Volume Resuscitation: Hemorrhagic vs. Septic Shock

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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

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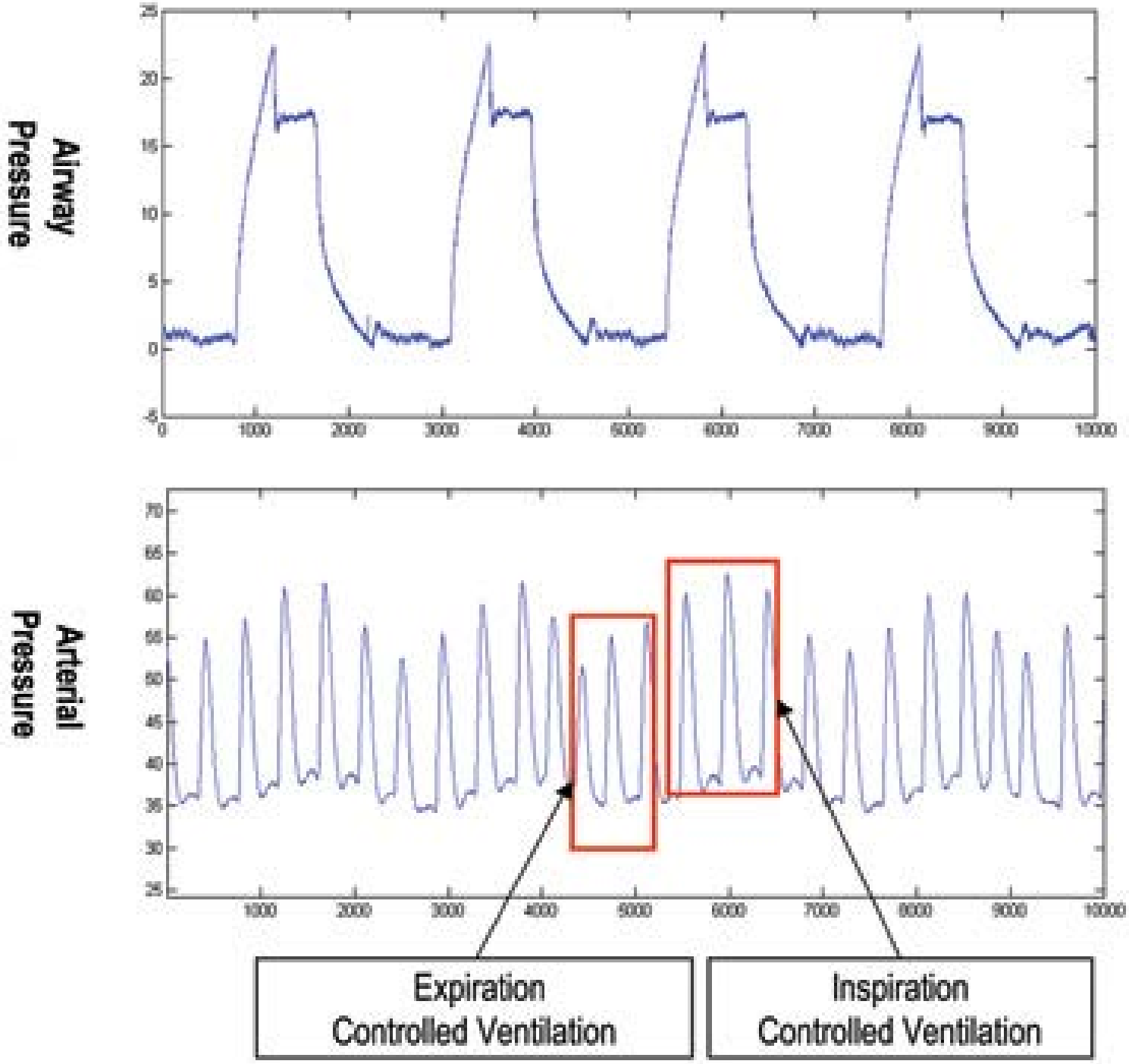
Monitoring Volume Status

- 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


Airway Pressure
Arterial Pressure
Expiration Controlled Ventilation
Inspiration Controlled Ventilation

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 resusciation 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

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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

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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
  - Stabliziation 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

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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

- Boyd et al. Crit Care Med 2011 Vol 39, No2
  - 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

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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

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

Volumes are expressed as median (25–75%).

