# Assessment of volume responsiveness

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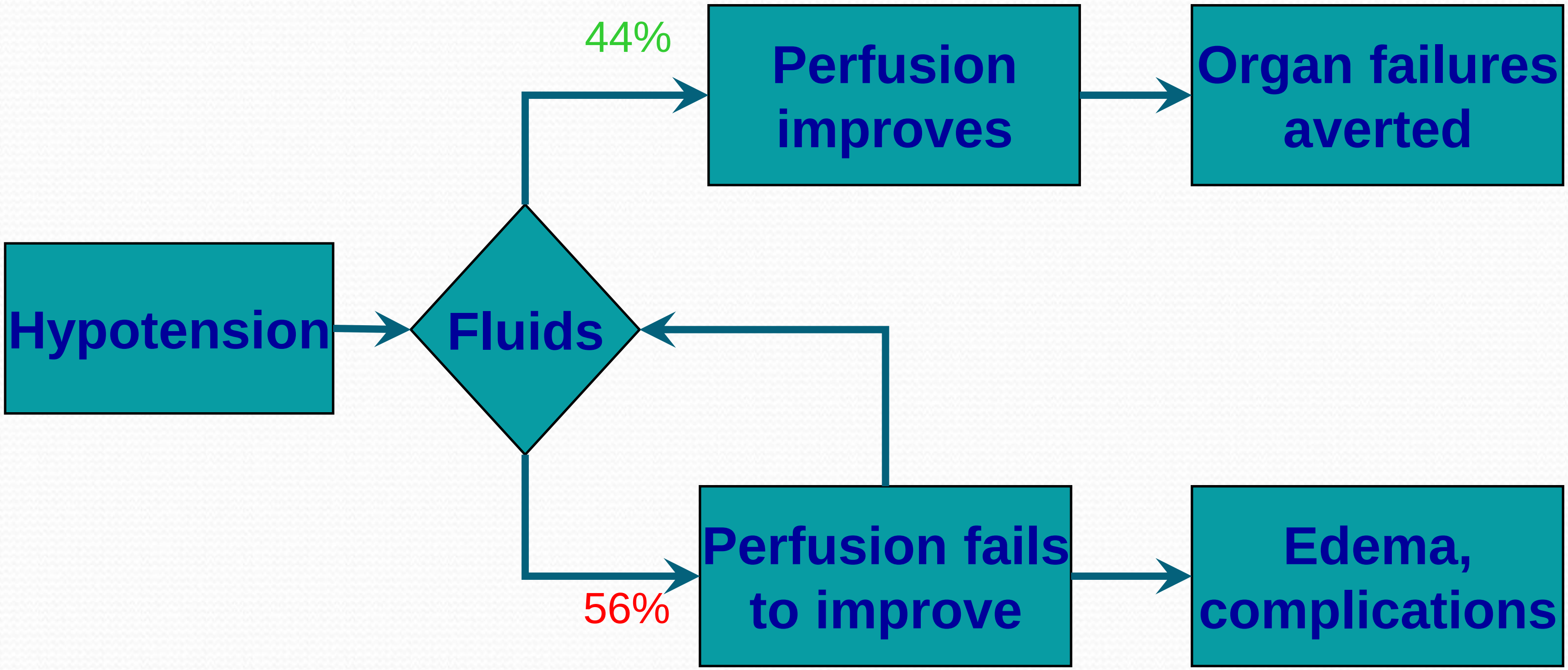
Ordibehesht 1397

# Fluids for Hypotension: 2 Paths




Durairaj L, Schmidt GA. Chest 133:252-63, 2008

# introduction

Liberal vs. conservative fluid management leads to increased morbidity , more ICU stay .

Each one liter of positive fluid balance during the first 72 hrs of ICU stay is associated with a 10% increase in mortality .

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# Methods of fluid balance assessment

