Sepsis Wave II Webinar Series

Sepsis Reassessment
Presenters

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Fluid Reassessment in Sepsis

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Disclosures

- ACEP Sepsis Expert panel – Vice Chair
- ACEP CMMI TCPI SAN – Sepsis Project Manager
Objectives

- Review various methods of Fluid Reassessment
  - Static
  - Dynamic
  - Respiratory Variation - PPV and SVV
Sepsis Toolkit

Sepsis Initiative Page:

https://www.acep.org/Advocacy/E-QUAL-Network-Sepsis-Initiative/
**SEP-1**

**Severe Sepsis Bundle**
- **WITHIN 3 HOURS**
  - Measure serum *Lactate*
  - Obtain *Blood Cultures* prior to antibiotics
  - Administer *Broad Spectrum Antibiotics*
- **WITHIN 6 HOURS**
  - Repeat measurement of serum *Lactate* if initial is > 2.0

**Septic Shock Bundle**
- **WITHIN 3 HOURS**
  - *Severe Sepsis Bundle* PLUS
  - Resuscitation with 30mL/kg crystalloid fluids
- **WITHIN 6 HOURS**
  - *Severe Sepsis Bundle* PLUS
  - Repeat volume status and tissue perfusion assessment
  - Vasopressor administration
Septic Shock Bundle

- **WITHIN 6 HOURS OF PRESENTATION**
  - Repeat volume status and tissue perfusion assessment
    - Two Methods:
      - Focused physical exam *must* include:
        - Vital signs
        - Cardiopulmonary exam
        - Capillary refill
        - Peripheral pulse evaluation
        - Skin exam

  - Documented by provider
    - *After initial bolus*
Septic Shock Bundle

• **WITHIN 6 HOURS OF PRESENTATION**
  • Repeat volume status and tissue perfusion assessment
    • Two Methods:
  • **OR any two of the following:**
    • Central venous pressure measurement
    • Central venous oxygen measurement
    • Bedside cardiovascular ultrasound
    • Passive leg raise or fluid challenge

• **Documented by provider**
  • - *After initial bolus*
Fluid Responsiveness

- Increase in Stroke Volume of 10-15% after the patient receives 500 cc of a fluid bolus.

- Conceptually by increasing the stroke volume, oxygen delivery to the tissues will increase.
  - Cardiac Output = Stroke Volume x Heart Rate
  - Cardiac Output x Hemoglobin x Arterial O₂ Saturation = DO₂
Stroke volume

Normal ventricular systolic function

Poor ventricular systolic function

Significant response

No response

Cardiac preload

Preload challenge
- Mechanical ventilation
- EEO test
- PLR test
- "Mini" fluid challenge

Annals of Intensive Care 2016 6:111
How to predict fluid responsiveness?

- Static
- Dynamic
- Respiratory Variation
- Ultrasound
Static Measures

- Vitals Signs
- Capillary Refill
- Urine output
  - Lack sensitivity
- CXR
  - Poor reliability
Static Measures

- CVP
  - Measures preload
  - Not predictive of fluid responsiveness
  - Controversial, but part of SEP-1

- Central venous oxygen measurement
  - Resuscitation endpoint
  - Not predictive of fluid responsiveness
Dynamic Measures

- Passive Leg Raise

The passive leg-raising test consists of measuring the hemodynamic effects of a leg elevation up to 45°. A simple way to perform the postural maneuver is to transfer the patient from the semi-recumbent posture to the passive leg-raising position by using the automatic motion of the bed.
Passive Leg Raise

- Bolus without a bolus
- Requires a measure of Cardiac Output
  - Echo
  - Carotid flow
  - ETCO\textsubscript{2}
  - PPV / SVV
  - Thermodilution
Capnometry - *Increased* PETCO₂

<table>
<thead>
<tr>
<th>Output</th>
<th>Pulmonary Perfusion</th>
<th>Alveolar Ventilation</th>
<th>Technical Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>Increased CO</td>
<td>Hypoventilation</td>
<td>Inadequate Gas Flow</td>
</tr>
<tr>
<td>Malignant Hyperthermia</td>
<td>Increased BP</td>
<td>Bronchial Intubation</td>
<td>Leaks in System</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td></td>
<td>Partial Obstruction</td>
<td>Faulty Ventilator</td>
</tr>
<tr>
<td>Tourniquet Release</td>
<td>Rebreathing</td>
<td></td>
<td>Exhausted CO₂ Absorber</td>
</tr>
</tbody>
</table>

*Under conditions of constant lung ventilation, PETCO₂ monitoring can be used as a monitor of pulmonary blood flow*
**Increased PETCO$_2$ >5%**


Pulse Pressure Change

- Pulse Pressure is the difference between systolic and diastolic pressures.

