Shock Management With Non-Invasive Monitoring

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DISCLOSURE

Dr. Latham has declared no conflicts of interest related to the content of his presentation.

Disclosure

- No Business Interests
- No Consulting
- No Speakers Bureau
- No Off Label Use to Discuss

Objectives

- Describe the goal of resuscitation in shock.
- Describe the utility of the heart-lung interaction to predict volume responsiveness.
- Recognize the limitations of respiratory induced variability in hemodynamics to predict volume responsiveness.
- Recognize applications and limitations of bioreactance derived hemodynamic monitoring..
- Recognize applications and limitations of doppler indexed CO estimate derived hemodynamic monitoring.
- Recognize applications and limitations of pulse contour analysis derived hemodynamic monitoring.

Clinical Case

- JP is a 42 yo female admitted with a 4 day history of progressive dyspnea, cough, fevers, and myalgia. She is profoundly hypoxemic on presentation with diffuse alveolar infiltrates on her CXR and is immediately intubated in the ED. She is hypotensive and severe sepsis is recognized. She is given appropriate antibiotic coverage and bolused 30 mL/Kg of crystalloid. Her rapid flu is positive.
- Vent settings: Vt 350 (6mL/Kg), RR 28, PEEP 12, FiO_2 1.0
- Post fluid vitals: T 39, BP 80/40, HR 95 (NSR), RR 28
- PPV: 18
- Pulse Contour Analysis: SVI 35, CI 3.3, SVV 19

Clinical Case Question

- Which of the following would you do next?

A. Start Norepinephrine. She's had all the fluid she needs.
B. Bolus crystalloid and re-assess the PPV/SVV
C. Perform a PLR and assess for >10% change in SVI
D. Await the CVP when central line placement is completed

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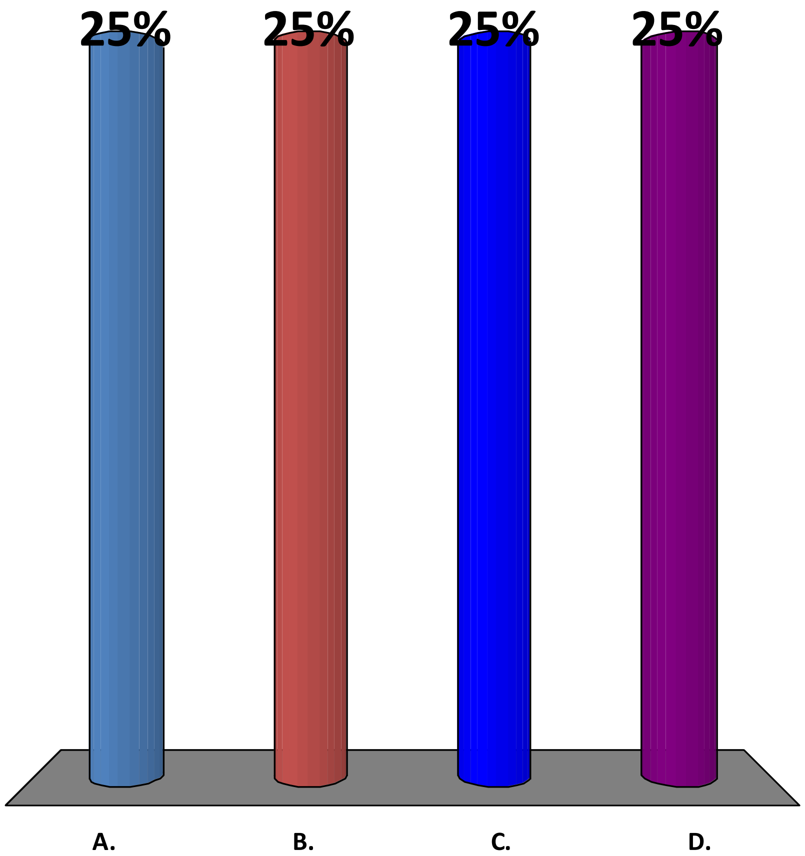

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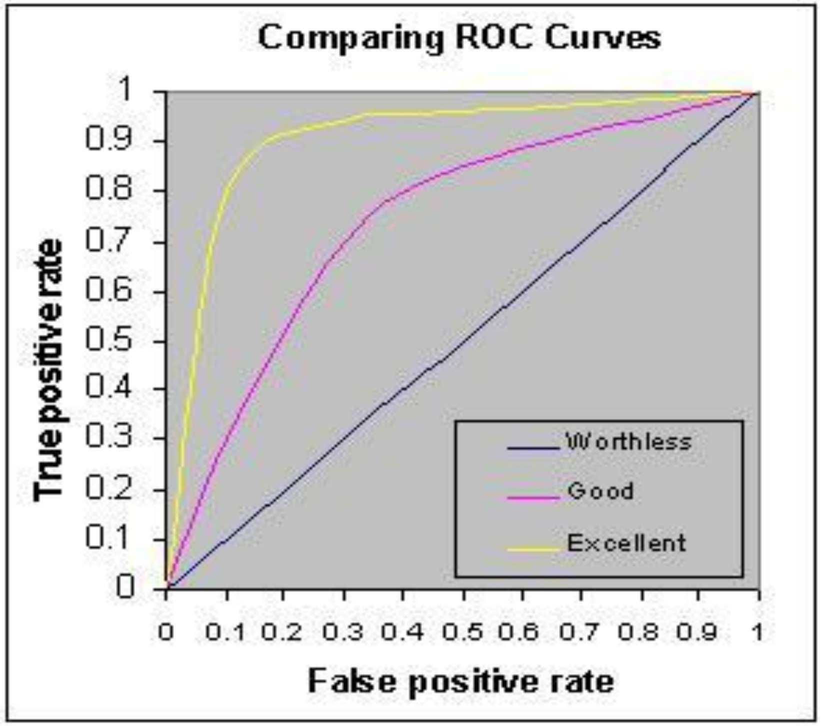
Goal of Resuscitation

- Achieve Adequate Perfusion Pressure
  - MAP > 65 mmHg
    - Volume Replacement
    - Vasopressors
    - Inotropic
- Improve Microcirculatory Flow
  - Rapidly treat underlying cause of shock
- Limit Tissue Edema

Volume Expansion in Shock

- Assess for Volume Responsiveness
  - 50% of Critically Ill are Volume Responsive

