Assessment & Management of ICU Volume Status

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Volume assessment in the critically ill patient is widely thought to be one of the most difficult aspects of critical care

Volume assessment in:

25 seconds

25 hours

25 minutes

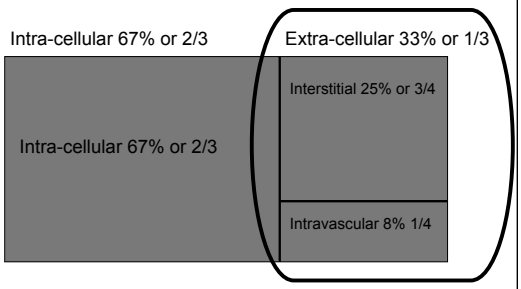
Purist?

or Pragmatist…?

Background (*aka reminder*):

- H_20 can move freely between all compartments
- Salt cannot move freely between all compartments
  - Distributes to extracellular space
    - Intravascular and interstitial
- Volume Status = Salt Status
- IVNS (or LR) ALWAYS fluid of choice for volume resuscitation
  - Not ½ NS, not D5W…

Salt: Where Does it Go?



IV Fluids

- Solute in a particular IVF determines where the IVF distributes
- For example…
  - D5W distributes to all compartments
  - IVNS (0.9%)-only to the extracellular space
  - LR – only to the extracellular space
  - Plasma expanders (pRBC, FFP, albumin, hetastarch) – only to the intravascular space

IV Fluid Examples…

- 1 Liter of ½ NS (0.45%)
- Same as 500 cc of 0.9% and 500 cc of H_20
  - 335 cc to intracellular space
  - 125 cc to interstitial space
  - 40 cc to intravascular space

  > 500 cc of H_20

  - 375 cc to interstitial space
  - 125 cc to intravascular space

  > 500 cc of IVNS

IV Fluid Examples…

- 1 Liter of D5W
  - 67% or 670 cc to intracellular space
  - 25% or 250 cc to interstitial space
  - 8% or 80 cc to intravascular space
- 1 Liter of IVNS (0.9%)
  - ¾ or 75% or 750 cc to interstitial space
  - ¼ or 25% or 250 cc to intravascular space

Volume Status: Basic Definitions

- Hypovolemia or Volume Depletion: Too little salt
- Euvolemia: Just the right amount of salt
- Hypervolemia or Volume Overload: Too much salt
- Dehydration: Too little H_20

Hypovolemia

- *True* hypovolemia
  - *Easier* to identify, *easier* to treat
  - Output > Input Losses can be external (e.g. bleeding, diuresis, Gi losses) or internal (e.g. "3rd spacing")
- *Relative* hypovolemia
  - *Harder* to identify, *harder* to treat
  - Increase in venous capacitance (e.g. sepsis, medications, post op inflammatory response)

Fluid Responsiveness:

- DEFINITION: increase in cardiac index after infusion of fluid

Case #1

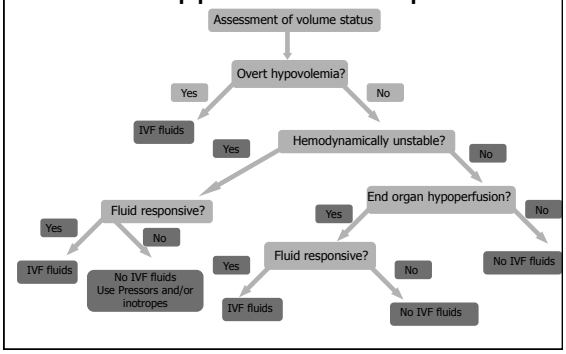
57 year old with 3d h/o N/V/D. No h/o CHF but CXR with bilateral infiltrates. He "appears" volume depleted. HR 116, SBP 90 systolic and O2 sat 91% on NRB mask but no increased work of breathing. Of note he continued to take his home meds including a diuretic and "other BP meds".

What is your next step? Choose one of the following:

1) Bolus 1 liter IVNS and reassess
2) Lasix 20mg IV x 1 and reassess
3) Transfuse blood to improve oxygen delivery
4) Intubate for hypoxemic respiratory failure
5) Nothing…admit to ICU and observe

critically ill

Practical approach to the patient…



What's in your toolbox?

