Maine Medical Center
MaineHealth

Fluids/Lytes/Nutrition

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GENERAL SURGERY LECTURE 10.13.22

Total Body Water

- Roughly 2/3 of total body weight is water (**men**); **infants** have a little more body water, **women** have a little less
- 2/3 of water weight is intracellular (mostly muscle)
- 1/3 of water weight is extracellular
  - 2/3 of extracellular water is interstitial
  - 1/3 of extracellular water is in plasma

- **Volume overload** – most common cause is iatrogenic; first sign is **weight gain**
- **0.9% normal saline**: Na ___ and Cl ___
- **Lactated Ringer's solution**
  - **(LR; ionic composition of plasma):** Na 130, K 4, Ca 2.7, Cl 109, bicarb 28
- **Plasma Osmolarity:**
  - (2 x Na) + (glucose/18) + (BUN/2.8)
  - Normal: 280 – 295

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Estimates of Volume Replacement

- 4 cc/kg/hr for 1st 10 kg
- 2 cc/kg/hr for 2nd 10 kg
- 1 cc/kg/hr for each kg after that
- Best indicator of adequate volume replacement is _____

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- Best indicator of adequate volume replacement is **urine output**
- **Other indicators?**

- During open abdominal operations, fluid loss is _____unless there are measurable blood losses
- Usually do not have to replace blood lost unless it is **>500cc**
- **Insensible fluid loss** – 10 cc/kg/day, 75% skin, 25% respiratory, pure water

- During open abdominal operations, fluid loss is 0.5 – 1.0 L/hr unless there are measurable blood losses
- Usually do not have to replace blood lost unless it is **>500cc**
- **Insensible fluid loss** – 10 cc/kg/day, 75% skin, 25% respiratory, pure water

- **IV replacement after major adult gastrointestinal surgery**
  - During operation and 1st 24 hours, use ___
  - After 24 hours, switch to _____
    - 5% dextrose will stimulate insulin release, resulting in amino acid uptake and protein synthesis (also prevents protein catabolism)
    - D5 ½ NS @ 125/hr provides 150 gm glucose per day (525 kcal/day)

- **IV replacement after major adult gastrointestinal surgery**
  - During operation and 1st 24 hours, use **LR**
  - After 24 hours, switch to **D5 ½ NS with 20 mEq K^+**
    - 5% dextrose will stimulate insulin release, resulting in amino acid uptake and protein synthesis (also prevents protein catabolism)
    - D5 ½ NS @ 125/hr provides 150 gm glucose per day (525 kcal/day)

GI Fluid Secretion

- Stomach 1 – 2 L/day
- Biliary system 500 – 1000 ml/day
- Pancreas 500 – 1000 ml/day
- Duodenum 500 – 1000 ml/day

- **Normal K^+ requirement:** 0.5 – 1.0 mEq/kg/day
- **Normal Na^+ requirement:** 1 – 2 mEq/kg/day

GI Electrolyte Losses

- Sweat – hypotonic
- Saliva – K^+ (highest concentration of K^+ in body)
- Stomach – H^+ and Cl^-
- Pancreas – HCO_3^-
- Bile – HCO_3^-
- Small intestine – HCO_3^-, K^+
- Large intestine – K^+

- **Gastric losses** – replacement is:
  - D5 ½ NS with 20 mEq K^+
- **Pancreatic/biliary/small intestine losses** – replacement is:
  - LR
- **Large intestine (diarrhea) losses** – replacement is:
  - LR
- **GI losses** – replacement rate should be:
  - **cc: cc**
- **Urine output** – should be kept at least 0.5 cc/kg/hr; should not be replaced, usually a sign of normal postoperative diuresis
  - New trends that for a person < 100kg, 30cc/h periop is acceptable

Potassium

- **HyperK** – peaked T waves initial finding on EKG
  - **Calcium gluconate** (membrane stabilizer for heart)
  - **Sodium bicarbonate** (causes alkalosis, K enters cell in exchange for H)
  - **10 U insulin and 1 ampule of 50% dextrose** (K driven into cells along with glucose)
  - **Kayexalate**
  - **Dialysis** if refractory
- **Hypokalemia** – T waves disappear
  - May need to replace Mg+ before you can correct K+
- Replacement

Sodium

- **Hypernatremia** – restlessness, irritability, ataxia, seizures
  - Correct with D5W slowly to avoid brain swelling
    - 8-10 mEq per day
  - Total free water deficit = 0.6 X patient's wt (kg) X [(Na +/140) – 1]

Sodium

- **Hyponatremia** – headache, delirium, seizures, nausea, vomiting
  - Na deficit = 0.6 X (weight in kg) X (140 – Na)
  - _____is the first treatment for hyponatremia, then **diuresis**, then NaCl replacement
  - Correct Na slowly to avoid central pontine myelinosis **(no more than 1 mEq/hr)**
  - _____ **can cause pseudohypontremia** – for each 100 increment of glucose over normal, add 2 points to the Na value
  - SIADH results in hyponatremia