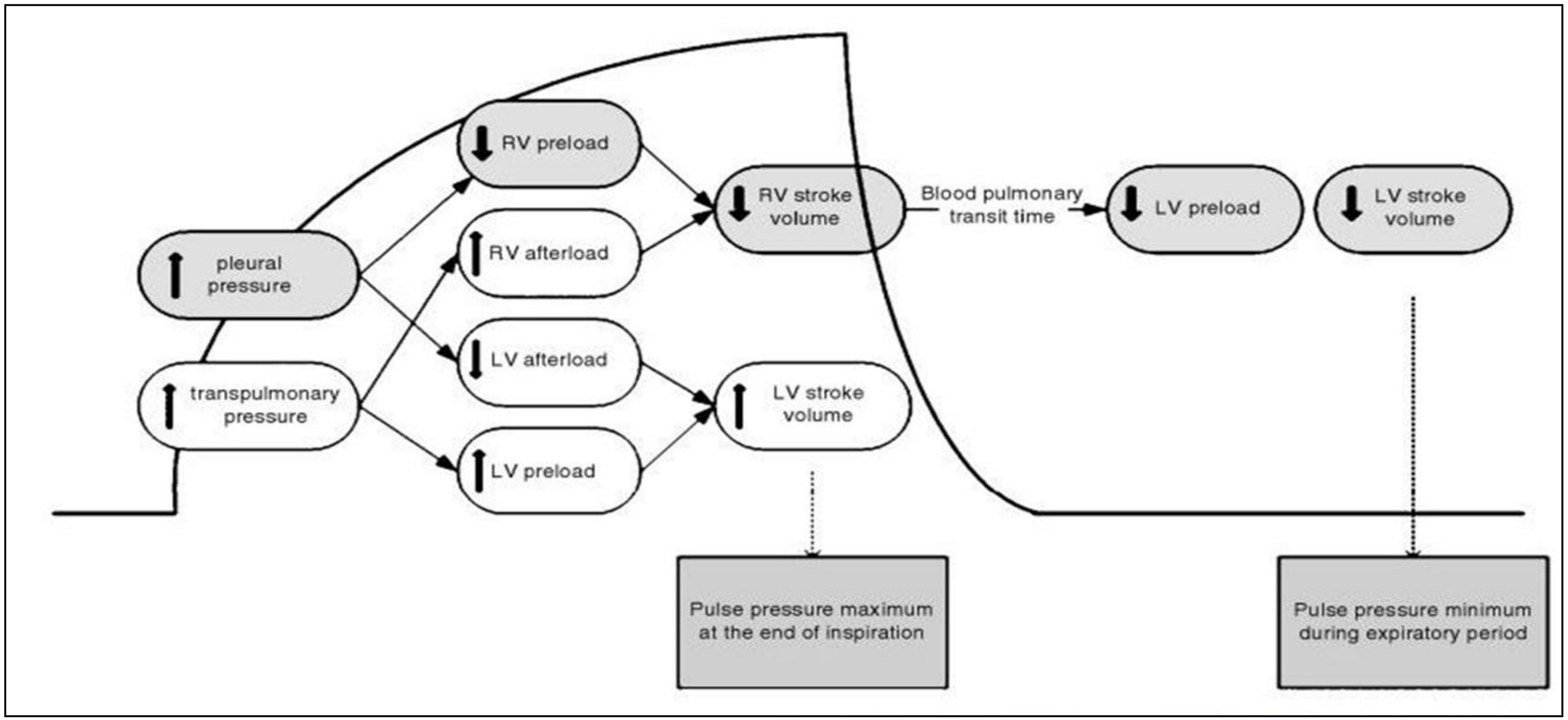


CVP ROC: 0.56
PPV ROC: 0.96
SVV ROC: 0.84

Marik P, et al. Critical Care Med 2009; 37:2642-2647.
Marik P, et al. CHEST 2008; 134:172-178.

Volume Expansion in Shock

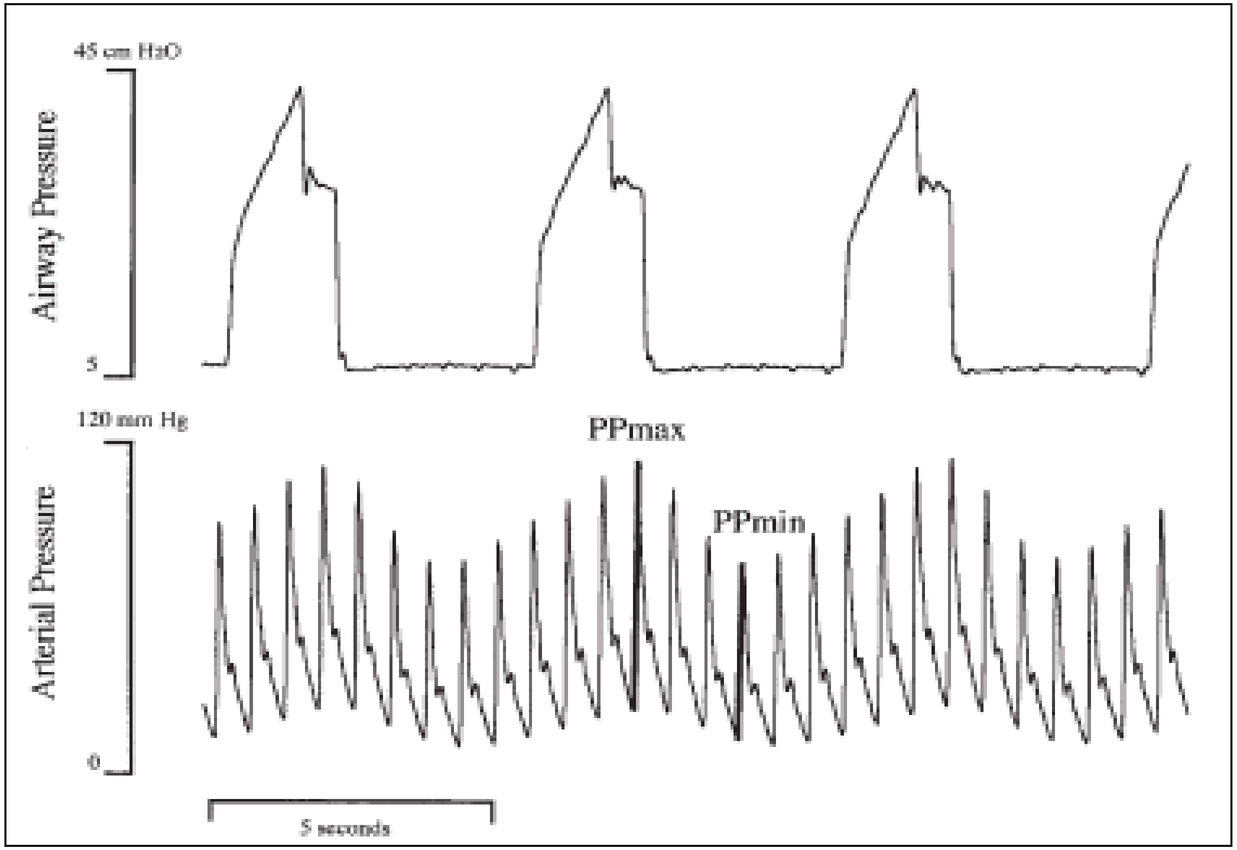
- Heart-Lung Interaction



Michard F, Teboul JL. Critical Care 2000;4:282-289.

Volume Expansion in Shock

- Heart-Lung Interactions



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Volume Expansion in Shock

- Technology Derived Stroke Volume
  - Bioreactance
    - NICOM
  - Pulse contour analysis
    - EV1000
    - LiDCO
    - PiCCO
  - Doppler based
    - Esophageal Doppler
    - USCOM
    - Bedside Echo

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Clinical Case Question

- Which of the following will alter the accuracy of PPV/SVV

A. Tidal Volume > 8mL/Kg
B. Spontaneous Respirations on Ventilator
C. HR/RR > 3.6
D. Sinus Rhythm
E. Normal Chest Wall Compliance

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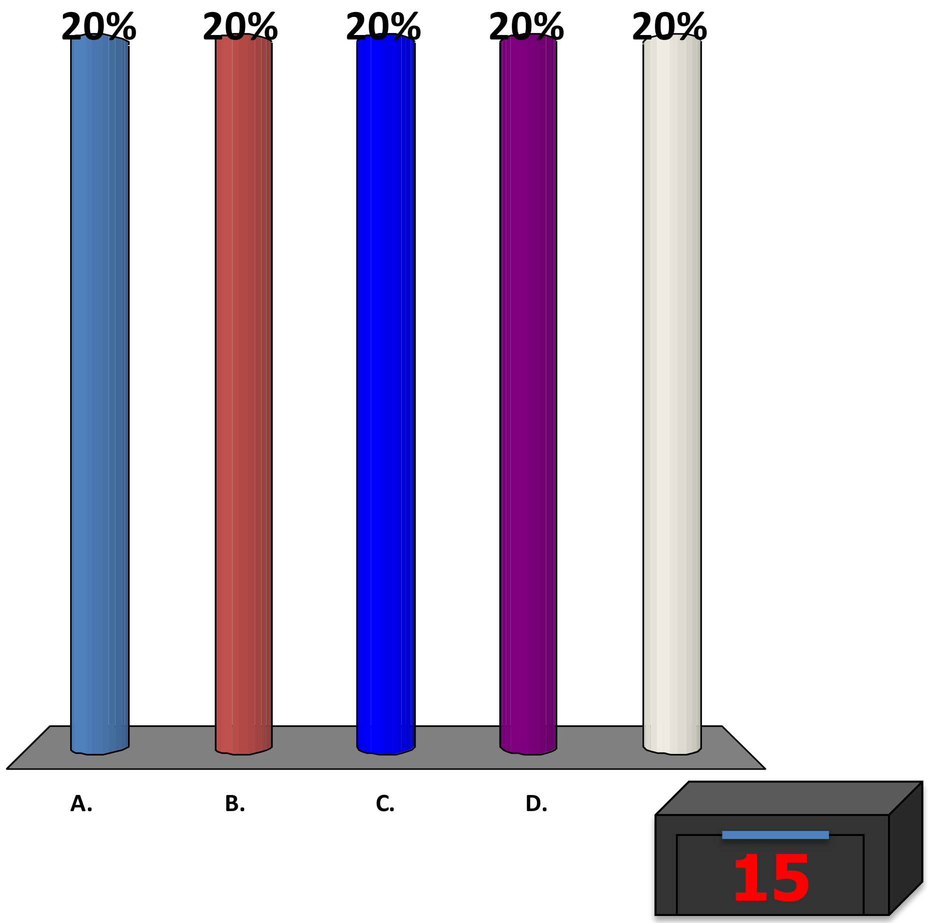