Hx

PE

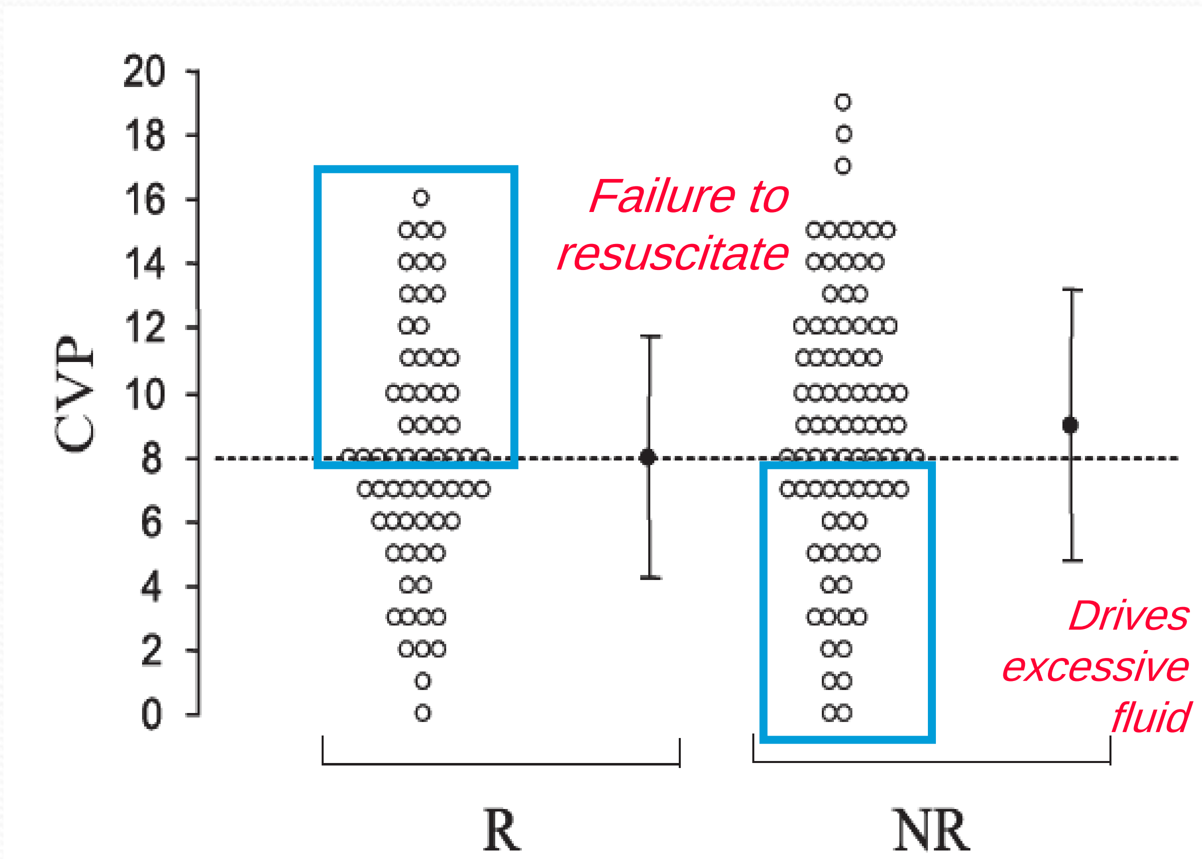
Fluid chart

Static

**Dynamic**

# CVP: Poor Target for Fluid Rx

150 volume challenges; sepsis




Osman D et al. Crit Care Med 2007;35:64

# What do dynamic tests mean ?

Dynamic tests evaluates :

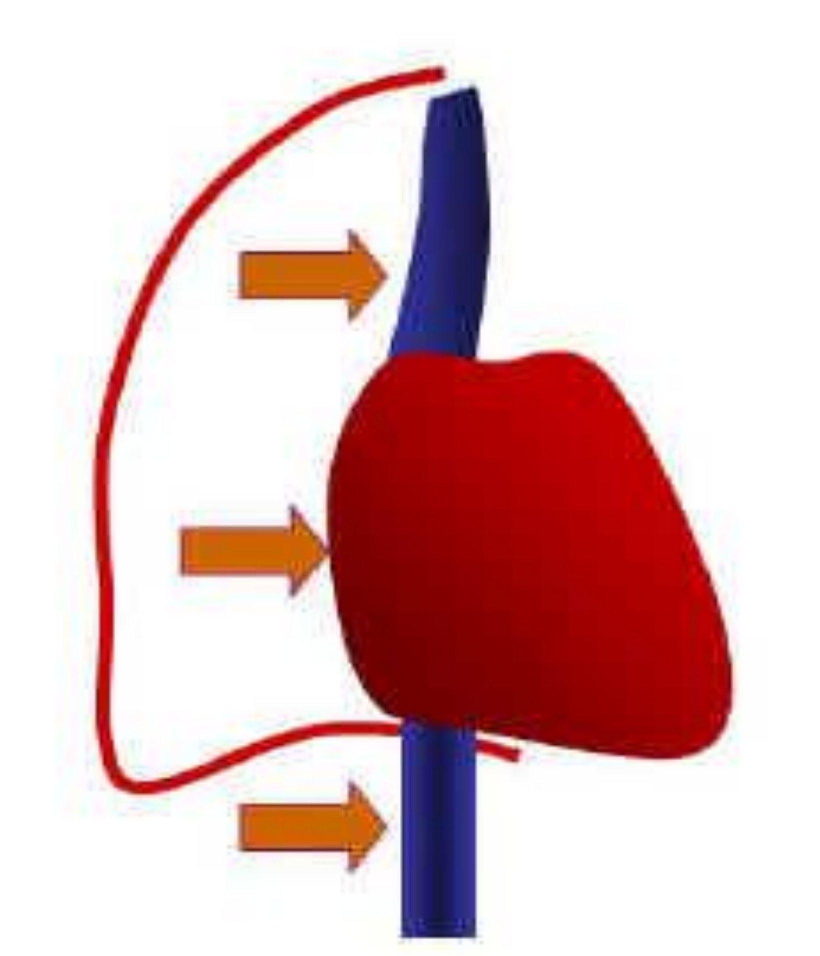
1- Relationships between two heart chambers( Can LV handle volume received by RV ?)

2- Relationship between respiratory system and heart

3- Relationship between volume and container in Rt side ( venous) and Lt side ( arterial perfusion and output)

4- Real time vs. snap shot view.

