Pro/Con Debate:
CVP should not be routinely monitored in critically ill patients

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Objectives

• Review basics of CVP, venous return & cardiac output
• Explore key limitations to CVP monitoring
  – physiologic arguments
  – clinical studies
• Discuss dynamic indices and fluid responsiveness
• Convince you that CVP monitoring should have a much more limited role in the ICU
CVP Monitoring

• Why are we interested in CVP monitoring?
  – Traditionally, used to optimize preload & avoid fluid overload
  – Provides some information about cardiac function
    • RV failure
    • Valve dysfunction
    • Arrhythmias
Venous Return & Cardiac Function: Back to Basics

- CVP is only a very small part of venous return/cardiac output

- Venous Return (VR) = Mean Circulatory Filling Pressure – CVP

  Venous Resistance

- CVP measured is intramural, but desired value is *transmural pressure*
Cardiac output is determined by the intersection of return function and cardiac function.
Concept of Limits

Limit of “return function”

Lowering Pra will not increase VR

Limit of “cardiac function”

Raising Pra will not increase Q

Magder AJRCCM 2004
Effect of increase in Ppl

During expiration
Decrease in PP
Arterial Pressure

Magder AJRCCM 2004
Limitations of CVP Monitoring

- Not a measure of circulating blood volume
  - The body attempts to maintain homeostasis (adequate transmural CVP)
  - MCFP a better measure (but difficult to determine)
- CVP is a static hemodynamic variable
- CVP affected by many other variables
↑ CVP

- Decreased cardiac fxn
- Increased Ppl (especially increased PEEP)
- Increased right heart afterload
- Increased Vs plus decreased cardiac fxn

↓ CVP

- Decreased Vs leading to decreased venous return
  - hypovolemia
- Venodilation (↑ Vu)
- Increased venous resistance
Limits of Static Markers

Monnet & Teboul Curr Opin Crit Care 2007
CVP fails to predict fluid responsiveness

- Multiple studies and meta-analyses fail to demonstrate utility of CVP in predicting who will respond to fluid therapy
- Thus, the central reason for its use in the ICU and OR is without supporting evidence
• Literature review and analysis of 12 studies of fluid responsiveness in ICU
• 334 pts, 406 fluid challenges
• 55% septic, 84% on mechanical ventilation
• RAP (CVP)
  • No baseline difference in responders vs. non-responders in 3/5 studies
Limited Utility of CVP

**Figure 1.** Mean RAP before volume expansion in responders and nonresponders.

Michard & Teboul *Chest* 2002
The Tale of Seven Mares

+ 4 more
Further Lack of Evidence

- Expansive literature search to identify all trials evaluating the relationship between CVP & blood volume or the association between CVP or Δ CVP and fluid responsiveness
  - 24 studies identified
  - 5 comparing CVP with measured blood volume; 19 studied relationship between CVP/ΔCVP & change in cardiac performance after fluid challenge
CVP and Blood Volume

Marik et al. Chest 2008
Disappointing results for CVP

<table>
<thead>
<tr>
<th>Source</th>
<th>Setting</th>
<th>Type</th>
<th>Patients, No.</th>
<th>Methodology</th>
<th>AUC†</th>
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Pooled

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Authors’ conclusion:

• “Based on the results of our systematic review, we believe that CVP should no longer be routinely measured in the ICU, operating room, or emergency department.”

(In other words, what are we doing?)
Dynamic Indices—
Challenging the Frank-Starling Curve

• Induce a change in cardiac preload, observe the effect on cardiac output
  – Fluid challenge (rapidly)
  – Passive leg raise
  – Heart-lung interactions
    • Use the hemodynamic impact of mechanical ventilation to determine volume responsiveness
    • Systolic pressure variation
    • Pulse pressure variation

Monnet & Teboul *Curr Opin Crit Care* (13) 2007
Systolic Pressure Variation

Baseline ("apnea")

mmHg

dUP

PAP

CVP

dDown

SPV

Insp

Insp

Insp

Magder AJRCCM 2004
Effect of decreasing volume on SPV

Decreasing blood volume

Magder AJRCCM 2004
Pulse Pressure Variation

Michard et al. AJRCCM 2000
Dynamic Variables & Fluid Responsiveness

Table 5—Positive and Negative Predictive Values of Dynamic Parameters

<table>
<thead>
<tr>
<th>Source</th>
<th>Patients, No.</th>
<th>Parameters Tested</th>
<th>Best Threshold Value</th>
<th>Positive Predictive Value, %</th>
<th>Negative Predictive Value, %</th>
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<tr>
<td>Magder et al⁵</td>
<td>33</td>
<td>ΔRAP</td>
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<td>Michard et al¹²</td>
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<td>ΔPP</td>
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<td>Feissel et al¹³</td>
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<td>ΔVpeak</td>
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Michard & Teboul Chest 2002
Prospective, observational study

22 sedated, paralyzed pts with early ARDS; lung protective ventilation

Numerous static and dynamic markers were measured before and after volume challenge

Baseline PPV % > 12% predicted volume responsiveness; CVP & PCWP did not!
PPV helpful, CVP not

ROC area: 0.768
Threshold: 11.8%
Sensitivity: 68%
Specificity: 100%

Source of the Curve:
- CVP
- GEDVI
- PPV
- Reference Line
- PCWP
- ITBVI
- SVV
Dynamic indices and other critically ill patient populations

- PPV predicts fluid responsiveness in:
  - Post-CABG patients
    - Kramer et al., *Chest* 2004; 126
    - PPV value of ≥ 11% (sens 100%, spec 93% to predict fluid responsiveness)
  - Septic patients with acute circulatory failure
    - Michard et al., *AJRCCM* 2000; 162
    - PPV value ≥ 13% (sens 94%, spec 96% to predict fluid responsiveness)
Limitations to Dynamic Indices

- Limited utility in spontaneously breathing patients
- Unfamiliar concepts for many—easy to misinterpret.
- Arterial pressure curves often distorted, or dampened
- Challenging to use in patients with arrhythmias
- Fluid responsiveness requires fluid required
Conclusions

• CVP is not a valid predictor of fluid responsiveness or circulating blood volume
• Dynamic indices are superior in predicting fluid responsiveness
• CVP may be helpful when the value is extremely high or low