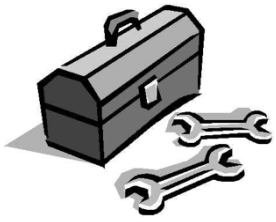
Labs

CXR

Vitals

Exam

Clinical history



Echo

PPV

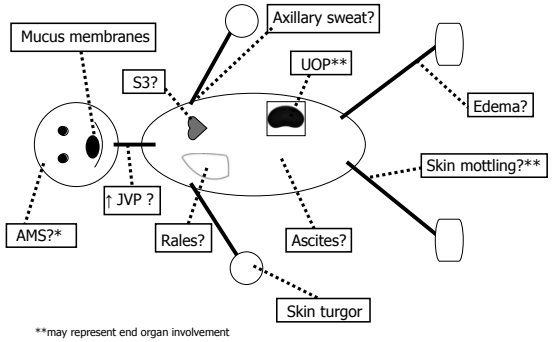
SVV

Passive leg raise

Toolbox:

- Physical Exam
- Laboratory Data
- Radiographic Data
- Hemodynamic Monitoring – Non-invasive
- Hemodynamic Monitoring - Invasive

The "volume assessment" physical exam



**may represent end organ involvement

End organ hypoperfusion? Use your exam…

- Hypotension
- Decreased UOP
- Mental status changes
- Hypoxia
- Mottled skin

Non-specific findings

**Remember: while none of these findings are sensitive or specific, important to consider the findings in context…

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Key points from Case #1

- Use your exam
- Hypoxia can improve with improved cardiac output
  - May be sign of end organ compromise
- Clinical history important -> takes BP meds so this BP of 90 is "inappropriate" for this patient
- Overt hypovolemia -> give IVF

Case #2

Call from ICU RN at 0330: Hi, Dr. P. Mr. Smith was admitted last night (~ 24 hrs ago) with pneumonia and septic shock. He has had decreased urine output for the last 2 hours (< 30cc/hr x 2 hr). What would you like me to do? Choose one of the following:

1) 500 cc fluid bolus (crystalloid)
2) 500 cc fluid bolus (colloid)
3) Lasix 20mg IV x 1 now
4) Call for a renal consult
5) Request more information…

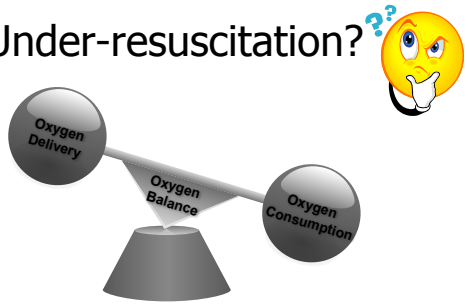
More information…

- What is his volume status?
- What are his vitals?
- Clinical history?
- Is this a change?

BOTTOM LINE:

- Does he have evidence of compromised end organ perfusion?

Under-resuscitation?

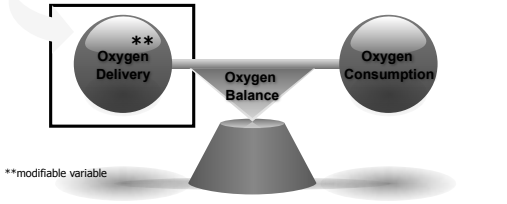


Indirect measures of compromised end organ perfusion:

1) serum lactate
2) $ScvO_2$

Goal of resuscitation: Balance

fluid -> improved cardiac output -> improved organ perfusion -> improved oxygen delivery…



**modifiable variable

Labs

- BUN/Cr (what is his baseline?)
- Spot Urine Na^+
- Serum Na^+ (not helpful)
- Serum lactate
- $ScvO_2$ (if central venous catheter present)

Oliguria

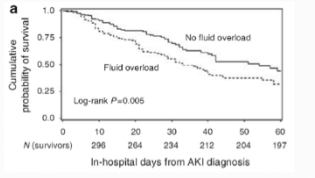
- Oliguria is a SIGN not a diagnosis
  - Signal to look for the cause
  - *May be* appropriate (acute kidney success)
- Not ALL oliguria is volume related
  - Examples:
    - AKI (e.g. ATN, AIN, obstruction)
    - CKD (diminished GFR)
    - Hypernatremia (some causes)
    - SIADH
- Diuretics in the ICU are NEVER a *treatment* for oliguria, they are *treatment* for volume overload
- No improved outcomes with conversion from oliguric to non-oliguric AKI

What's the downside of fluid?

- Increased risk of death and adverse outcomes
  - Significant? YES
  - True? MAYBE. Observational data.
  - Described in AKI, ARDS, Sepsis…
- Caution in severe hyponatremia, LV dysfunction, anuria

Fluid Overload is Bad

Outcomes (dialyzed patients)



Prospective multicenter observational trial

396 patients

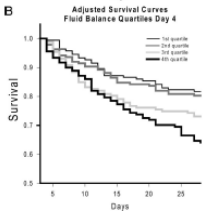
Fluid overload:>10% increase in weight

OR for death 2.07 associated with fluid overload at dialysis initiation

Bouchard et al. KI, 2009.