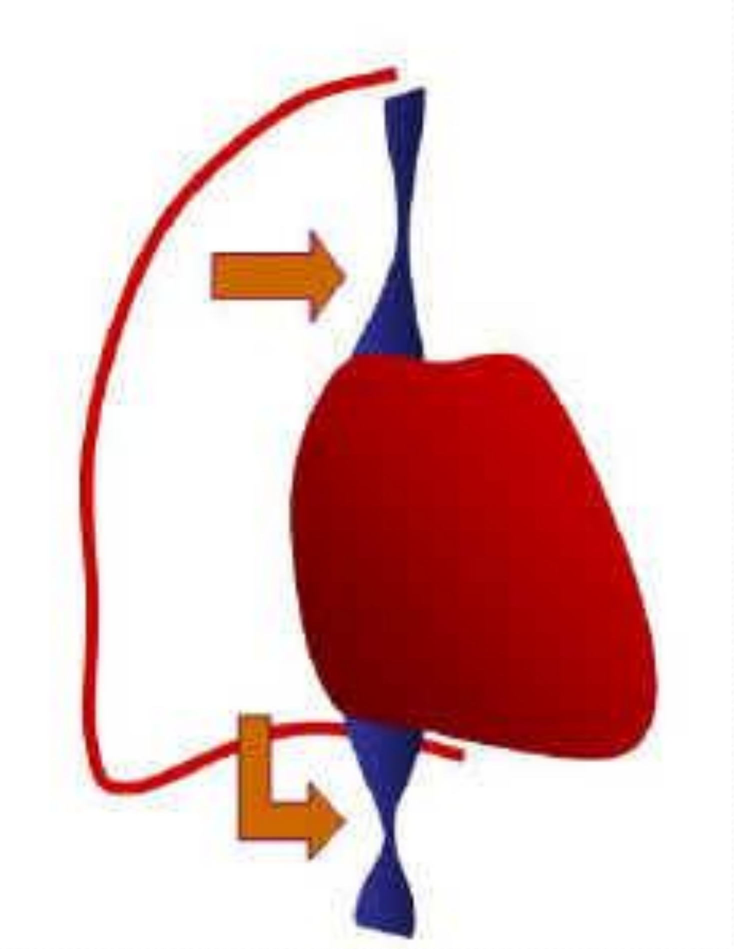
# Positive Pressure and Venous Return – Taking advantage of Heart-Lung Interactions



In a volume resuscitated patient:

- Venous return does not fall during inspiration on PPV
- Intrathoracic pressure is positive
- Intrabdominal pressure also rises
- Pressure gradient between the abdomen and thorax is maintained

# Positive Pressure and Venous Return – Taking Advantage of Heart-Lung Interactions

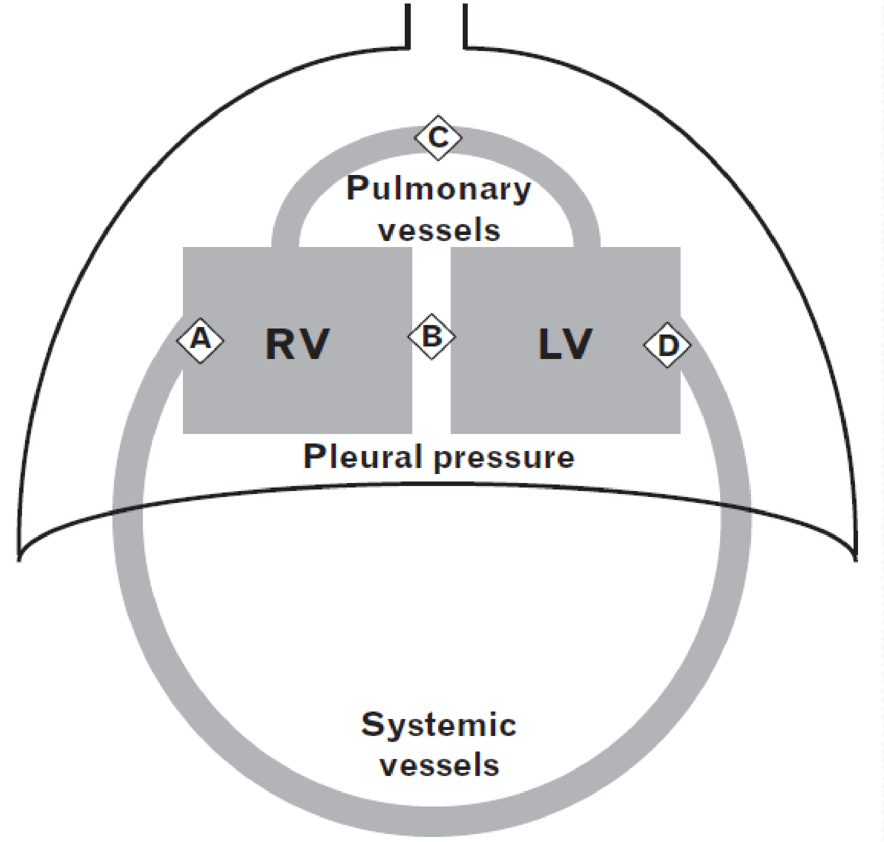


In volume depleted patient on PPV:

Collapse of intra-abdominal veins and SVC occurs as a result of positive intrathoracic pressure