- Pulse pressure variation is the change in pulse pressure with respirations:
  - Various devices can measure:
    - Sinus Rhythm
    - Mechanical Ventilation with TV > 8cc/kg

- PPV > 12% is predictive of Fluid Responsiveness.
Pulse Pressure Variation

- The rationale is that, during positive pressure ventilation, insufflation decreases preload of the right ventricle. When transmitted to the left side, this induces a decrease in preload of the left ventricle. If left ventricular stroke volume changes in response to cyclic positive pressure ventilation, this indicates that both ventricles are preload dependent.
Stroke Volume Variation

- Looks at the area under the curve of an arterial line tracing and calculates the change in volume as a surrogate for stroke volume.
  - Various devices can measure, but patient must
    - Sinus Rhythm
    - Mechanical Ventilation with TV > 8cc/kg
  - Newer non invasive devices use the pulse oximetry waveform
    - Similar constraints, including perfusion
### Some Monitoring Systems

<table>
<thead>
<tr>
<th>Technology</th>
<th>Device</th>
<th>Invasiveness</th>
<th>Principle</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioreactance</td>
<td>NiCOM</td>
<td>Non-invasive</td>
<td>Bioreactance</td>
<td>Non-invasive. Continuous</td>
<td>Fewer validation studies</td>
</tr>
<tr>
<td>Plethysmographic wave form analysis</td>
<td>Radical7</td>
<td>Non-invasive</td>
<td>Plethysmograph wave form analysis</td>
<td>Continuous CO measurements. Non-invasive.</td>
<td>Decreased accuracy with poor perfusion.</td>
</tr>
<tr>
<td>Pulmonary artery catheter</td>
<td>Vigilance</td>
<td>Central arterial catheter</td>
<td>Thermodilution</td>
<td>CO measurement gold standard.</td>
<td>Highly invasive. Intermittent CO measurements.</td>
</tr>
<tr>
<td>Pulse contour analysis</td>
<td>FloTrac</td>
<td>Arterial catheter</td>
<td>Pulse wave analysis</td>
<td>Continuous CO measurements.</td>
<td>In consistent CO tracking.</td>
</tr>
<tr>
<td>LiDCO</td>
<td>Arterial catheter</td>
<td>Lithium dilution</td>
<td>Continuous CO measurements.</td>
<td>Requires frequent calibration.</td>
<td></td>
</tr>
<tr>
<td>PICCO</td>
<td>Central arterial &amp; venous catheters</td>
<td>Thermodilution</td>
<td>Continuous CO measurements.</td>
<td>Invasive. Requires calibration.</td>
<td></td>
</tr>
<tr>
<td>PRAM</td>
<td>Arterial catheter</td>
<td>Pulse wave analysis</td>
<td>No calibration. Continuous CO measurements.</td>
<td>Few studies validating use.</td>
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</table>
End-expiratory Occlusion Test

- Interrupting mechanical ventilation for a few seconds stops this cyclic impediment in venous return. Cardiac preload transiently increases. If cardiac output increases, this indicates fluid responsiveness.

- A 15 second expiratory occlusion is performed and an increase in pulse pressure or cardiac index predicts fluid responsiveness with a high degree of accuracy.

  - The patient must be able to tolerate the 15 second interruption to ventilation without initiating a spontaneous breath.

Dynamic Measurement - Ultrasound

- Echo - Velocity Time Index
- Carotid Doppler Flow
- Esophageal Doppler
- IVC variation
- Lung ultrasound
DIY PPV

- See the ACEP CCM Section newsletter Spring 2016 by Susan Wilcox, MD

- Requires an arterial line
- Normal sinus rhythm
- Mechanical ventilation
  - Ventilated with at least 8 mL/kg of tidal volume
- Have no significant alternations to chest wall compliance, such as an open chest
DIY PPV

- Condense the waveform to 6.25 mm/sec
DIY PPV

- Measure during inspiration with a cursor
DIY PPV

- Measure during exhalation with a cursor
Numerous studies have found that a PPV of > 12% is associated with volume responsiveness in the operating room and ICU alike. (no ED studies)

A meta-analysis of PPV to predict fluid responsiveness found a sensitivity and specificity of 0.89 and 0.88 respectively.
Conclusion

- In the ED, Ultrasound is probably the best tool
  - Cardiac, Lung, IVC
- There are many new devices, but all have limitations
- A true fluid challenge works too, but too much can lead to fluid overload
- Just because fluid responsive, does not mean you have to give fluids - use resuscitation endpoints
- A lack of fluid responsiveness is also important
What's Next?

• Complete Sepsis Portal Activities
• Questions? Contact the E-QUAL team at equal@acep.org