Fluid resuscitation in septic shock: A positive fluid balance and elevated central venous pressure are associated with increased mortality*

John H. Boyd, MD, FRCP(C); Jason Forbes, MD; Taka-aki Nakada, MD, PhD; Keith R. Walley, MD, FRCP(C); James A. Russell, MD, FRCP(C)



Limitation: Retrospective

Quartile 3 & 4 had statistically significant increase in mortality compared to 1 & 2

Suggests that CVP may be unreliable marker after 12 hours of septic shock

Optimal survival correlated with cumulative fluid balance of 3L at 12 hours

Fluid Overload is Bad

- Conservative fluid strategy decreases time on ventilator in ARDS
  - (FAACT Trial, ARDSnet)
- Association between positive fluid balance and increased mortality in patients with AKI, HR 1.21
  - Mean fluid balance significantly different between survivors and nonsurvivors
  - Among patients requiring RRT mortality higher in those with greater increase in fluid balance 64.6% vs 44.8%
  - (SOAP study, 1120 AKI patients)

Payen et al. Critical Care, 2008.

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Key points from Case #2

- Ask for more information. Use all your tools available.
- Not all oliguria requires fluid or a diuretic
- IV fluid IS an intervention, use it wisely
- Fluid overload is associated with adverse outcomes
- Consider your endpoint…? Indication for IVF

Case #3

70 year with ARDS due to pneumonia on the vent for 5 days. Initially treated according to surviving sepsis guidelines and aggressively resuscitated. Exam significant for 2+ LE edema, lungs coarse but no rales. CVP is 12. MAP in the 50s and UOP dropped to < 0.5cc/kg/hr. SCr 1.9 (down from admission but not back to baseline).

What is the next step? (choose all that apply)

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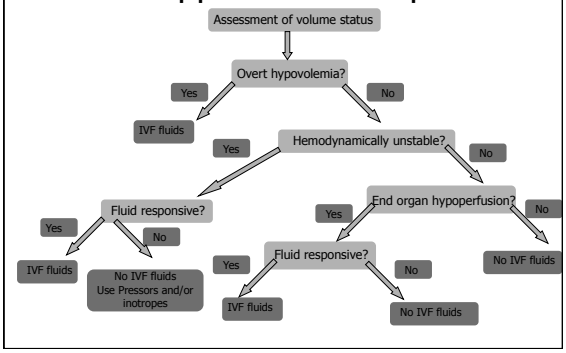
Practical approach to the patient…

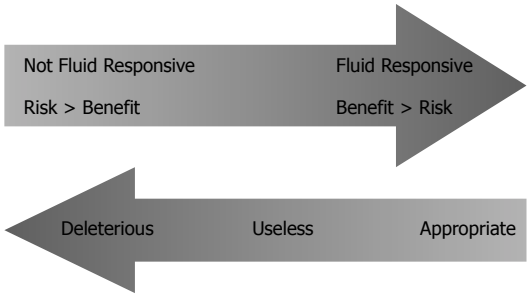
critically ill



The real question is…

Fluid Responsiveness???

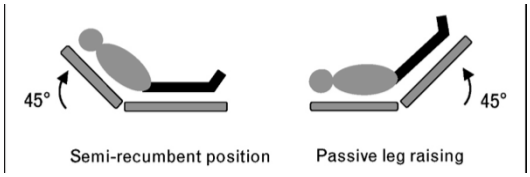
Fluid Responsiveness:
Where is your patient on the spectrum?



Non-Invasive Tools

- Echo
  - TTE
    - IVC size and collapsability (≥ 12 -18%) *(Barbier et al. Int Care Med. 2004;30 (9):1740-1746. Feissel et al. Int Care Med. 2004;30(9)1834-1837)*
  - TEE
    - Measurement of aortic flow
- CXR
  - Vascular Pedicle width *(Martin et al. Chest 2002;122(6): 2087-2095. Miller et al. Curr Opin Crit Care 2006;12:255-262)*
- Passive leg raise (PLR)

Passive Leg Raise

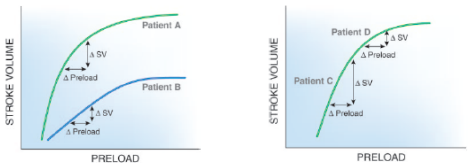


Strengths: Reversible "self volume challenge", Sensitivity as high as 97% and specificity 94%

Limitations: Not good in awake or head injured patients

Lafanechere A, Pene F, Goulenok C, et al. Crit Care 2006; 10:R132
Monnet X, Rienzo M, Osman D, et al. Crit Care Med 2006; 34:1402–1407.
Boulain T, Achard JM, Teboul JL, et al. Chest 2002; 121:1245–1252

Fluid Responsiveness



Important! Assessment of preload is not an assessment of preload dependence or fluid responsiveness.