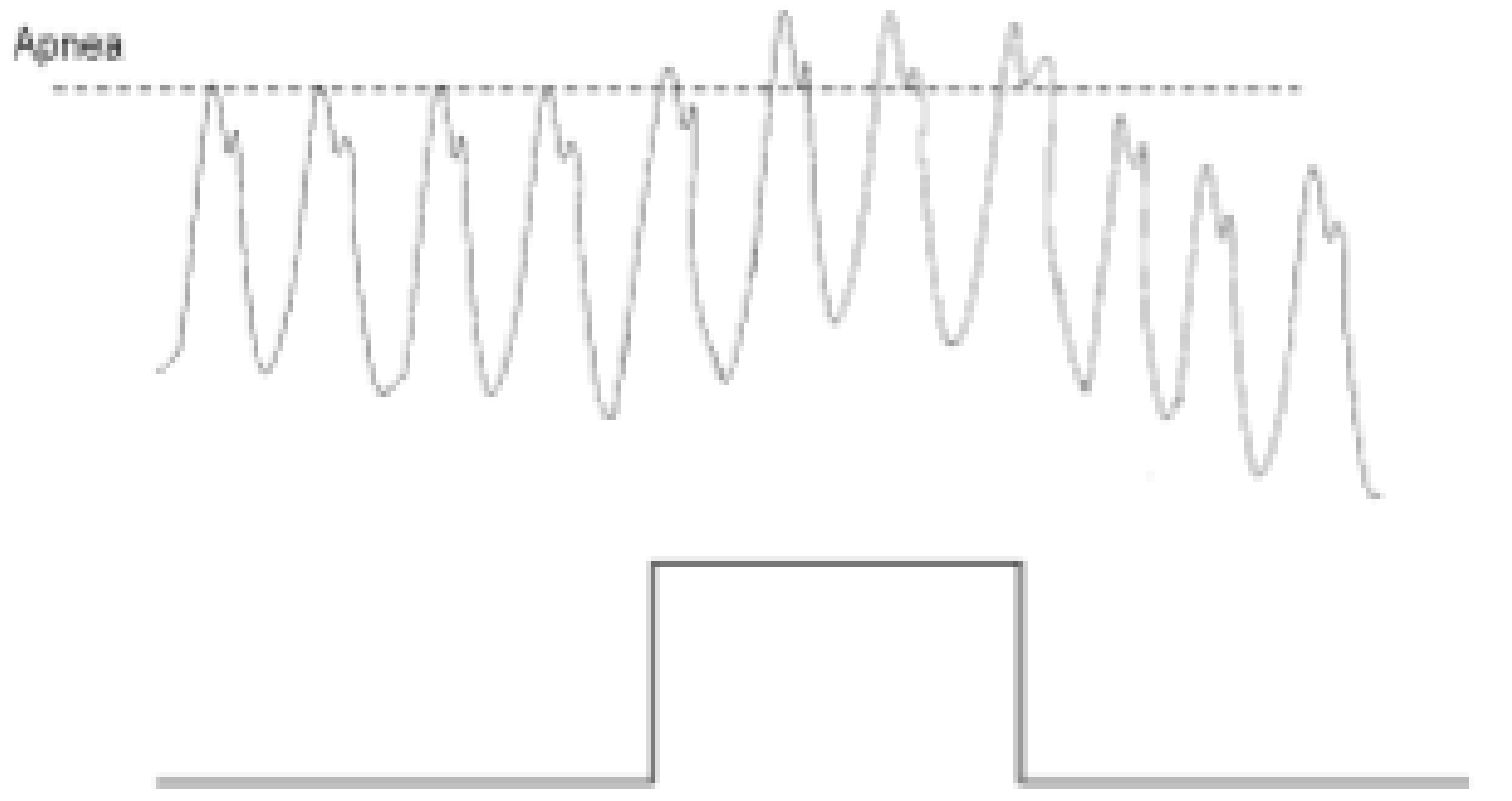
This results in a fall in venous return RV stroke volume, LV preload and cardiac output

