Volume Resuscitation: Hemorrhagic vs. Septic Shock

Tony Bottiggi MD
Hypoperfusion

• Time dependent emergency
  – Results in oxygen debt

• Hemorrhagic shock
  – Acute decrease in cardiac output leads to hypotension
  – First response is increase in HR
  – Catecholamine release
    • Increase PVR
    • Narrows pulse pressure
    • Very little increase in organ perfusion
Hypoperfusion

- Multiple other hormones and cytokines are release which affect the microcirculation
  - Contraction of arterioles with cessation of blood flow
Monitoring Volume Status

• Swan/CVP
  – Was “Gold Standard”
  – Recent studies show that neither the absolute pressure nor the trend are reliable in predicting the response to a fluid challenge
  – Routine use not recommended
  – There are exceptions
    • Severely ill
    • Acute coronary syndrome
Monitoring Volume Status

- CVP with MVO2 saturation
  - Decrease MVO2 is indirect indicator of poor tissue perfusion

- ECHO
  - Excellent diagnostic tool
  - Poor monitoring device
Monitoring Volume Status

• Important to determine where patient is on their Starling Curve
  – Pulse pressure Variation or Stroke Volume Variation
    • Have been found to be reliable predictors of volume responsiveness
  – Limitations
    • Ventilator settings (need passive breathing and TV 8 cc/kg), chest wall compliance, pharmacologically induced changes in ventricular and aortic compliance, arrhythmias
Fluid Administration

• Beware of “normal” blood pressure
  – Vasoconstriction decreases vascular space
  – Less volume in less space may still have same BP
    • End organ perfusion decreased
  – A young patient can lose up to 40% blood volume before vascular collapse occurs!
Goals of Resuscitation

• Restoring circulating volume
  – Fluid

• Restoring the microcirculation

• Preventing clot disruption
  – Leads to rebleeding

• Maintain perfusion to brain and other vital organs
Rebleeding

• Fluid bolus increases BP by improving CO
  – In pt who is still actively bleeding or recently stopped with an early clot this increase in pressure can be harmful
  – Can increase bleeding from open vessels or disrupt the clot itself
  – Will see an initial rise in BP then a second drop as bleeding accelerates
  – More volume given, etc
Rebleeding

- This is the “transient responder” described in ATLS

- Treatment
  - Definitive anatomic source control
  - Tolerance of hypotension until hemostasis is achieved
Rebleeding

- **Fast bleeders**
  - Drop their MAP sooner and therefore start making clot earlier

- **Slow bleeders**
  - Take longer to become hypotensive
  - Rapid bolus will reverse low MAP and delay formation of clot
    - Can lead to rebleeding
Hypotensive Resuscitation

• Animal models show that using a lower than normal BP as a guide to fluid resuscitation reduces the risk of death in hemorrhagic shock.

• Goal of resuscitation prior to hemorrhage control is to prevent hemodynamic collapse.

• Study of penetrating torso trauma
  – Survival with goal MAP of 60 vs 80
Septic Shock

- Pt with peritonitis is hypotensive from
  - Loss of intravascular fluid
  - Dilation of vasculature
  - Negative ionotopic effects of endotoxin

- Tissue perfusion is usually better than hemorrhagic shock
  - Initial compensation is high flow, low pressure state that preserves oxygen delivery
Septic Shock

- Improved outcomes with early goal directed therapy
  - More rapidly restores volume status during the early phase during efforts at source control
  - Opposite of hemorrhagic patient
- Do not delay definitive source control for resuscitation
Fluids

- **Crystalloids**
  - Do not clot
  - Do not carry oxygen
  - Not as useful for hemorrhagic shock resuscitation
  - **NS**
    - Large volumes can predispose for hyperchloremic metabolic acidosis
Small Volume Resuscitation

- Hypertonic saline
  - Longer intravascular time with less redistribution
    - <1:1.5 (crystalloid 1:3 to 1:10)
  - Theoretically massive crystalloid resuscitation can lead to:
    - Pulm edema
    - Hypoalbuminemia
    - Coagulopathy
    - Abdominal compartment syndrome
    - Cardiac function
    - Ileus
    - Bowel anastomotic complications
Small Volume Resuscitation

• Other potential advantages of hypertonic saline
  – Improvement in microvascular flow
  – Control of ICP
  – Stabilization of BP and CO
  – No immune dysfunction or coagulopathy

• SVR needs to be followed by conventional therapy once source control is achieved
Small Volume Resuscitation

• Meta-analysis
  – No advantage in survival outcomes to hypertonic solution resuscitation
Colloids

- Albumin, hydroxy ethyl starch, dextran
- No significant survival benefit
Blood

- Patients who are bleeding should receive blood
- Emergency surgical patients who are not bleeding should initially receive crystalloid
- Restores oxygen carrying capacity
- Other products help restores coagulation system
- May need to transfuse despite “normal” laboratory values
Blood

