenance fluid would you start?
  - A) NS @ 125 ml/hr
  - B) ½NS @ 125 ml/hr
  - C) LR @ 125 ml/hr
  - D) NS @ 150 ml/hr
  - E) ½NS @ 150 ml/hr
  - F) LR @ 150 ml/hr
  - G) D5NS @ 125 ml/hr
  - H) D5½NS @ 125 ml/hr
  - I) D5LR @ 125 ml/hr
  - J) D5NS @ 150 ml/hr
  - K) D5½NS @ 150 ml/hr
  - L) D5LR @ 150 ml/hr
Mrs. Clonorchis Sinensis

- The night of surgery her urine output is 30 ml/hr, her pulse is 114.
  - 1) Is this adequate urine output?
    - 50 ml/hour
  - 2) What testing is needed?
    - Hematocrit
    - Spot urine sodium
    - FeNa
    - Recorded Ins and Outs
Fractional Excretion of Sodium (FeNa)

- \( \text{Urine}_{\text{Na}} \times 100 \)
- \( \text{Plasma}_{\text{Na}} \)
- \( \text{Urine}_{\text{Cr}} \)
- \( \text{Plasma}_{\text{Cr}} \)

- Values < 1 are prerenal
- Values > 2 are renal
Mrs. Clonorchis Sinensis

How would you improve her urine output?

- Lasix 20 mg IV
- Increase maintenance fluid to 200 ml/hour
- NS 500 ml bolus
- NS 1000 ml bolus
- NS 1000 ml bolus × 2
- Hespan 500 mg over 8 hours
- 2 units of pRBC’s
- 5% albumen over 1 hour
- 25% albumen over 1 hour
Mrs. Clonorchis Sinensis

- During the course of the night Mrs. S’s hematocrit is stable (34 from 38). She has a spot urine sodium of < 10. You have given 7 liters of fluid from 7 pm to 4 am. She has no signs of pulmonary edema. What do you do next?

  - Lasix 20 mg
  - Increase maintenance fluid to 200 ml/hour
  - NS 500 ml bolus
  - NS 1000 ml bolus
  - NS 1000 ml bolus × 2
  - Hespan 500 mg over 8 hours
  - 2 units of pRBC’s
  - 5% albumen over 1 hour
  - 25% albumen over 1 hour
Mrs. Clonorchis Sinensis

- The morning arrives and Mrs. S’s urine output remains above 70 ml/hr. She however has persistent tachycardia, 110 to 120. She is lethargic and complains of a headache, chest pain and SOB. You are rightfully concerned about what?

- MI
- Pulmonary embolism
- Pulmonary edema
- Anemia

How would you evaluate for these complications?
- Troponin, CK-MB, EKG
- Spiral CT of the chest
- CXR, JVD, Lung exam
- Hematocrit
Mrs. Clonorchis Sinensis

- After ruling out MI, PE, pulmonary edema and acute blood loss; Mrs. S feels great. It is POD 2. She has just started to tolerate clears. Her urine output has climbed to 120 ml/hr. After evening rounds, however, she again complains of SOB. A pulse oximeter reads 88%.
Mrs. Clonorchis Sinensis

- What’s happening?
  - Pulmonary edema and mobilization of fluid
- Management
  - 1) Lasix 40-80 mg with assessment by pulmonary exam and urine output every eight hours
  - 2) DECREASE FLUID RATE
POD 4 arrives. Mrs. S is tolerating regular diet. She has diuresed 8 liters of fluid. Before discharge she complains of a bloody discharge / drainage from her incision. What is your management?

- Assessment with q-tip reveals copious amount of serosanguinious fluid.
- Fascia is intact
- Packing wet to dry TID. No antibiotics. Home health
Case #2 (Mrs. Ascaris Lumbricoides)

- Mrs. A is referred for ascites and a pelvic mass (12 × 10 cm). She is in pain, has nausea and vomiting. Her past medical history is significant for HTN, DM, CAD and cirrhosis from alpha 1 antitrypsin disease. She is expedited to the O.R. Preoperative labs reveals a HCT 28, Cr 1.5, AST 60, ALT 70, PT 15 with INR 1.5.

- The surgery reveals an extensive ovarian carcinoma. It is optimally debulked. Ascites measured 6 liters and blood loss of 400 cc

- Intraoperative resuscitation was 2 units pRBC’s, 3000 cc of NS.
Mrs. Ascaris Lumbricoides

- NOS is as expected. Mrs. A has been bolused with 4 liters of crystalloid. Her urine output is suboptimal. What next...?
  - Lasix 20 mg
  - Increase maintenance fluid to 200 ml/hour
  - NS 500 ml bolus
  - NS 1000 ml bolus
  - NS 1000 ml bolus × 2
  - Hespan 500 mg over 8 hours
  - 2 units of pRBC’s
  - 5% albumen over 1 hour
  - 25% albumen over 1 hour
Mrs. Ascaris Lumbricoides

- Despite further hydration and colloid, her urine output is dismally low 10 ml/hour. She has a decreased O2 saturation 84%. What next…?
  - CXR
  - EKG
  - Troponin, CK-MB
  - Echo
  - Call fellow
  - Call attending
  - Swan-ganz
  - Spiral CT of chest
  - CBC
  - Nebulizer
  - Intubation
  - ICU
An ICU admission later, Mrs. A has a swan-ganz catheter. Her wedge pressure is 24 mm, her CVP is 16 mm. She continues to have minimal urine output: < 10 ml/hour. Her serum Cr has risen to 2.3. What can be done to improve her urine output and spare her kidneys from ATN?

- Lasix 20 mg
- Increase maintenance fluid to 200 ml/hour
- NS 500 ml bolus
- NS 1000 ml bolus
- NS 1000 ml bolus × 2
- Hespan 500 mg over 8 hours
- 2 units of pRBC’s
- 5% albumen over 1 hour
- 25% albumen over 1 hour
Parasite #3
Case #3 (Mrs. Diphyllobothrium Latum)

- Mrs. L is an unfortunate woman. She had an extensive frozen pelvis from an MMT of the uterus. Her SB mesentery was tethered necessitating a proximal ileostomy. It is POD 3 and she continues to have a prolific amount of succus. Your nurse points out to you that her respiratory rate is close to 40.
Mrs. Diphyllobothrium Latum

- What key electrolytes and vitamins are being lost?
  - Na
  - Cl
  - K
  - Mg
  - Bicarbonate
  - Vitamin A, D, E, K
  - Vitamin B12
Mrs. Diphyllobothrium Latum

- The daily loss of succus is 5 liters. How is this best replaced?
  - Lasix 20 mg
  - Increase maintenance fluid to 200 ml/hour
  - NS 500 ml bolus
  - NS 1000 ml bolus
  - NS 1000 ml bolus × 2
  - Hespan 500 mg over 8 hours
  - 2 units of pRBC’s
  - 5% albumen over 1 hour
  - 25% albumen over 1 hour
An ABG reveals a pH of 7.21 and a CO$_2$ of 20. What is the acid-base disturbance?

- Metabolic acidosis
- Metabolic alkalosis
- Mixed
- Respiratory alkalosis
- Respiratory acidosis
Mrs. Diphyllobothrium Latum

- How would you best manage her high output?
  - Somatostatin (Octreotide)
  - Cholestyramine
  - Omeprazole
  - Decreased lipid diet
  - High calorie, protein diet
  - Pepcid