# Heart-Lung Interactions

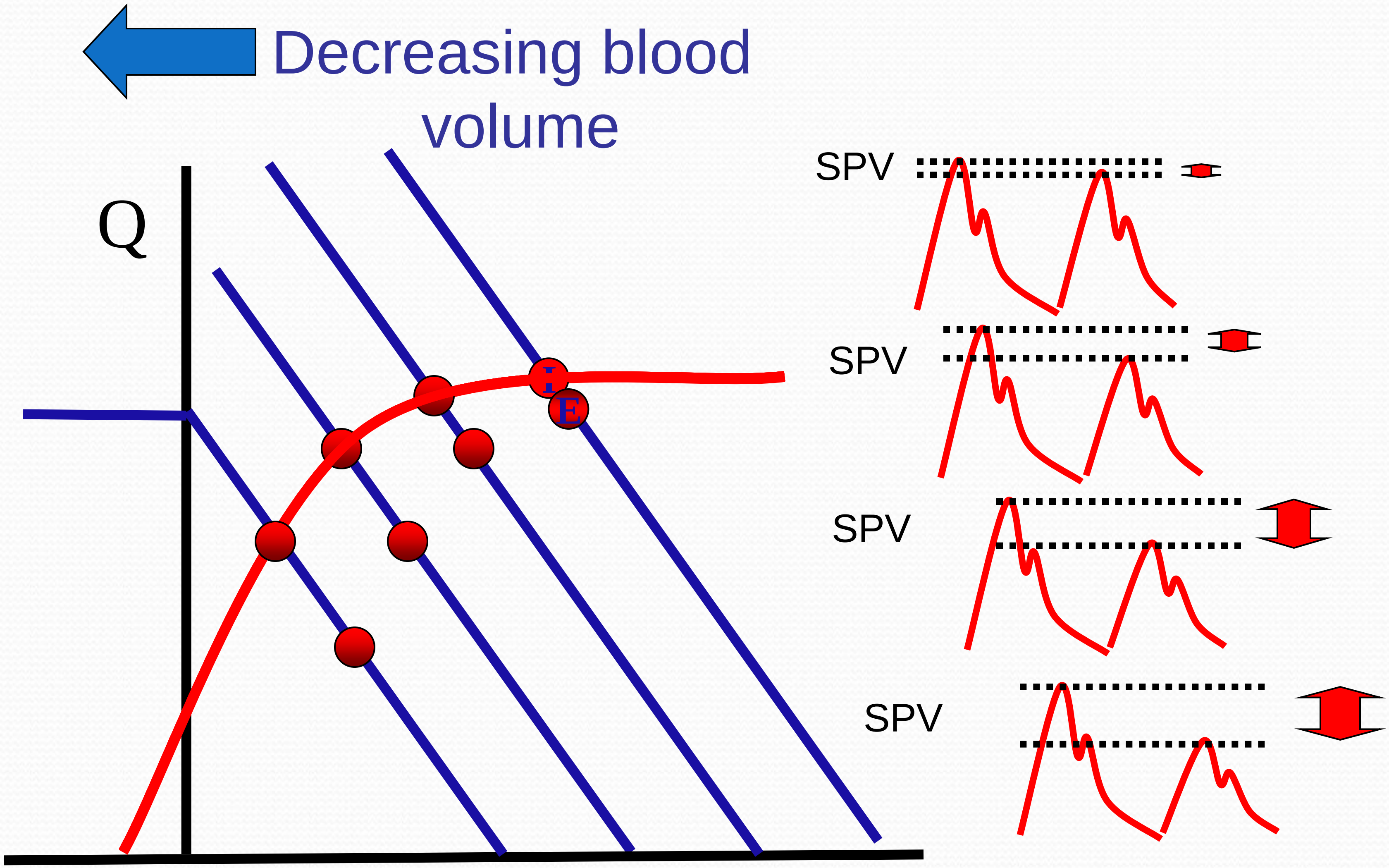



**Lowers RV preload**
Raises RV afterload
Raises LV preload
Lowers LV afterload

*Schmidt GA: Curr Opin Crit Care 2013; 19:51*
*Mahjoub Y, et.al: Crit Care Med 2009; 37:2570*


Apnea

# Effect of decreasing volume on SPV




*Magder S: AJRCCM 169:151, 2004*

# Dynamic Methods

Pulse Pressure Variation( PPV)

Stroke Volume Variation ( SVV)

Perfusion Index & Plethysmogaphic Variability Index( PI /PVI)

Esophageal doppler

IVC diameter change

Passive Leg Raising Test ( PLR )

End Expiratory Occlusion test ( EEO).

# Dynamic Predictors

Not relying on ultrasound:

Arterial pulse pressure variation (PPV)

Stroke volume variation (pulse contour, bioreactance)

Passive leg raising

Ultrasound-dependent

Aortic, brachial flow velocity variation

IVC diameter variation

SVC diameter variation

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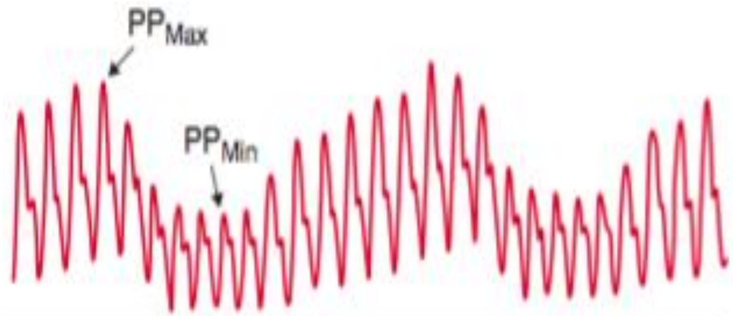



Note: The arterial blood pressure tracing is not drawn to scale

$PP_{Max} = 150-70 = 80$

$PP_{Min} = 120-60 = 60$

$PPV = (PP_{Max} - PP_{Min})/([PP_{Max} + PP_{Min}]/2)$

$PPV = 80-60/([80+60]/2) = 29\%$

**Figure 45-16.** Pulse pressure variation. Pulse pressure variation (PPV) is calculated as the difference between maximal ($PP_{Max}$) and minimal ($PP_{Min}$) pulse pressure values during a single mechanical respiratory cycle, divided by the average of these two values. (Note that the arterial blood pressure trace is drawn for illustrative purposes and not to scale.)

More than 13% variation in PPV indicates volume responsiveness

9%-13% is the gray zone

# Devices For PPV and SVV.

- PiCCO
- LiDCO/Pulse Plus
- Flotrac/Vigilo

# PiCCO

PiCCO is a device made by Phillips that enables continuous hemodynamic monitoring using a femoral or axillary thermodilution a-line (proprietary) and a central venous line.