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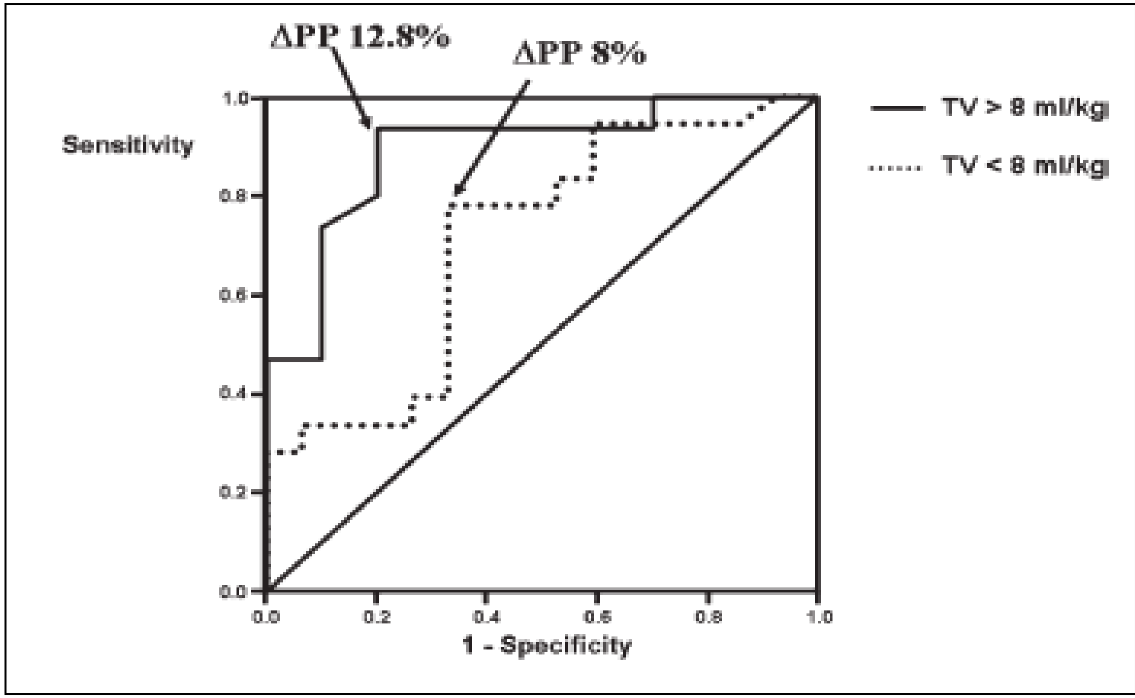
Tidal Volume Effects on PPV/SVV

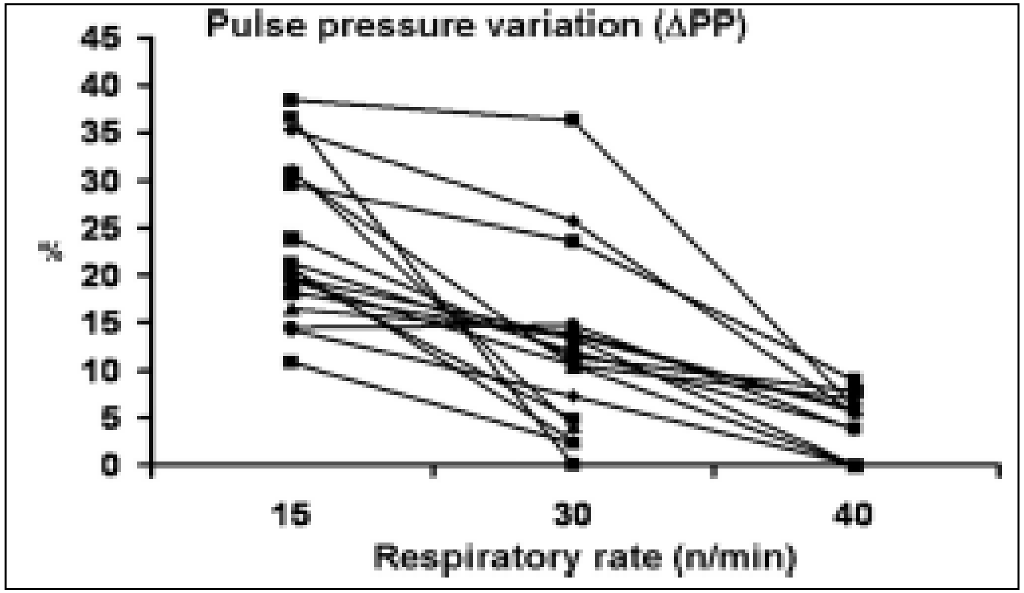
- 60 Patients
- Single Center
- PA Cath as control
  - Responders vs Non
- PPV ROC Curves
  - Vt > 8: 0.89
  - Vt < 8: 0.71
- Change in CI
  - Unaffected by Vt



DeBacker D. Int Care Med. 2005; 31:517-23.

RR effects on PPV/SVV

- 13 Patients
- Mechanically ventilated
  - RR varied 14 to 30-40
- PPV altered by RR
  - 21% at RR of 14
  - 4% at RR 30-40
- HR/RR > 3.6
- CI not effected by RR



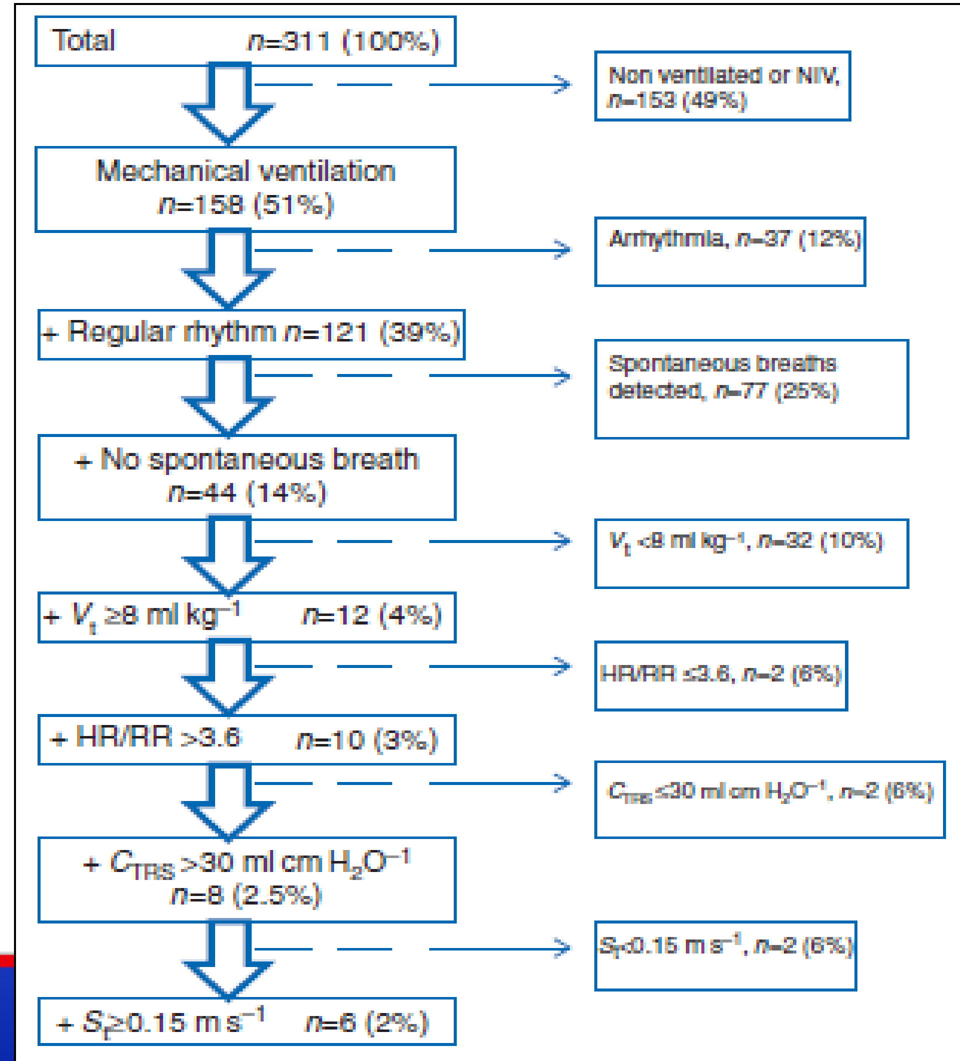
DeBacker, D. Anesthesiology. 2009; 110:1092-97.

