

# Fluid Management

## Eval of Intravascular Volume

- HPI
  - Hypovolemia: vomiting, diarrhea, fever, sepsis, trauma
  - Hypervolemia: weight gain, edema, acute renal failure, liver disease (ascites)
- PE
  - Hypovol: skin turgor, mucous membranes, tachycardia, orthostasis
  - Hypervol: pitting edema, rales, wheezing
- Labs
  - Hypovol: rising Hct, metabolic acidosis, Ur specific gravity > 1.010, Na(Ur) < 10, Osm (Ur) > 450, hypernatremia, BUN:Cr > 10:1

## Intraoperative Intravascular Assessment

- **CLINICAL EVALUATION is key!!!**
- Vitals
  - HR, BP, and their changes with positive pressure ventilation
  - Pulse Oximetry: waveform wander from baseline
- Foley Catheter
  - UOP
- Arterial Line
  - Serial ABGs, Hct, electrolytes
  - Commonly used for anticipated blood loss, fluid shifts, prolonged OR time
- Central Venous Pressure
  - Trends often more informative than absolute value
  - Catheter serves as additional central IV access for medications (vasopressors, inotropes) and fluids
  - Consider benefits and risks of placing central line
- Pulmonary Artery pressure
  - Most commonly used in RV dysfunction, PHTN, valvular pathology (AS, MR), LV dysfunction
- Transesophageal Echocardiogram
  - Most commonly used in major heart surgeries and liver transplant
  - Valuable in acute, persistent hemodynamic instability

## Fluid Compartments

Males = 60% H<sub>2</sub>O by weight  
 Females = 50% H<sub>2</sub>O by weight

	Fluid as % of TBW (%)	Fluid as % of body weight (%)	Volume, in 70 kg male (L)
Intracellular	67	40	28
Extracellular			
- Interstitial	25	13	9
- Intravascular	8	7	5
<b>TOTAL</b>	<b>100%</b>	<b>60%</b>	<b>42 L</b>

TBW = Total Body Water

**Q: What is the intravascular volume of a 90 kg male?**

**A: 90 kg x 7% = 6.3 L**

## Crystalloids

	Osm (mOsm/L)	Na <sup>+</sup> (mEq/L)	Cl <sup>-</sup> (mEq/L)	K <sup>+</sup> (mEq/L)	Ca <sup>2+</sup> (mEq/L)	Lactate (mEq/L)	pH
<b>NS</b>	308	154	154				5.0
<b>LR</b>	273	130	109	4	3	28	6.6

### Advantages

- NS**
- Preferred for diluting pRBCs
  - Preferred in brain injury
- LR**
- More physiologic
  - Lactate is converted to HCO<sub>3</sub><sup>-</sup> by liver

### Disadvantages

- May cause hyperchloremic metabolic acidosis
- Hyperchloremia → low GFR
- Watch K<sup>+</sup> in renal patients
- Ca<sup>2+</sup> may cause clotting with pRBCs

## Colloids

### Mechanism

- Intravascular volume expansion from increased oncotic pressure

### Hetastarch (6% hydroxyethyl starch, HES)

- Hespan (in NS) and Hextend (in LR) solutions
- Solution of highly branched glucose chains (average MW 450 kD)
- Degraded by amylase, eliminated by kidney
- Intravascular t<sub>1/2</sub> = 25.5 hrs; tissue t<sub>1/2</sub> = 10-15 days
- Dose: < 20 ml/kg/day (max is roughly 1 L/day)
- Side effects:
  - Can increase PTT (via factor VIII/vWF inhibition), and clotting times
  - Anaphylactoid reactions
  - Can decrease platelet function
- Contraindications: coagulopathy, heart failure, renal failure

### Albumin (5% and 25%)

- Derived from donated blood; heat-treated (60 degree C x 10 hrs)
- Use 5% for hypovolemia; 25% for hypovol in Pts with restricted fluid and Na intake
- Min. risk for viral infection (hepatitis or HIV); ? risk of prion transmission
- Expensive; shortages

## Colloids

### Dextran 40, 70

- Not used at Stanford
- Side effects: anaphylactic reactions (1:3300), antiplatelet activity, renal dysfunction (obstructive), may prolong bleeding time
- Doses > 20 ml/kg/day can interfere with blood typing.

### General Indications for Colloids

- Inadequate intravascular volume resuscitation with aggressive crystalloid administration
- Concern for fluid overload with excessive crystalloid (ie. CHF, pulmonary edema, bowel edema)
- Pts with large protein losses (burns)

## Crystalloid or Colloid?

### Advantages

- Crystalloid**
- Lower cost
  - Higher UOP

### Disadvantages

- Requires 3-4x more volume for the same hemodynamic effect (due to redistribution)
- Short IV t<sub>1/2</sub> (20-30 min)
- Dilutes plasma proteins → peripheral/pulmonary edema

**Colloid**

- Restores IV volume and HD with less volume, less time
- Longer IV t<sub>1/2</sub>
- Maintains plasma oncotic pressure
- Less cerebral edema
- Less intestinal edema

- Expensive
- Coagulopathy (dextran > HES)
- Avoid in hepatic failure
- Limited by max dose

## “Classical” Fluid Management

### Maintenance

- “4-2-1 Rule” = 4 ml/kg/hr for the 1<sup>st</sup> 10 kg, 2 ml/kg/hr for the next 10-20 kg, and 1 ml/kg/hr for each additional kg above 20 kg.