Looks at both static and dynamic parameters:

Fluid responsiveness: SVV and PPV

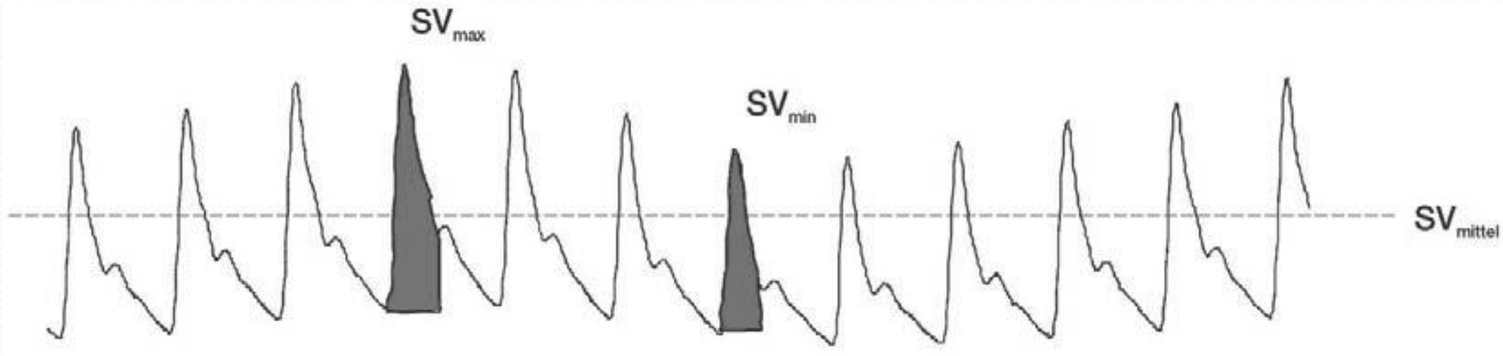
CO measurement - .and pulse contour analysis

Extravascular Lung Water .

# PiCCO

SVV – determined by analysis of the continuous arterial pulse contour – uses the area under the systolic curve for beat-to-beat determination of stroke volume and their variation over the respiratory cycle – can also use for determining volume responsiveness

> 10% is considered to be responsive



# FloTrac/Vigileo


No calibration needed, derives measurements based on compliance and patient characteristics (gender, age, height and weight – derived from experimental cadaver data)

Measures the pulsitility of the arterial waveform by calculating the standard deviation of the arterial pressure wave over a 20s period – multiplied by the compliance

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# LiDCO

- Made by the LiDCO group in London
- Measures Cardiac output using a small dose of lithium injected in the periphery and then generating an arterial lithium concentration-time curve by withdrawing blood past a lithium sensor attached to the patient's a-line
- It then uses proprietary software to calculate continuous beat-to-beat cardiac output, by analysis of the arterial blood pressure tracing.

# Practical Limitations

$V_T$ should be 8-12 cc/kg

Cardiac rhythm must be regular

Patients must be ventilated and passive

Wrong vessel (aorta)

Acute cor pulmonale: false positive

Abdominal compartment syndrome

# 2011 Radical-7

$$PI = \frac{AC}{DC} \times 100\%$$

Equation 2

$$PVI = \frac{PI_{Max} - PI_{Min}}{PI_{Max}} \times 100\%$$

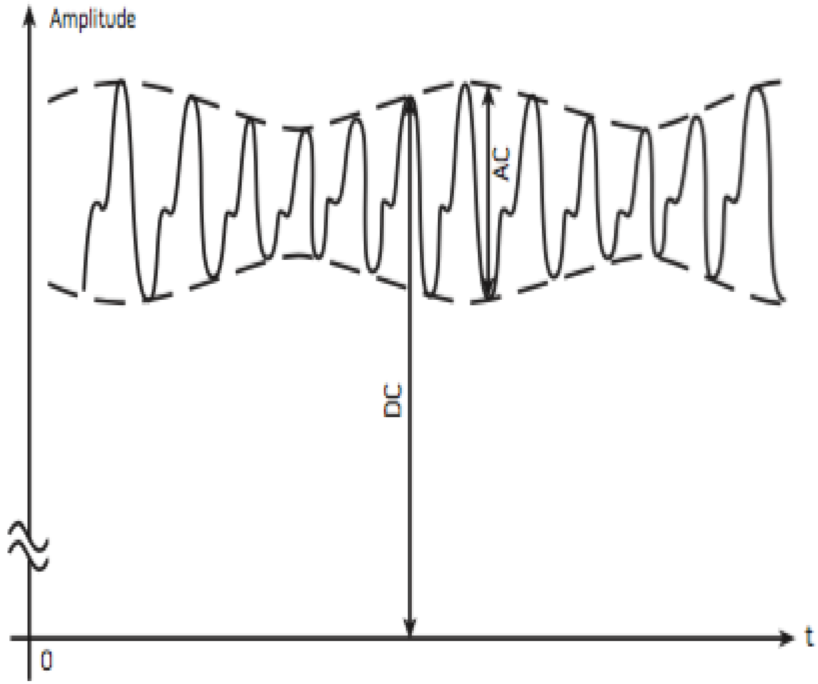



*Figure 3.* Graphic representation of raw infrared signal processed internally by the pulse oximeters, where AC represents the variable absorption of infrared light due to pulsating arterial inflow and DC represents the constant absorption of infrared light due to skin and other tissues.