Optimal PPV/SVV Parameters

- Mechanically Ventilated
  - No Spontaneous Respirations
  - Vt > 8mL/Kg
- No Arrhythmia
- HR/RR > 3.6
- No valvular disease
- Total respiratory compliance > 30 mL/cm H_20

Optimal PPV/SVV Parameters

- Mahjoub, et al.
  - Br J of Anesth 2013
  - Doi:10.1093/bja/aet442
- Prospective Observ
- 26 ICU's
- 311 Patients
- Very low percentage of patients meet all criteria.



Goal of Resuscitation

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  - MAP > 65 mmHg
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    - Vasopressors
    - Inotropic
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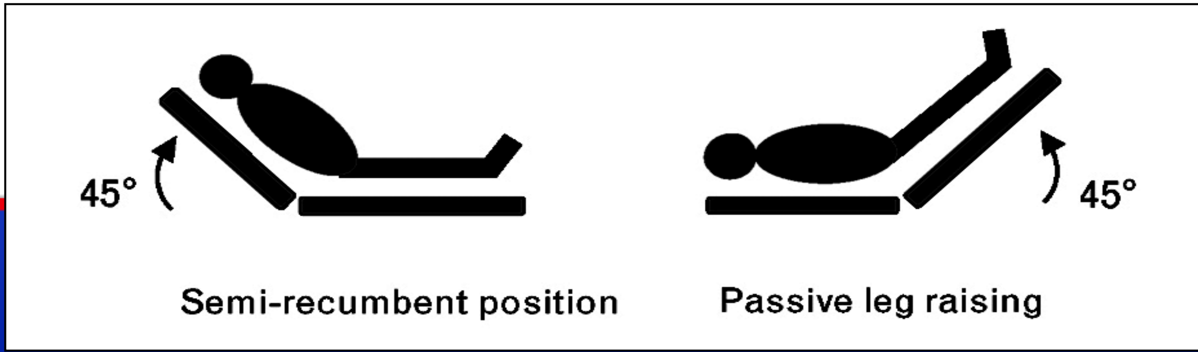
- Limit Tissue Edema

Volume Responsiveness

- Technique
  - Passive Leg Raise (PLR)
  - End Expiratory Hold
  - Volume Expansion
    - 500mL w/in 30 min
- Technology
  - Bioreactance
  - Doppler Derived
  - Pulse Contour Analysis

Volume Responsiveness

- Passive Leg Raise
  - Reversible Volume Expansion
    - 250-350 mL
  - 3-5 Minutes in supine position
  - Caution
    - Labile Hemodynamics
    - Severe Ventilatory Insufficiency
    - At Risk Airway



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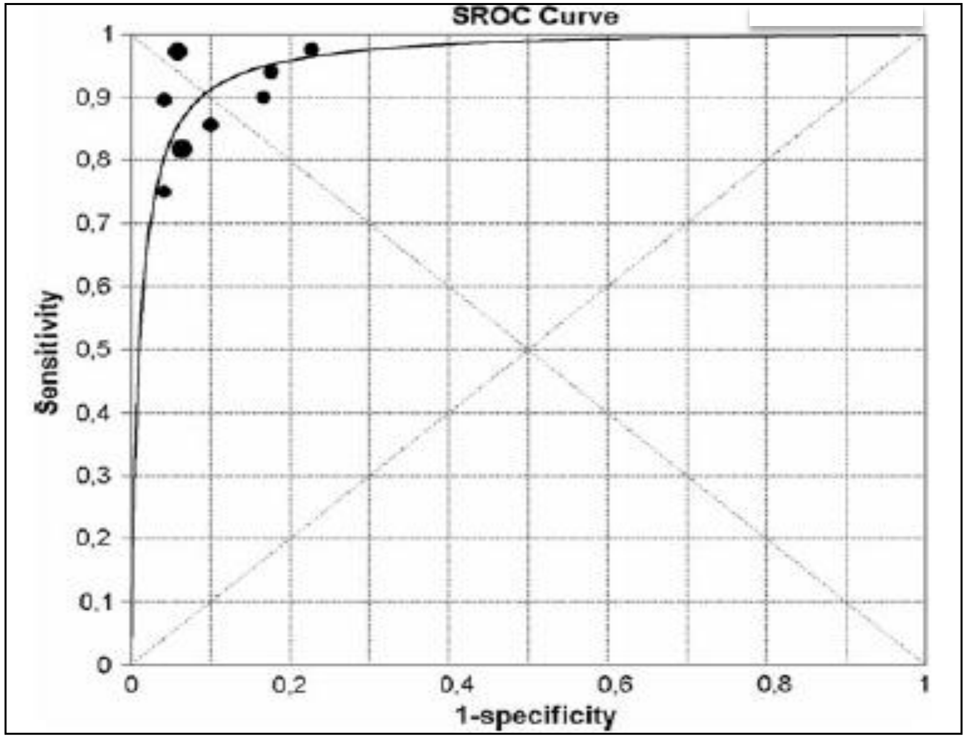
Passive Leg Raise

- Meta-Analysis
  - 9 Articles
  - 366 Pooled Interventions
  - ICU/Shock
- Mixed CI/SVI assessment
  - Doppler derived
  - Pulse contour analysis
- Mixed spontaneous ventilation
- Mixed Rhythms

- Results
  - PLR Accurately Predicts Volume Responsiveness
  - ΔSVI/CI > ΔPP
  - Unaffected
    - Technology used
    - Spontaneous Respiration
    - Arrhythmia

Cavallaro, F. Inten Care Med. 2010; 36:1475-83.

Passive Leg Raise



	Boluses	% Resp	AUC
	15		
	22	45	0.95
	71	52	0.96
	24	54	0.96
	24	54	
	34	50	0.89
	34	50	0.89
	102	46	0.89
	34	68	0.94
	30	67	0.96
	30	67	0.92
	34	41	0.94
Overall	366	52.9	0.95

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Clinical Question

- JP undergoes and end-expiratory hold for 15 seconds to assess for volume responsiveness. Which of the following is a contraindication to an end-expiratory hold?

A. Spontaneous respirations on the vent
B. Atrial Arrhythmia
C. Pao/FiO2 < 200
D. PEEP > 10
E. None of the Above

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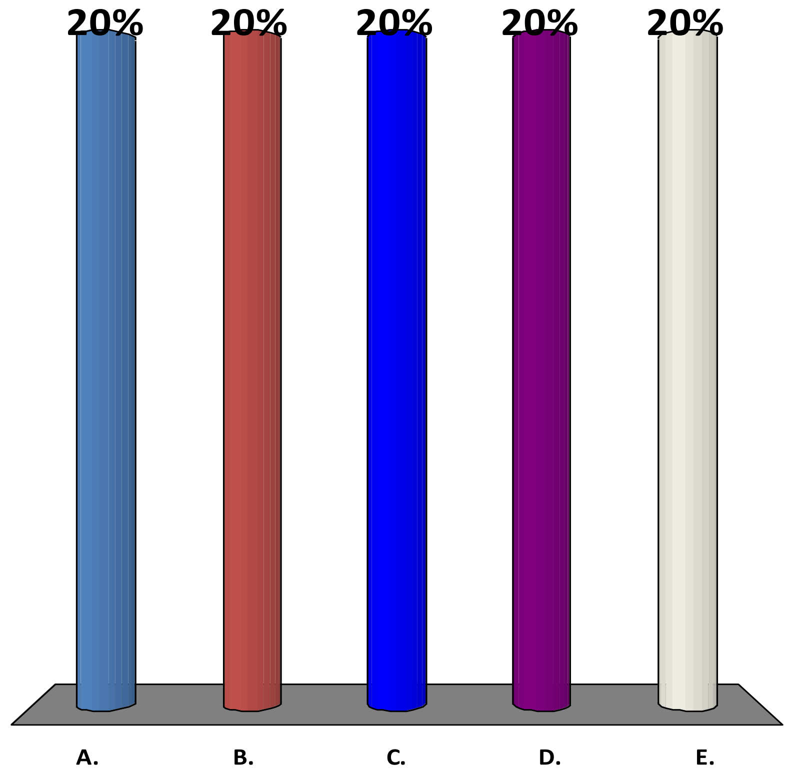

