E·QUAL | EMERGENCY QUALITY NETWORK

Sepsis Wave II Webinar Series

Sepsis Reassessment

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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

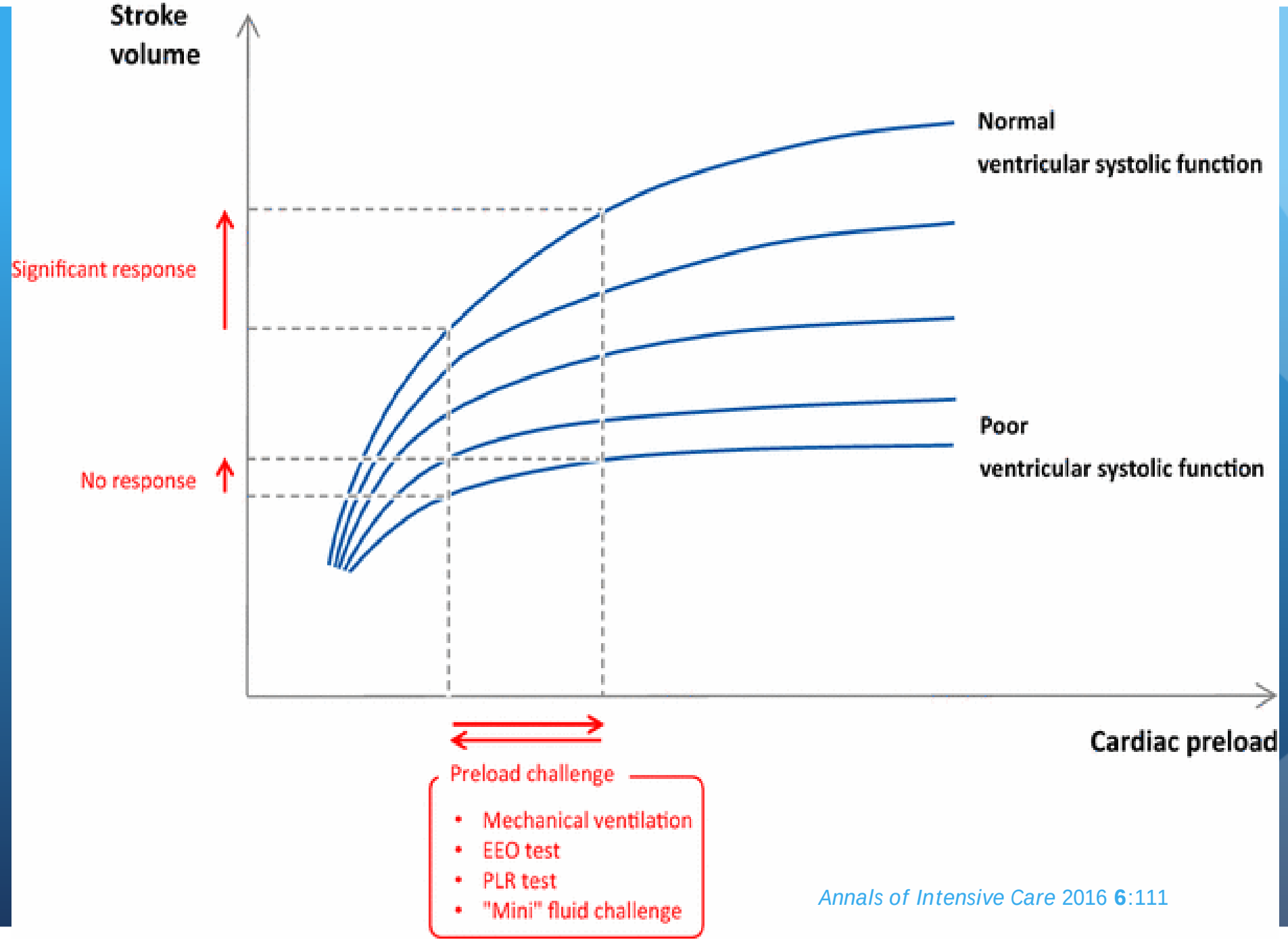
- *WITHIN 6 HOURS OF PRESENTATION*
  - Repeat volume status and tissue perfusion assessment
    - Two Methods:
  - **OR any two of the following:**
    - Central venous pressure measurement
    - Central venous oxygen measurement
    - Bedside cardiovascular ultrasound
    - Passive leg raise or fluid 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 O_2 Saturation = DO_2



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

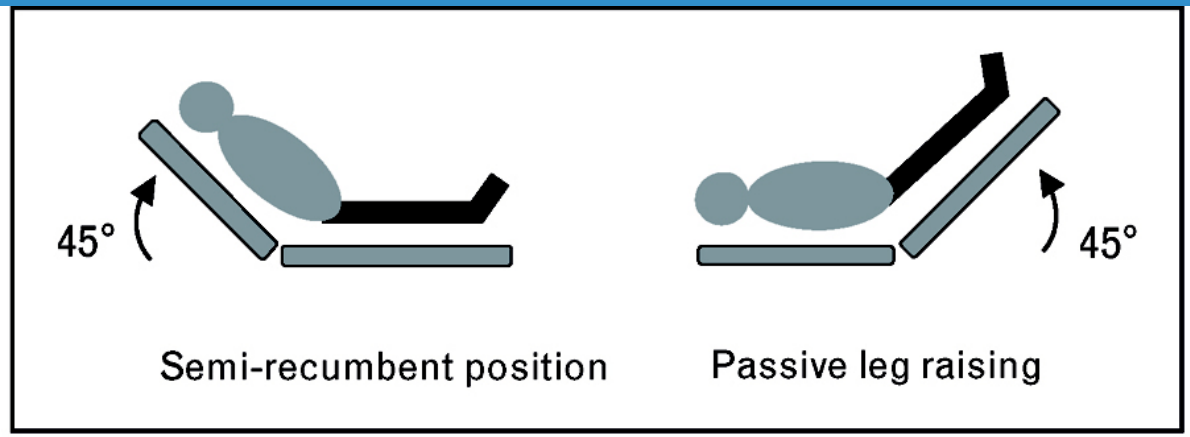
Static Measures

- 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
  - $ETCO_2$
  - PPV / SVV
  - Thermodilution