Clin J Am Soc Nephrol 3: 554-561, 2008

Static Measures: Limitations

- CVP or PaOP
  - Value shown in EGDT *(Rivers et al. NEJM 2001;345:1368-1377)*
  - CVP/ΔCVP poorly predicts volume responsiveness (pooled ROC 0.56, *Marik et al. Chest 2008;134:172-178*)
- Assessment of preload NOT preload dependence
- Low values are *more likely* to suggest hypovolemia BUT…
  - Estimates of intravascular volume based on any given level of filling pressure do not reliably predict response to fluid

Static Measures: Limitations

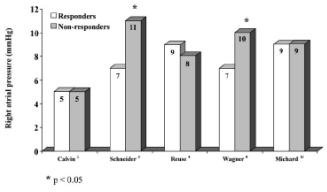


FIGURE 1. Mean RAP before volume expansion in responders and nonresponders.

Michard et al. Chest 2002:121(6) 2000-2008.

Dynamic Measures

- Application of physiology at the bedside
- Dyanamic parameters should be used preferentially, when available, to predict fluid responsiveness in the ICU patients

Dynamic Measures: Predicting Fluid Responsiveness

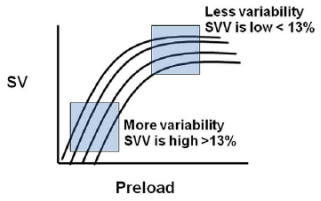
- PPV (pulse pressure variation) or SVV (stroke volume variation)
  - Benefits: High sensitivity and specificity
  - LIMITATIONS: must be ventilated, not reliable with vent dyssynchrony or arrythmias, more reliable with larger tidal volumes (*not standard of care*)
- Device options: FloTrac, PiCCO, LiDCO

Michard et al. AJRCCM 2000; 162: 134-138.

Dynamic Measures

SVV/PPV < 13% = NOT volume responsive

SVV/PPV > 13 % = Volume responsive



Dynamic vs Static Variables:

Ability to predict volume responsiveness

	Correlation (r)	AUC
PPV	.78 (.74–.82)	0.94 (0.93–0.95)
SPV	.72 (.65–.77)	0.86 (0.82–0.90)
SVV	.72 (.66–.78)	0.84 (0.78–0.88)
LVEDAI	—	0.64 (0.53–0.74)
GEDVI	—	0.56 (0.37–0.67)
CVP	.13 (−.01–.28)	0.55 (0.48–0.62)

29 studies

685 patients

56% responded to fluid challenge

Parameter	PPV (n = 14)	SVV (n = 5)
ROC area	0.94 (0.92–0.96)	0.84 (0.81–0.87)
Sensitivity	0.89 (0.82–0.94)	0.82 (0.75–0.98)
Specificity	0.88 (0.81–0.92)	0.86 (0.77–0.92)
Positive likelihood ratio	7.26 (4.46–11.80)	5.77 (3.43–9.72)
Negative likelihood ratio	0.12 (0.07–0.21)	0.21 (0.15–0.30)
Diagnostic odds ratio	59.86 (23.88–150.05)	27.34 (13.46–55.53)

PPV, pulse pressure variation; SVV, stroke volume variation; ROC, receiver operating characteristic.

Marik et al. Crit Care Med 2009 Vol 37, No 9.

The "fluid challenge"

- Reserved for the hemodynamically unstable or those with evidence of hypoperfusion
- Benefits
  - Evaluate real time response
  - Prompt correction
  - Minimize risk of fluid overload

Why Give Fluid?

- Correct true hypovolemia
- Improve end organ perfusion
- Oliguria - DEPENDS

When NOT to give fluid?

- Just because…
  - Avoid "maintenance" IVF in critically ill patients (large amount of IVF through IV meds)
  - "usual care" most often leads to volume overload
  - Clearly identify a reason for fluids
- To target an arbitrary CVP
- No evidence of overt hypovolemia or end organ hypoperfusion

Case #3

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Fluids in the ICU: Misconceptions

- Fluid should be withheld because CVP is high
- Fluid should be withheld because there is pulmonary edema on CXR
- Fluid should be withheld because patient already received large volume in short amount of time
- Tachycardia should prompt increase in fluids
- Give fluids to target CVP 12 to exclude hypovolemia
- Oliguria should prompt increase in fluids

Key Concepts

- Volume assessment in the critically ill patient is widely thought to be one of the most difficult aspects of critical care.
- No single vital sign, physical exam finding, laboratory data or hemodynamic measurement is sufficient for volume assessment. Assessment depends on the ability to integrate all this information. Use all your tools in the toolbox!
- A dynamic measure of volume responsiveness is more important than a static measure of volume status.
- Not all oliguria should be treated with volume or a diuretic.
- Remember that IV fluid is a therapeutic and therefore the clinician must always question IF fluid is needed and if so what is the end-point.
- Volume overload is associated with increased mortality.

Remember…

Taking Care of Patients is a Team Sport!

Especially when it comes to volume in the ICU

Remember…No clinical parameter should be evaluated in isolation.

Questions are guaranteed in life; Answers aren't.

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