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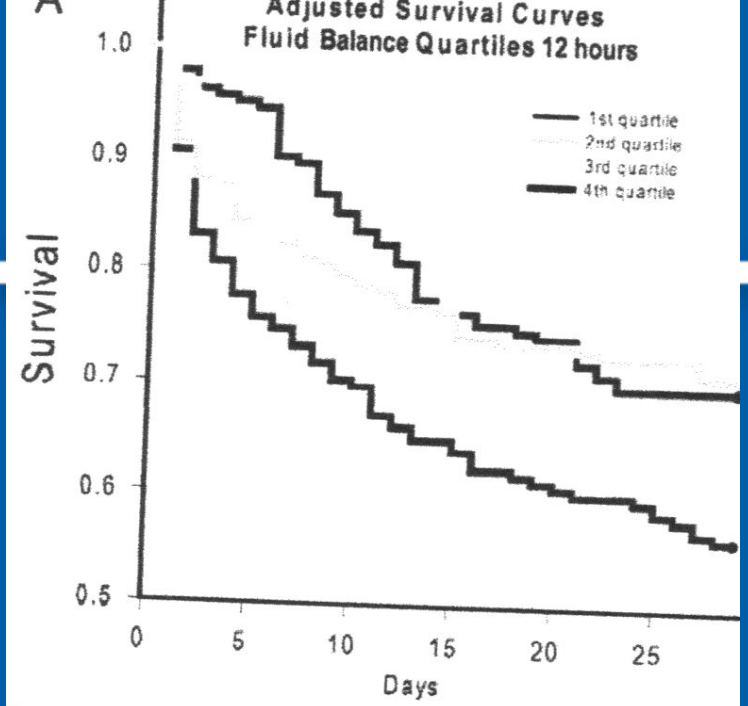

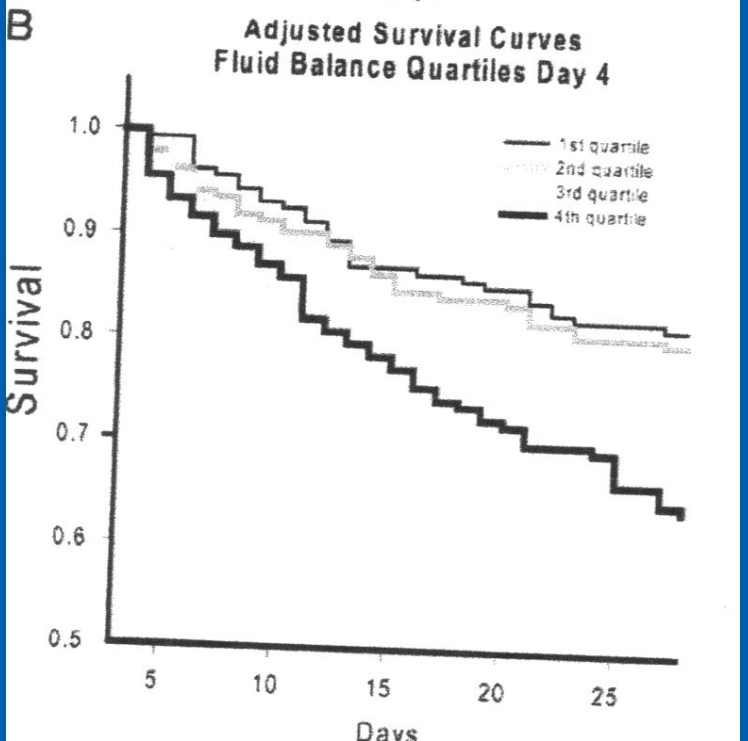

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Post Resuscitation Fluid Balance

- 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

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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
  - Murphy et al. Chest 2009; 136:102-109
  - Rosenberg et al. J Intensive Care Med 2009; 24:35-46
- Large volume resuscitation increases extravascular lung water
  - Increased capillary permeability, pulmonary venous constriction

Post Resuscitation Fluid Balance

- Brouchard et al. Kidney Int 2009; 79:422-427
  - Volume overload decreased the likelihood of renal recovery independent of the severity of renal failure

Post Resuscitation Fluid Balance

- Durairaj L, Schmidt S. Fluid Therapy in Resuscitated Sepsis Less Is More. Chest Vol: 133; 1 2008.
  - 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

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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 cystalloids mattered
    - Blood, plasma, FFP, colloid dropped out of the forward regression model as well as APACHE II score

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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

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