# PVI Calculation

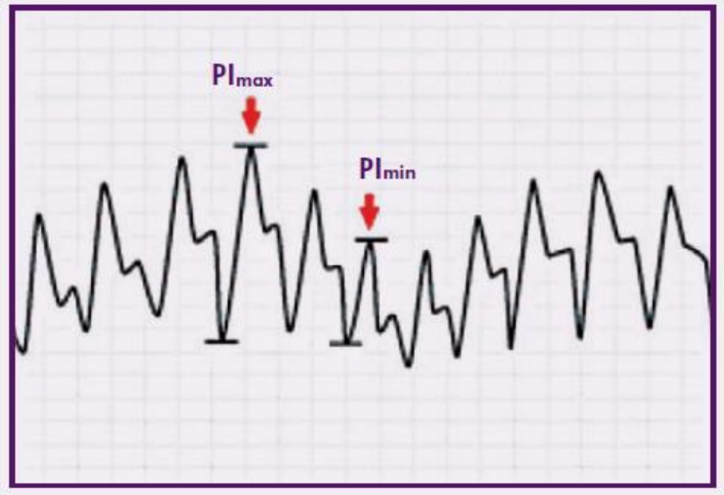
- Automated measurement

Changes in plethysmographic waveform amplitude over the respiratory cycle

PVI is a percentage from 1 to 100%:

1 - no pleth variability

100 - maximum pleth variability




$$PVI = \frac{PI_{max} - PI_{min}}{PI_{max}} \times 100$$

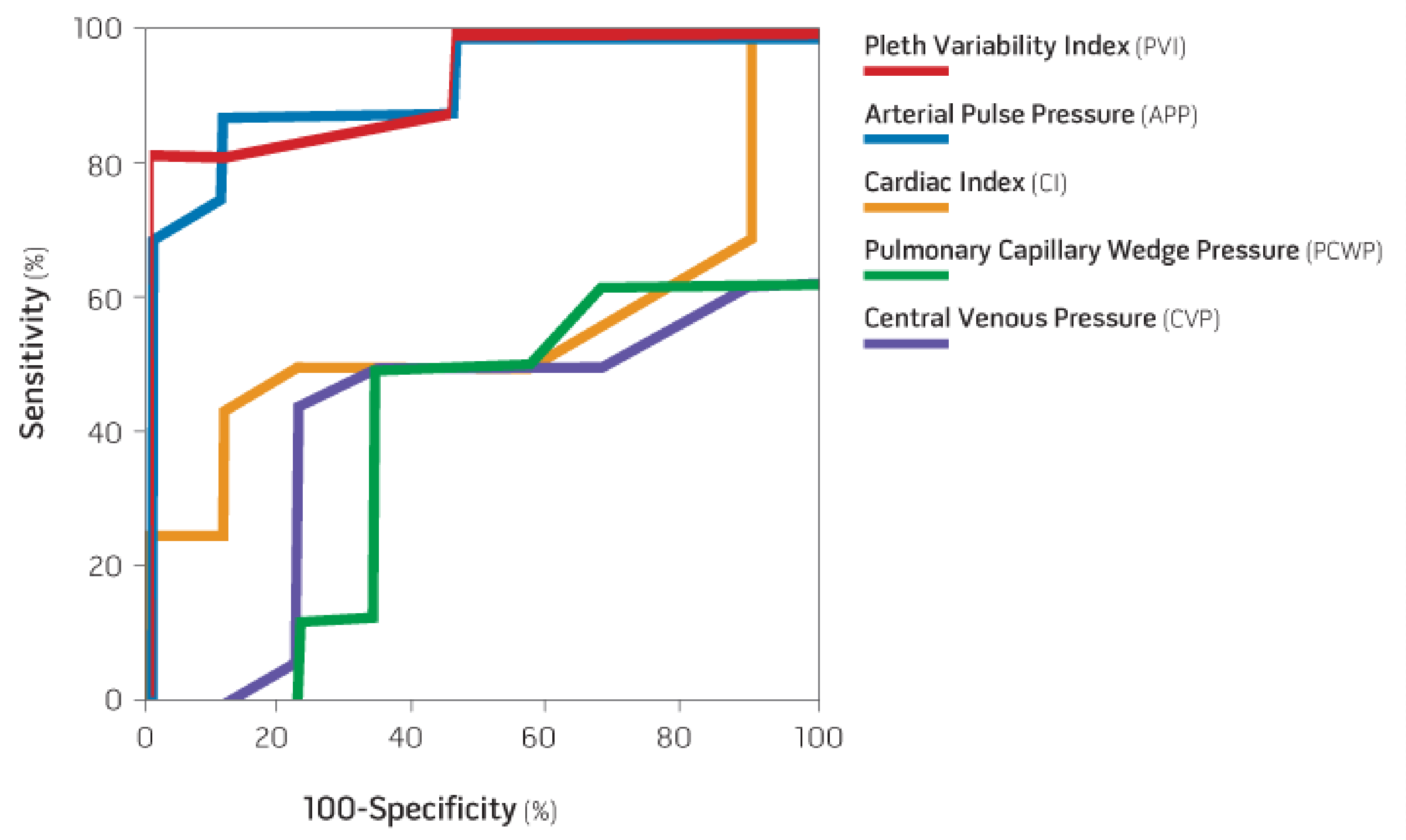
# LIMITATIONS OF PVI

reduced reliability during arrhythmias, right heart failure, spontaneous breathing activity, and low tidal volume (<8ml/kg).