- FFP replaced in 1:1 ratio
- Platelets in 1:1 or 1:1.5 ratio
- In septic patients
  - Early transfusion to HCT of 30% per surviving sepsis guidelines based upon Rivers paper
  - Prn transfusion of FFP, plts based upon clinical course and observed intraoperative findings
End Point

• Goal is an awake, stable patient
• MOV2 as mentioned earlier
Post Resuscitation Fluid Balance
Post Resuscitation Fluid Balance

- Studies are now showing that a positive fluid balance is associated with an increased mortality
- FACCT trial
  - Longer ventilator days in patients with ALI
  - Trend towards increased mortality
Post Resuscitation Fluid Balance

  - Retrospective review
  - Fluid balance correlates modestly with CVP and dose of norepinephrine at 12 h
  - No association on day 4

- A CVP <8 at 12 hours correlated with survival
Post Resuscitation Fluid Balance

- Uchino et al. Crit Care; 10:R174
  - Positive fluid balance is a positive predictor of mortality
  - Odds ratio 1.0002 for each ML per day
Table 1. Fluid intake, urine output, and net fluid balance at 12 hrs and cumulative day 4 balance

<table>
<thead>
<tr>
<th></th>
<th>Quartile 1 (Dry)</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>Quartile 4 (Wet)</th>
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<tbody>
<tr>
<td><strong>12 hrs</strong></td>
<td></td>
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<tr>
<td>Intake, mL</td>
<td>2900 (2050–3900)</td>
<td>4520 (3700–5450)</td>
<td>6110 (5330–7360)</td>
<td>10,100 (8430–12,100)</td>
</tr>
<tr>
<td>Output, mL</td>
<td>2200 (1100–3920)</td>
<td>1590 (960–2560)</td>
<td>1180 (600–2070)</td>
<td>1260 (600–2400)</td>
</tr>
<tr>
<td>Balance, mL</td>
<td>710 (−132–1480)</td>
<td>2880 (2510–3300)</td>
<td>4900 (4290–5530)</td>
<td>8150 (7110–10,100)</td>
</tr>
<tr>
<td><strong>Day 4</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Intake, mL</td>
<td>16,100 (12,800–19700)</td>
<td>18,500 (15,700–22,500)</td>
<td>22,800 (19,700–26,700)</td>
<td>30,600 (26,200–36,000)</td>
</tr>
<tr>
<td>Output, mL</td>
<td>14,600 (11,500–20100)</td>
<td>11,000 (8210–14,500)</td>
<td>9960 (6940–12,900)</td>
<td>8350 (5100–12,300)</td>
</tr>
<tr>
<td>Balance, mL</td>
<td>1560 (−723–3210)</td>
<td>8120 (6210–9090)</td>
<td>13,000 (11,800–14,700)</td>
<td>20,500 (17,700–24,500)</td>
</tr>
</tbody>
</table>

Volumes are expressed as median (25–75%).
Post Resuscitation Fluid Balance

- VASST
  - At 12 hours
    - CVP > 12 had highest mortality
    - <8 had a survival advantage over 8-12
  - Increased risk of death was independent of APACHE II score
  - However in patients with CVP <8 there was survival advantage in patients with a positive fluid balance
    - Can give too little fluid
Post Resuscitation Fluid Balance

• Optimal survival appears to be a positive fluid balance of 3 liters at 12 hours.

• After 12 hours CVP does not predict fluid responsiveness and is not a reliable marker of fluid balance.
Post Resuscitation Fluid Balance

• Late accumulation of fluid in pts with lung injury correlates with increased mortality and LOS

• Large volume resuscitation increases extravascular lung water
  – Increased capillary permeability, pulmonary venous constriction
Post Resuscitation Fluid Balance

  - Volume overload decreased the likelihood of renal recovery independent of the severity of renal failure
Post Resuscitation Fluid Balance

  - Recommends no MIVF
    - Plenty of other fluids from meds, enteral feeds
  - Use PVV
    - If no Flo Trac can print A-line tracing on paper and calculate PVV with a ruler
Post Resuscitation Fluid Balance

- Schnuriger et al. J Trauma. 2011;70:603-610
  - Looked at anastomotic leak rates following colocolostomy after trauma
  - A 10.5 L positive fluid balance at 72 hours was an independent risk factor for leak
  - Only volume of crystalloids mattered
    - Blood, plasma, FFP, colloid dropped out of the forward regression model as well as APACHE II score
Conclusion

• Expedite source control
  – Hypotensive resuscitation in acute hemorrhage until this happens

• A conservative fluid approach is favored over a liberal approach

• Use goal directed therapy with dynamic monitoring methods