Capnometry –*Increased* $PETCO_2$

Output	Pulmonary Perfusion	Alveolar Ventilation	Technical Errors
Fever	Increased CO	Hypoventilation	Inadequate Gas Flow
Malignant Hyperthermia	Increased BP	Bronchial Intubation	Leaks in System
Sodium Bicarbonate		Partial Obstruction	Faulty Ventilator
Tourniquet Release		Rebreathing	Exhausted CO_2 Absorber

Under conditions of constant lung ventilation, $PETCO_2$ monitoring can be used as a monitor of pulmonary blood flow

Increased $PETCO_2$ >5%

- Monnet X[1], et al. **End-tidal carbon dioxide is better than arterial pressure for predicting volume responsiveness by the passive leg raising test.** Intensive Care Med. 2013 Jan;39(1):93-100
- Xiao-ting W[1], et al. **Changes in end-tidal CO2 could predict fluid responsiveness in the passive leg raising test but not in the mini-fluid challenge test: A prospective and observational study.** J Crit Care. 2015 Oct;30(5):1061-6.

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.

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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

Technology	Device	Invasiveness	Principle	Advantage	Disadvantage
Bioreactance	NICOM	Non-invasive	Bioreactance	Non-invasive. Continuous	Fewer validation studies
Plethymosgraphic wave form analysis	Radical7	Non-invasive	Plethysmograph wave form analysis	Continuous CO measurements. Non-invasive.	Decreased accuracy with poor perfusion.
Pulmonary artery catheter	Vigilance	Central arterial catheter	Thermodilution	CO measurement gold standard.	Highly invasive. Intermittent CO measurements.
Pulse contour analysis	FloTrac	Arterial catheter	Pulse wave analysis	Continuous CO measurements.	In consistent CO tracking.
	LiDCO	Arterial catheter	Lithium dilution	Continuous CO measurements.	Requires frequent calibration.
	PiCCO	Central arterial & venous catheters	Thermodilution	Continuous CO measurements.	Invasive. Requires calibration.
	PRAM	Arterial catheter	Pulse wave analysis	No calibration. Continuous CO measurements.	Few studies validating use.
	Clearsight/Nexfin	Non-invasive	Pulse wave analysis	Non-invasive. Continuous CO measurements.	Decreased accuracy in critical illness. Few validation studies.
	Volume view	Central arterial & venous catheters	Thermodilution	Continuous CO measurements.	Invasive. Requires calibration.

Clin Exp Emerg Med 2014; 1(2): 67-77.

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

Monnet X, et al. Predicting volume responsiveness by using the end-expiratory occlusion in mechanically ventilated intensive care unit patients. Crit Care Med. 2009;37:951–6

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

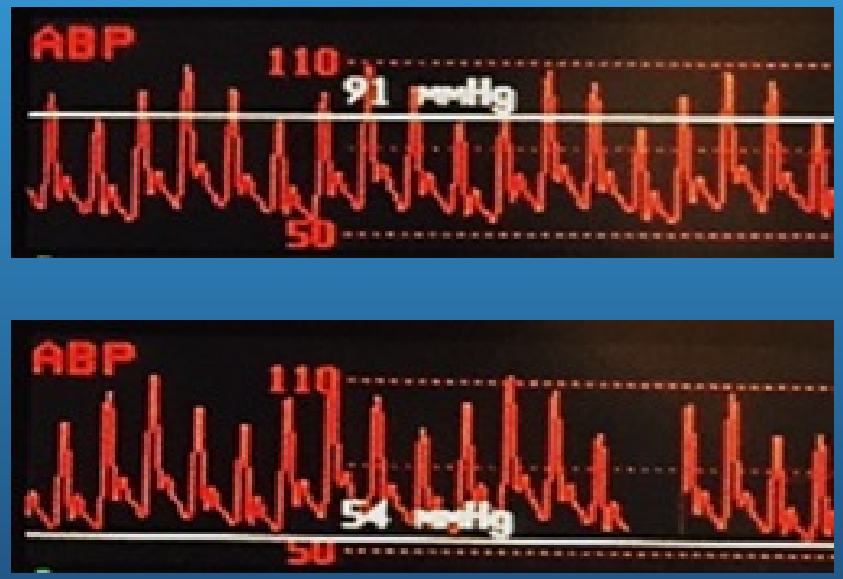
- Condense the waveform to 6.25 mm/sec

DIY PPV

- Measure during inspiration with a cursor

DIY PPV

- Measure during exhalation with a cursor



DIY PPV

$$\text{PPV \%} = \frac{\text{PPmax} - \text{PPmin}}{\text{Mean of the 2 PP}} \times 100$$

- 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

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What's Next?

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

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