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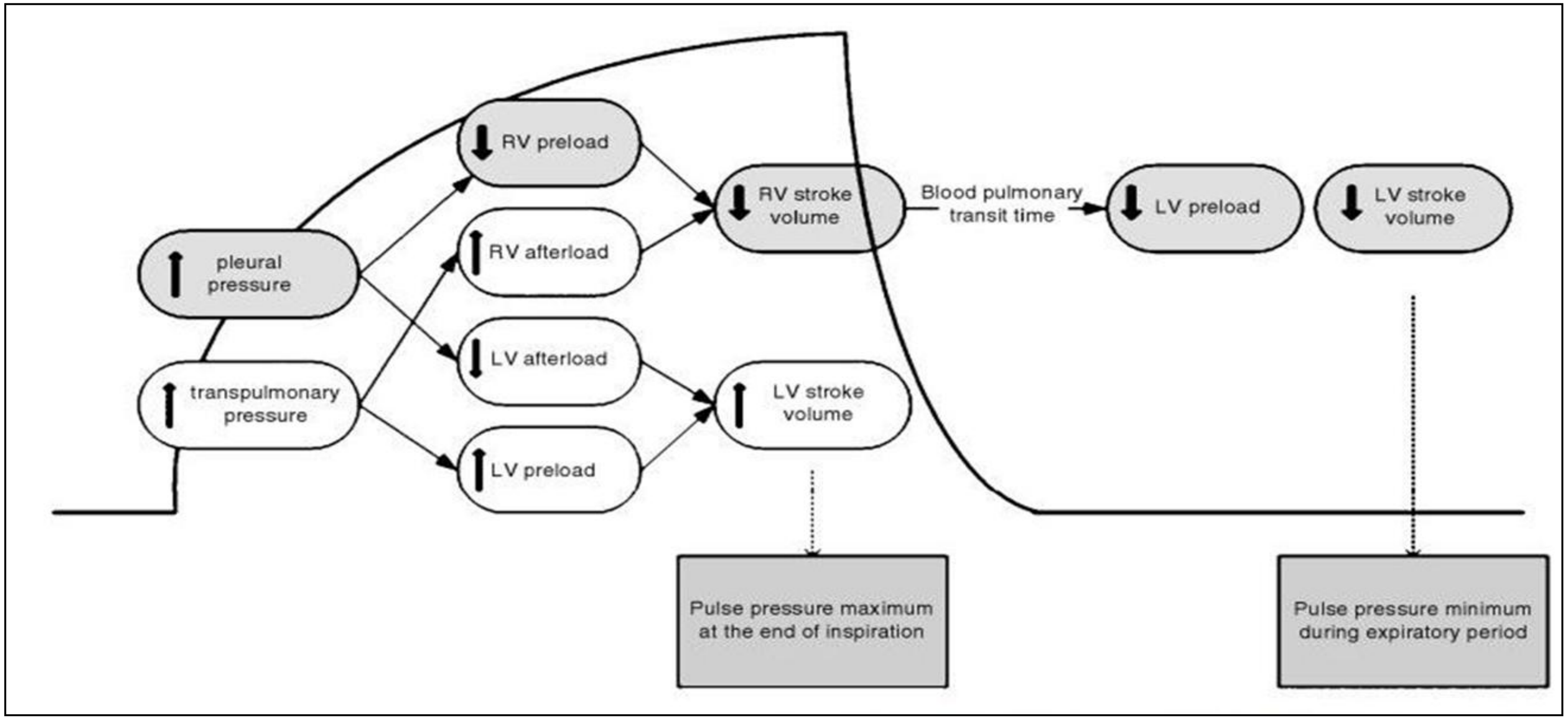
Volume Expansion in Shock

- Heart-Lung Interaction



Michard F, Teboul JL. Critical Care 2000;4:282-289.

End-Expiratory Hold

- 15 Second Pause at End-Expiration
  - Same maneuver to test for intrinsic PEEP
- Non-Invasive Maneuver
- Duration of Test Shorter than PLR
- Requires Fast Hemodynamic Assessment
  - 5-10 Secs

End-Expiratory Hold

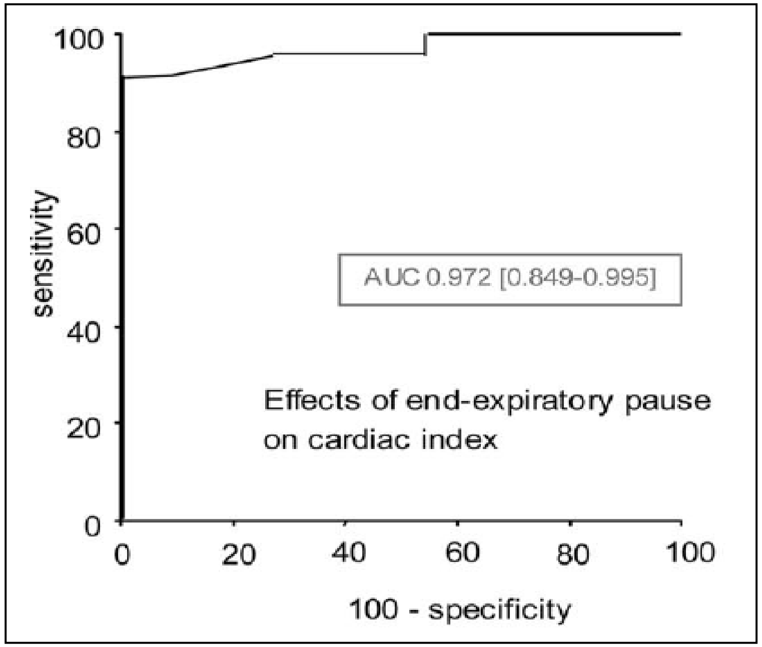
- 34 Critically Ill Patients
- 32% Arrhythmias
- 68% Spontaneous Resp
  - Mild effort
- Compared Δ CI
  - PLR/EEH/VE
  - Pulse contour analysis

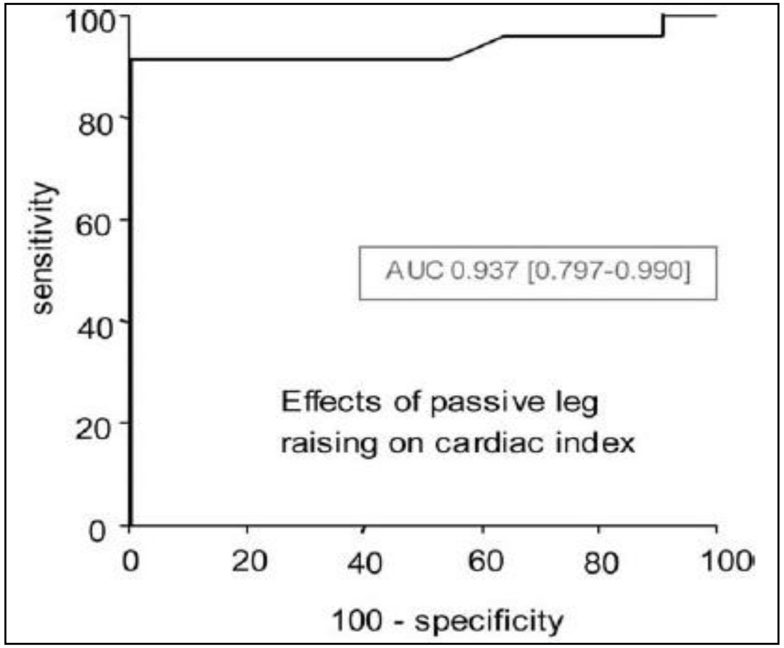
	Responders (n = 23)	Nonresponders (n = 11)
Sepsis (n)	22	10
ARDS (n)	18	5
Tidal volume (mL/kg)	6.8 ± 1.1	6.8 ± 1.1
Total PEEP (cm H_2O)	8 ± 3	7 ± 2
LV ejection fraction (%)	53 ± 9	53 ± 5
PaO_2/FIO_2 (mm Hg)	123 ± 57	195 ± 122
I/E ratio	0.4 ± 0.1	0.3 ± 0.1
Patients receiving norepinephrine (n)	18	5
Rate of norepinephrine infusion (μg/kg/min)	1.0 ± 0.3	1.1 ± 0.4

Monnet, X. Crit Care Med. 2009; 37:951-56.