Sodium

- **Hyponatremia** – headache, delirium, seizures, nausea, vomiting
  - Na deficit = 0.6 X (weight in kg) X (140 – Na)
  - **Water restriction** is the first treatment for hyponatremia, then **diuresis**, then NaCl replacement
  - Correct Na slowly to avoid central pontine myelinosis **(no more than 1 mEq/hr)**
  - **Hyperglycemia can cause pseudohypontremia** – for each 100 increment of glucose over normal, add 2 points to the Na value
  - SIADH results in hyponatremia

Calcium

- Normal 8.5 –10.0; Normal Ionized Ca 4.4 – 5.5
- **Hypercalcemia** (Ca usually > 13 or ionized > 6 –7)
  - Breast cancer most common malignant cause
  - No lactated Ringer's (contains Ca + +)
  - No thaizide diuretics (these retain Ca + +)
  - Tx: NS at 200-300 cc/hr, Lasix
    - For malignant disease → mithramycin, calcitonin, aldaronic acid, dialysis
  - Replacement

Calcium

- **Hypocalcemia** (Ca usually < 8 or ionized Ca <4) – hyperreflexia, Chvostek's sign (tapping on face produces twitching), perioral tingling and numbness, Trousseau's sign (carpopedal spasm), prolonged QT interval
  - May need to **correct Mg** before being able to correct Ca
  - **Protein adjustment for calcium** – for ever 1 g decrease in protein, add 0.8 to Ca

Magnesium

- Normal 2.0 – 2.7
- **Hypermagnesemia** – causes lethargic state; burn, trauma, and renal dialysis patients
  - Tx: calcium
- **Hypomagnesemia** – signs similar to hypocalcemia
- Replacement

Acute Renal Failure

- **FeNa** = (urine Na/Cr) / (plasma Na/Cr) –
  - best test for azotemia
- **Prerenal** – FeNa < 1%, urine Na < 20, BUN/Cr ratio >20, urine osmolality >500mOsm
  - 70% of renal mass must be damaged before ↑ Cr and BUN
- **Contrast dyes** – volume expansion best prevents renal damage: HCO_3^-, IV hydration.
- **Myoglobin** – converted to ferrihemate in acidic environment, which is toxic to renal cells
  - Tx: hydration, less evidence for urine alkalization
  - Goal UOP?
    - 0.5cc/kg/h

Postoperative goals

- Post-op Electrolyte Ranges:
  - K+ ≥ 4.0
  - Phos ≥ 3.0
  - Mg ≥ 2.0

Calories

- 25kcal/kg typical for critically ill patient
- Ideal body weight
- Protein requirement varies based on indication
  - Healthy patients: 0.8g/kg/d
  - Critically ill: 1.5g/kg/d
  - Up to 2.5g/kg/d for severe catabolism (eg burns)

Macros

- Lipids
  - 9.1kcal/g
- Glucose
  - 3.7kcal/g
- Protein
  - 4kcal/kg

- Oxidation of all three nutrients determines whole-body O2 consumption, CO2 production, heat production

Calorimetry

- Indirect calorimetry: "Metabolic cart," measured inhaled/exhaled O2/CO2, determine resting energy expenditure (REE)
  - Complicated, carts are tedious
- Multiple equations exist to estimate REE without a cart
  - THE SIMPLEST:
    - REE (kcal/d) = 25 (body weight in kg)
  - Body weight adjustments proposed for obese/superobese patients, no clear consensus

Respiratory Quotient

- CO_2 produced: O_2 consumed
  - Measurement of energy expenditure
- Pure fat: RQ 0.7
- Pure Protein: RQ 0.8
- Pure carbohydrate: RQ 1.0
- RQ > 1
  - ?
- RQ < 0.7
  - ?

Respiratory Quotient

- CO_2 produced: O_2 consumed
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- RQ > 1
  - Overfeeding
  - Lipogenesis
  - Treatment: reduce carbohydrate intake and caloric intake
- RQ < 0.7
  - ?

Respiratory Quotient

- CO_2 produced: O_2 consumed
  - Measurement of energy expenditure
- RQ > 1
  - Overfeeding
  - Lipogenesis
  - Treatment: reduce carbohydrate intake and caloric intake
- RQ < 0.7
  - Starvation
  - Ketosis
  - Treatment: increase carbohydrate and caloric intake
- Balanced nutrition: RQ 0.825

Nitrogen Balance

- N balance = N_{in}-N_{out}
- 6.25g protein = 1g nitrogen
- N balance = (g protein/6.25) – (24h urine g nitrogen +4)
  - Positive N balance
    - Anabolic
  - Negative N balance
    - Catabolic

Quick hits

- Glutamine:
  - Fuel for enterocytes (small bowel)
- Short chain fatty acids
  - Fuel for colonocytes
- TPN vs PPN:
  - TPN glucose based, PPN fat based
- Increase in kcal requirement in lactation:
  - 500kcal/d
- Increase in kcal requirement in pregnancy:
  - 300kcal/d