### Preexisting Fluid Deficits

- Multiply maintenance requirement by # of hours NPO.
- Give 1/2 over 1<sup>st</sup> hour, 1/4 over 2<sup>nd</sup> hour, and 1/4 over 3<sup>rd</sup> hour

### Ongoing Losses

#### Evaporative and Redistributive (“3<sup>rd</sup> space”) Losses

- Minimal tissue trauma (e.g. hernia repair) = 0-2 ml/kg/hr
- Moderate tissue trauma (e.g. cholecystectomy) = 2-4 ml/kg/hr
- Severe tissue trauma (e.g. bowel resection) = 4-8 ml/kg/hr

#### Blood Loss

- EBL = (suction canister - irrigation) + “laps” (100-150 ml each) + 4x4 sponges (10 ml each) + field estimate.
- Replace 1:2 with undiluted pRBCs, 1:1 with colloid, or 3:1 with crystalloid

#### Urine Output

- Replace 1:1 with crystalloid.

## Example

### 85 kg male s/f colon resection; NPO x 8 hours.

- Maintenance = 125 ml/hr
- Deficit = 125 ml/hr x 8 hrs = 1000 ml
- 3<sup>rd</sup> Space Losses = 6 ml/kg/hr = 750 ml/hr

	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5
Deficit	500	250	250	--	--
Main	125	125	125	125	125
3 <sup>rd</sup> Space	--	750	750	750	--
EBL	--	200 (x3)	200 (x3)	200 (x3)	--
UOP	300	100	100	100	100
ml/hr	925	1825	1825	1575	225
<b>TOTAL</b>	925	2750	4575	6150	<b>6375</b>

These calculations assume all EBL replaced 3:1 with crystalloid.

## Suggestions for Fluid Management

- Tailor management to patient, surgery, and clinical evaluation
- Consider the calculated “classical” fluid management
- Maintain stable VS, UOP > 0.5 ml/kg/hr, adequate CVP
- Use a balanced approach
  - Typically start with NS or LR
  - If Pt requires >2-3L fluids, consider alternating NS and LR
  - Consider colloid for persistent hypotension despite adequate crystalloid administration.
- Type and Cross for pBRC and other blood products prior to surgery if anticipating significant blood loss (ie. trauma, coagulopathy)

## Liberal vs. Restrictive Management

### Consequences of Excessive Peri-op Fluid Administration

- Increased mortality and length of ICU/hospital stay
- Increased myocardial morbidity
- Increased pulmonary, periorbital, and gut edema
- Increased PONV and delayed return of GI function
- Decreased hematocrit and albumin
- Decreased wound/anastomosis healing (edema)

### Suggestions for Rational Fluid Management

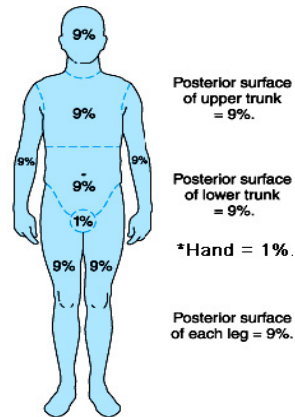
- Consider the calculated “classical” (i.e. liberal) fluid management, but use good clinical judgment.
- Tailor management to patient, surgery, and clinical picture.
- Maintain UOP > 0.5 ml/kg/hr, adequate CVP, and stable VS.
- Use balanced fluid therapy: use crystalloid for maintenance, replace EBL 1:1 with colloid.
- Consider conservative replacement of 3rd space losses or UOP unless VS unstable.

## Burns

- Increased evaporative losses.
- H<sub>2</sub>O, electrolytes, and protein shift from normal to burned tissue, causing intravascular hypovolemia.
- Volume to infuse is calculated by the Parkland Formula

### Parkland Formula

- Volume = %BSA x 4 ml/kg x kg
- Give 1/2 over the 1<sup>st</sup> 8 hours.
- Give 1/2 over the next 16 hours.
- Replace with LR.
- %BSA is determined by the "Rule of Nines"



## Intraoperative Oliguria

### 1. Pre-renal (decreased renal perfusion)

- Hypovolemia
- Decreased CO (LV dysfunction, valvular disease)
- Decreased MAP

### 2. Post-renal (post-renal obstruction)

- Foley kinked, clogged, displaced, or disconnected
- Surgical manipulation of kidneys, ureters, bladder, or urethra

### 3. Renal

- Neuroendocrine response to surgery (i.e. activation of renin-angiotensin-aldosterone system)

### Treatments

- Increase renal perfusion: fluids (bolus vs increased maintenance rate), vasopressors/inotropes, or Lasix
- Relieve obstruction: check Foley; consider IV dyes (e.g. indigo carmine, methylene blue) for patency of ureters (usually in Urology cases)

## References

- Holte K, Sharrock NE, and Kehlet H. 2002. Pathophysiology and clinical implications of perioperative fluid excess. *Br J Anaesth*, **89**: 622-32.
- Joshi GP. 2005. Intraoperative fluid restriction improves outcome after major elective gastrointestinal surgery. *Anesth Analg*, **101**: 601-5.
- Kaye AD and Kucera IJ. Intravascular fluid and electrolyte physiology. In Miller RD (ed), *Miller's Anesthesia, 6th ed*. Philadelphia: Elsevier Churchill Livingstone, 2005.
- McKinlay MB and Gan TJ. Intraoperative fluid management and choice of fluids. In Schwartz AJ, Matjasko MJ, and Otto CW (eds), *ASA Refresher Courses in Anesthesiology*, **31**: 127-37. Philadelphia: Lippincott Williams & Wilkins, 2003.
- Morgan GE, Mikhail MS, and Murray MJ. *Clinical Anesthesiology, 4th ed*. New York: McGraw-Hill Companies, Inc., 2006.