End-Expiratory Hold

	B0	PLR	B1	EEH	B2	VE
Res	2.3	2.9	2.4	2.7	2.4	3.3
NR	3.4	3.4	3.4	3.4	3.5	3.5





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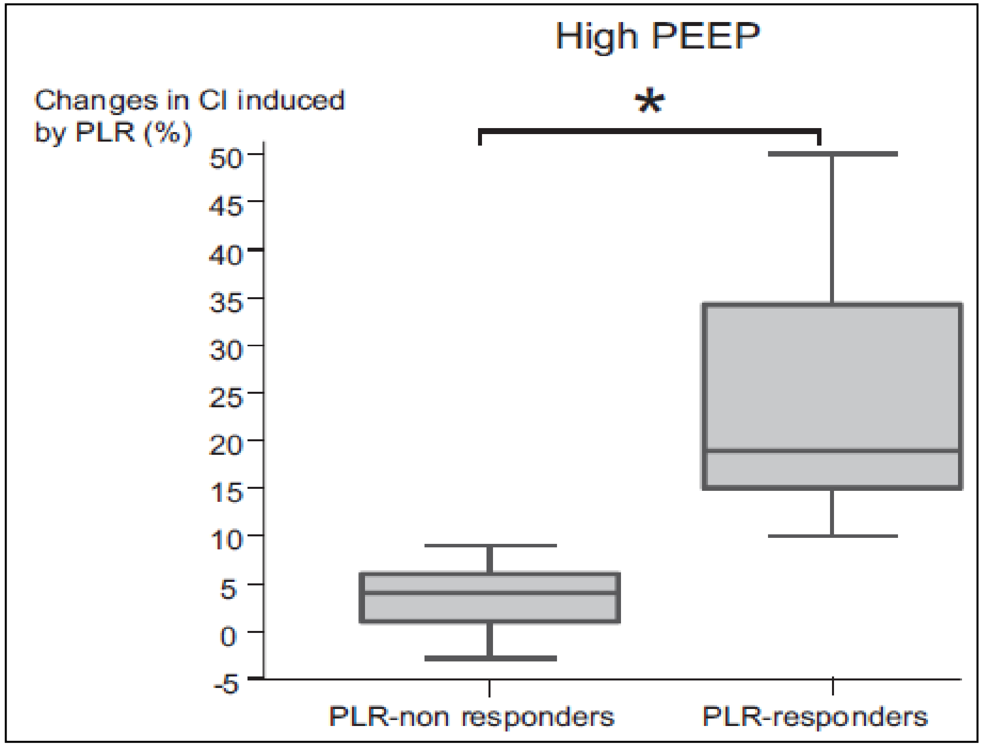
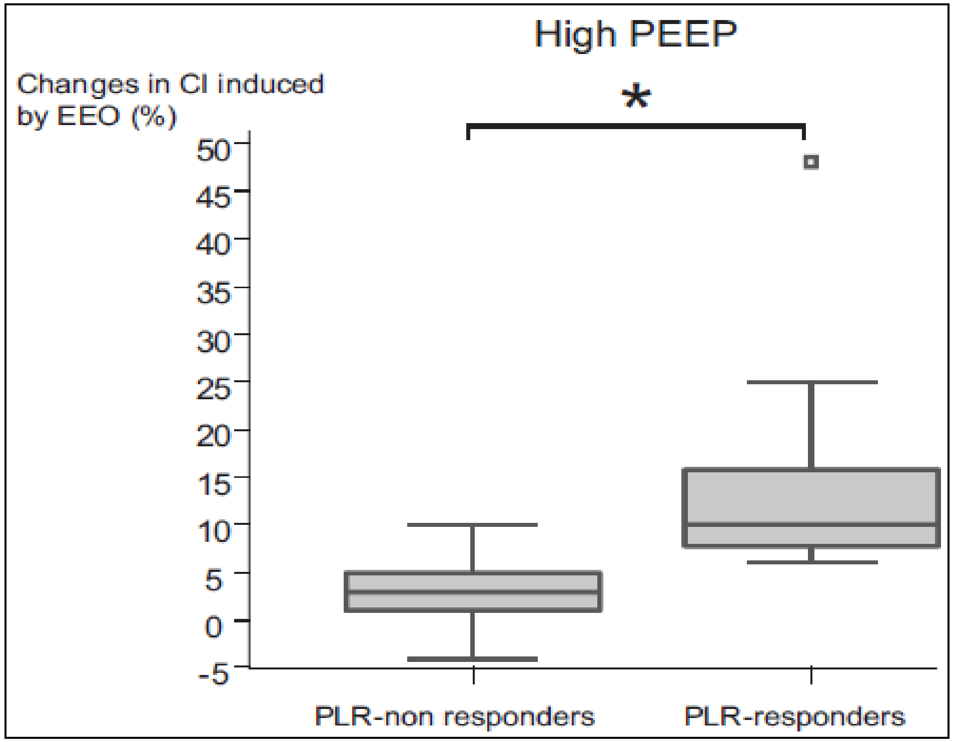
End-Expiratory Hold





Monnet, X. Crit Care Med. 2013; 41:1692-01.

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End-Expiratory Hold

- Alternative to PLR
- High AUC
- Not Effected by Spont Resp
- Not Effected by Arrhythmia
- Not Effected by High PEEP
- Need Rapid Assessment of Changes in SVI/CI
  - Pulse Contour Analysis
  - Doppler Derived Beat to Beat Analysis

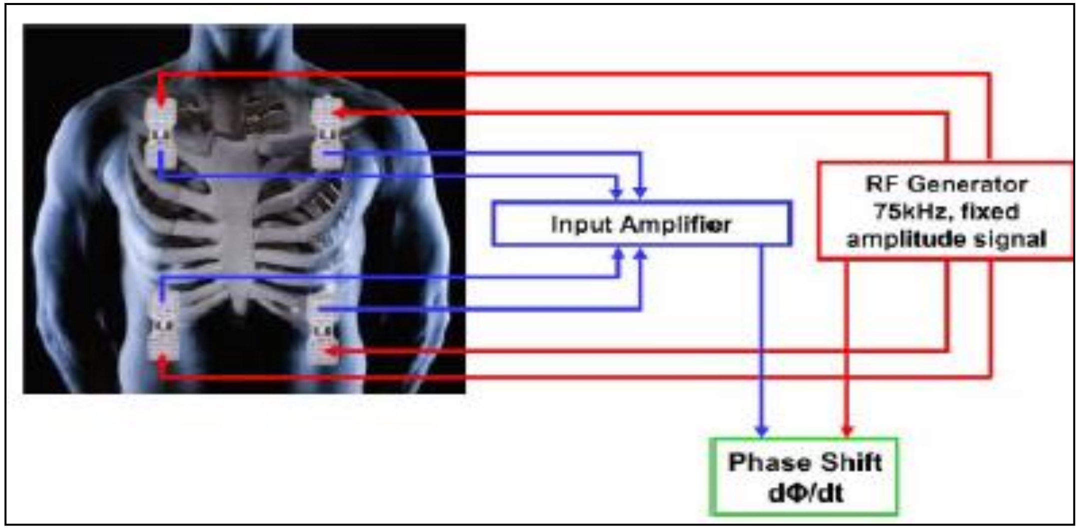
Volume Responsiveness

- Technique
  - Passive Leg Raise (PLR)
  - End Expiratory Hold
  - Volume Expansion
    - 500mL w/in 30 min

- Technology
  - Bioreactance
  - Doppler Derived
  - Pulse Contour Analysis

Bioreactance

- Completely Non-Invasive
- 4 Electrodes on Chest
  - Assess change in current
- Spontaneous Breathing
- Mobile Patient
- Updates every minute



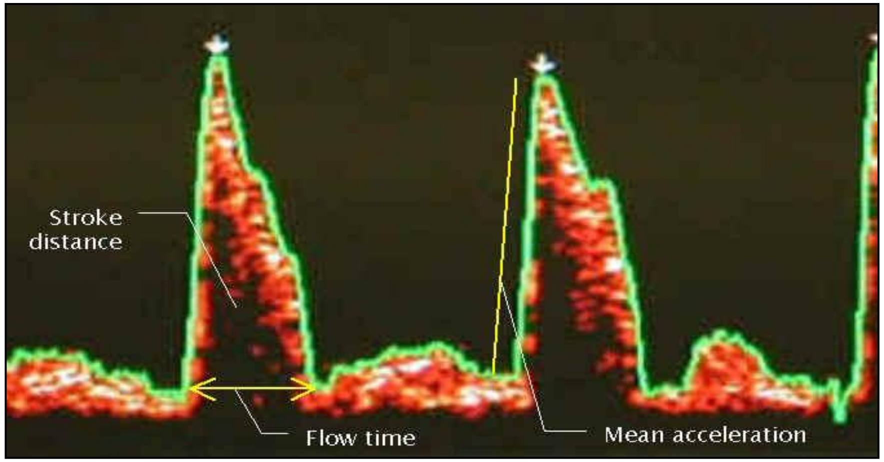
Bioreactance

- Tested in Various Settings
  - ER
  - ICU
  - Pregnancy
  - Pulmonary HTN
- Not Effected by External Electronics
- Applicable in Non-Physician Algorithms

- Limitations
  - Electrode Durability
  - Innaccurate
    - Severe AI
    - Thoracic Aneurysms
    - Balloon Pump
    - LVAD
    - ? Dense Infiltrates
    - Cautery

Doppler Derived CO

- Bedside Echo/US
- Esophageal Doppler
- USCOM
- SV = Vti x CSA
  - VTI = Velocity Time Integral
    - Velocity of blood flow per time through a vessel
  - CSA = Cross Sectional Area
    - LVOT
    - Distal Aorta
    - Large Arteries



Doppler Derived CO

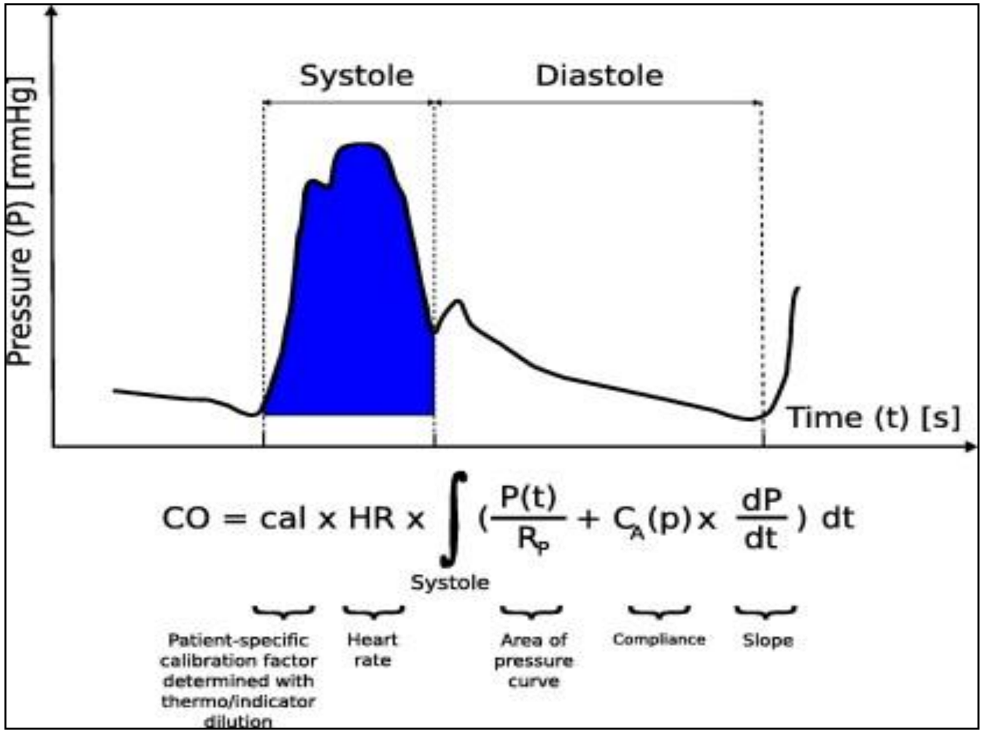
- **Pleuripotential Advantages**
  - Shock Assessment
  - Cardiac/Pulmonary/Abdominal/Vascular
  - Volume Responsiveness
    - IVC
    - Doppler derived SV
      - Echo
      - Automated devices
      - Spontaneously Breathing

Doppler Derived CO

- **Limitations**
  - Additional training
  - Availability of machines
  - Continuous monitoring unavailable
    - Limits resuscitation algorithms

Pulse Contour Analysis

- Estimation of SV
  - Area under the curve
    - Systolic portion
  - Presumed constants
    - Vascular compliance
    - Aortic impedance
    - PVR
  - Pulse Regularity
    - Improves accuracy



Pulse Contour Analysis

- Currently Available Devices
  - PiCCO
    - Calibration (Thermodilution)
  - LiDCO
    - Calibration (Lithium)
    - Non-calibration
  - Vigileo/EV-1000/FloTrac/VolumeView
    - Non-calibration—FloTrac
    - Calibration—VolumeView (Thermodilution)

Pulse Contour Analysis

- Advantages
  - Simple to use
  - Real time data
  - Utilize arterial line already in place
  - Continuous CO
  - Non-physician resuscitation protocols
- Disadvantages
  - Requires excellent waveforms
  - Re-calibration
  - SVV Limited to Optimal Parameters
    - Sinus Rhythm
    - Vt >8 mL/Kg
    - HR/RR > 3.6
    - No Spontaneous Resp

Clinical Question

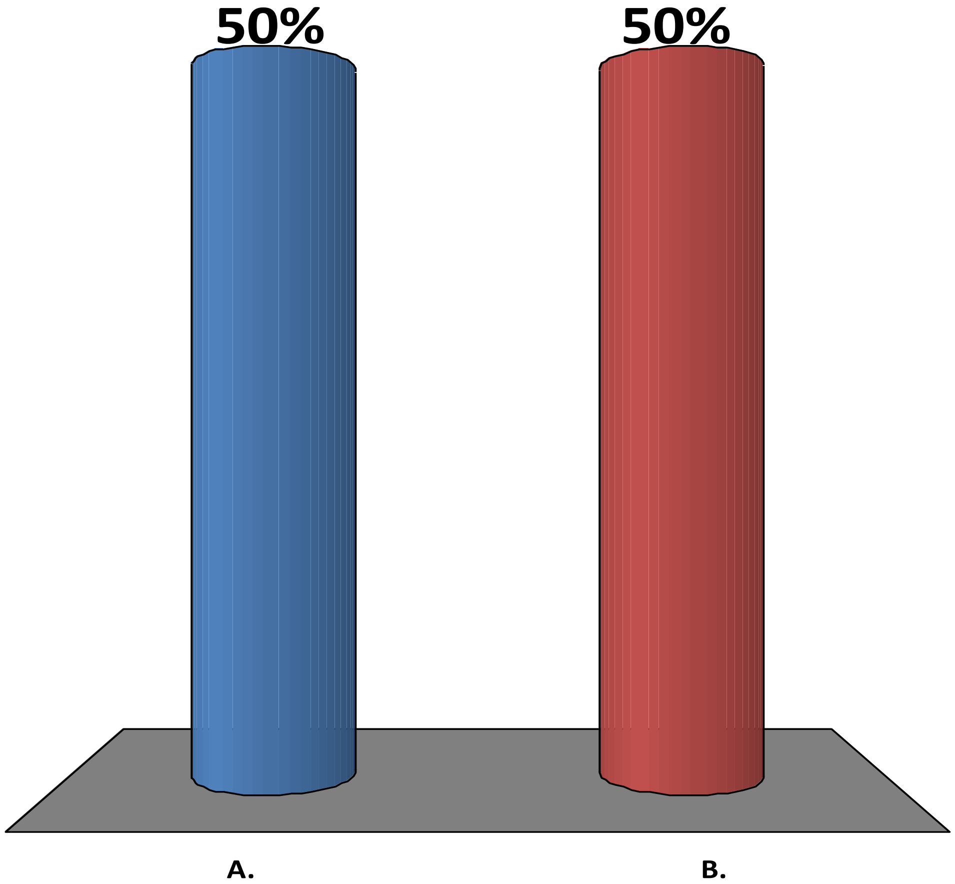
- The greater the fluid balance the higher the mortality?

A. True

B. False

The greater the fluid balance the higher the mortality?

A. True
B. False



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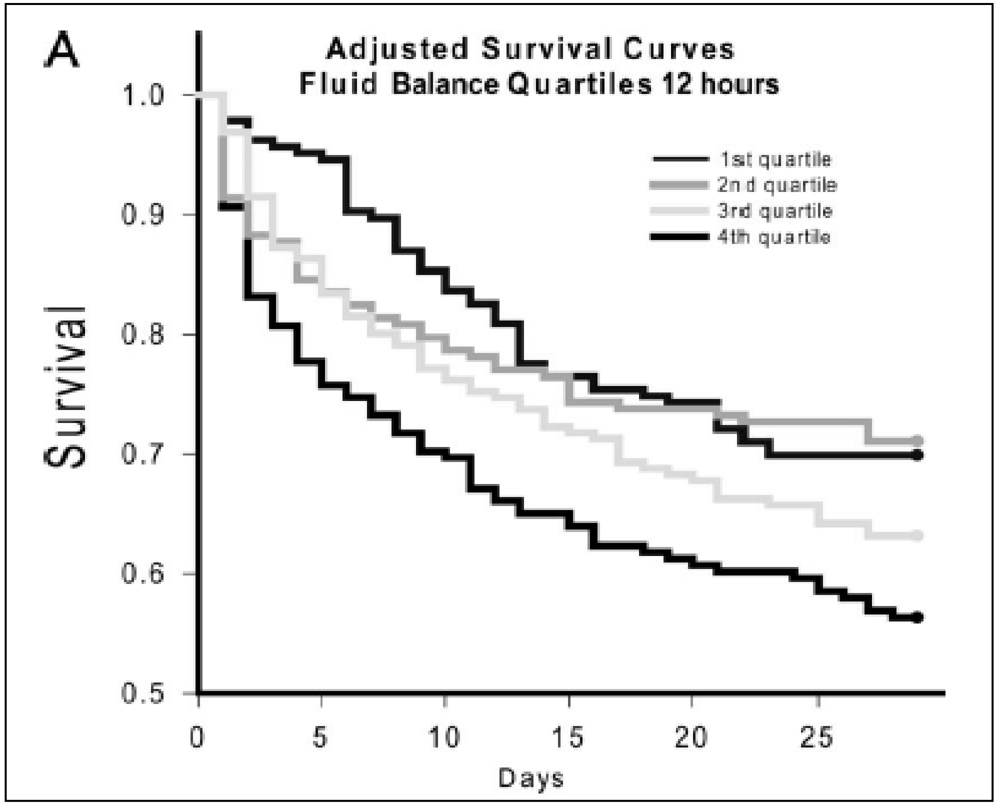
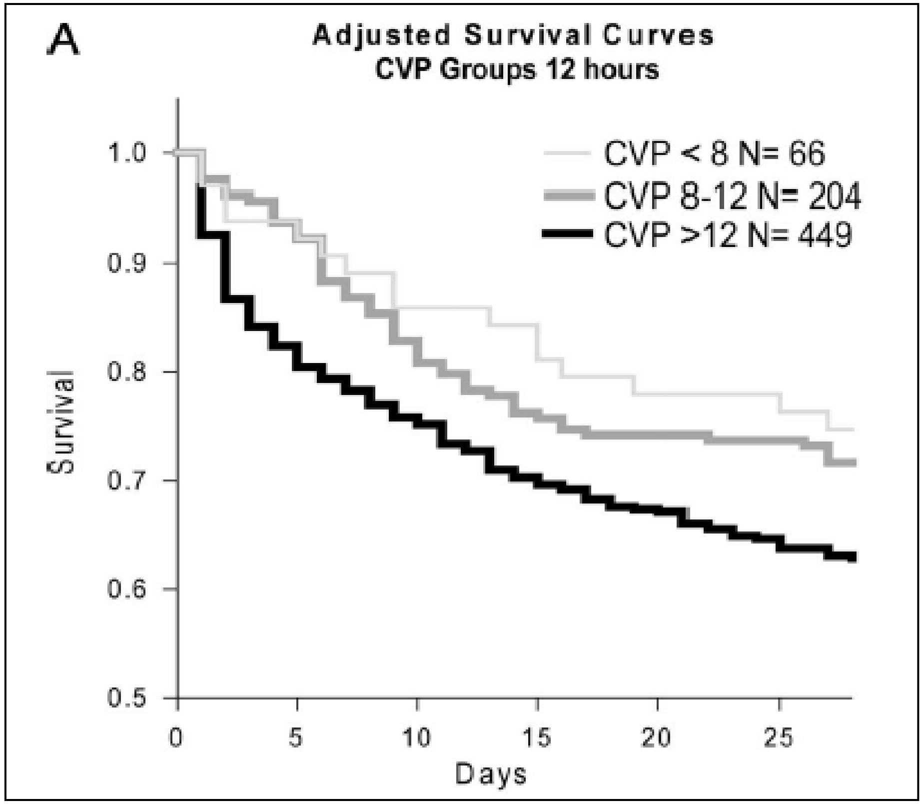
Fluid Balance and Mortality

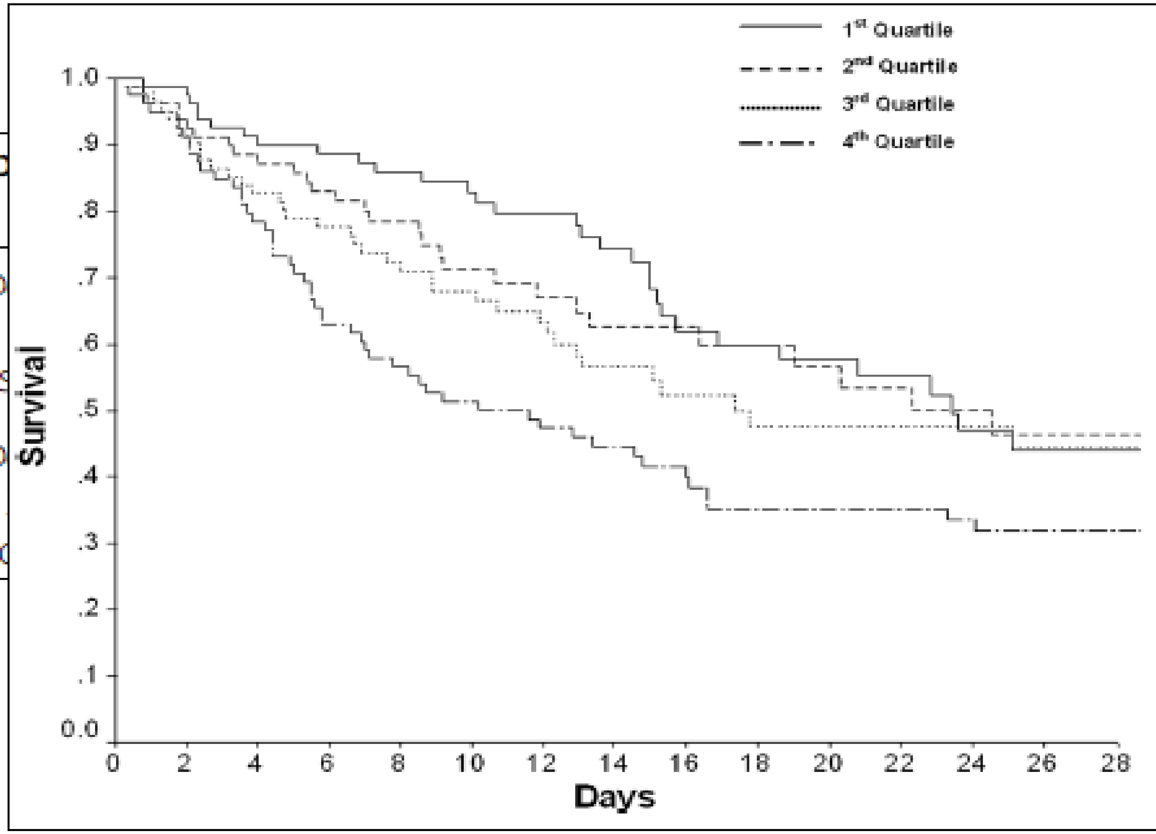




Boyd, J. Crit Care Med. 2011; 39:259-65.

Fluid Balance and Mortality

Variab	-value
Fluid b within septic s	.004
Fluid b within shock c	.022



Kollef, M. Crit Care. 2013; 17:R246.

Summary

- Follow Goals of Resuscitation
  - MAP > 65
  - Reverse underlying process
  - Avoid tissue edema
- Respiratory Induced Hemodynamic Variability
  - Clinical parameters limit actual utility
- ΔSVI/CI Cornerstone of Volume Response

Summary

- Simulate Volume Challenge
  - PLR
  - End-Expiratory Hold
- Utilize Technology to Assess ΔSVI/CI
  - Limitations exist with each technology
- Confident Volume Resuscitation