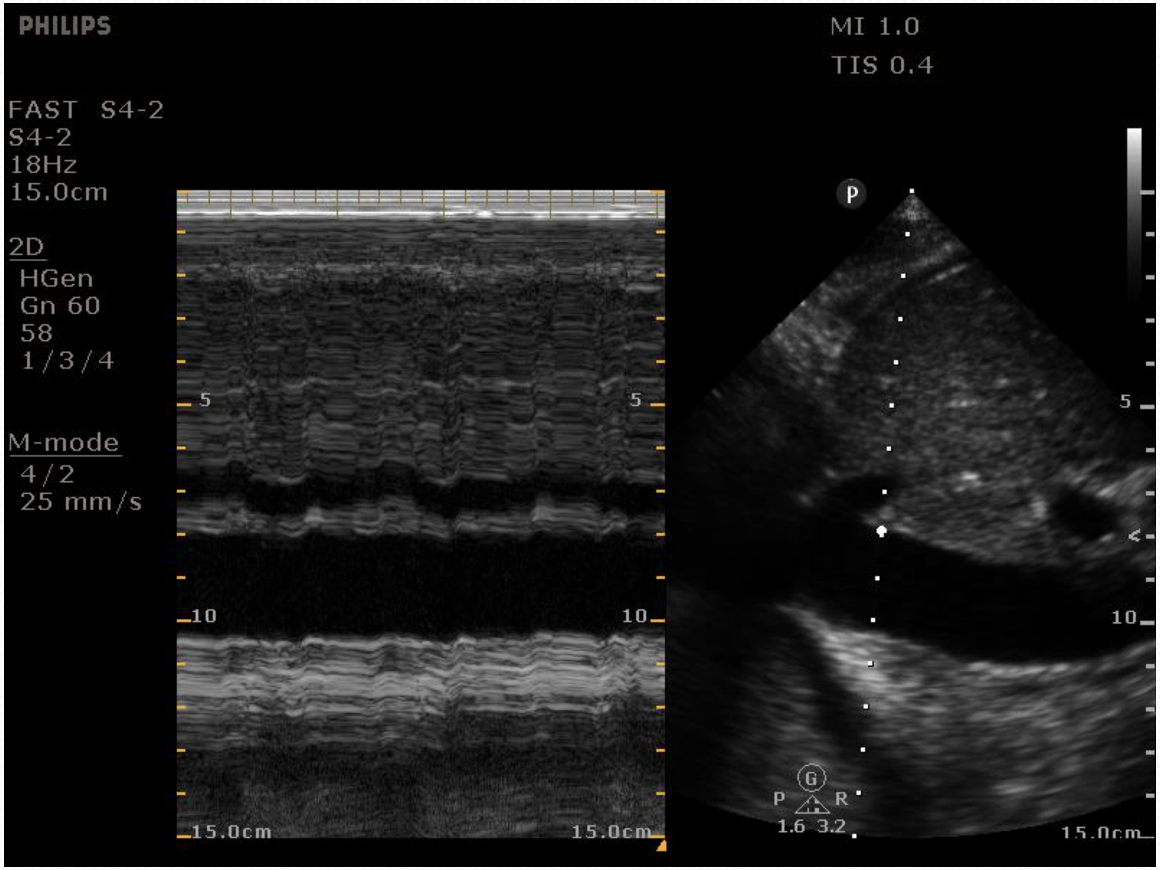
In general, PVI provides an accurate prediction of fluid responsiveness in mechanically ventilated adults under general anesthesia with a normal sinus rhythm.

PVI is less accurate and therefore not recommended for spontaneously breathing patients because the heart lung interactions and vasomotor tone are no longer consistent.

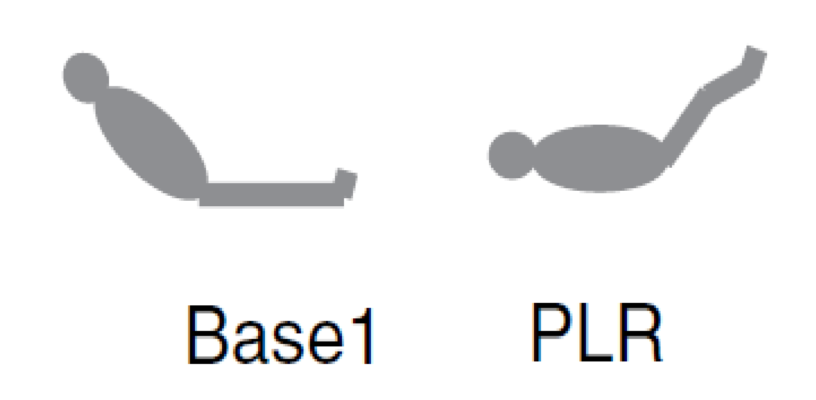
# PVI to Help Clinicians Assess Fluid Responsiveness During Surgery: Simil



# Ventilated: No ΔIVC

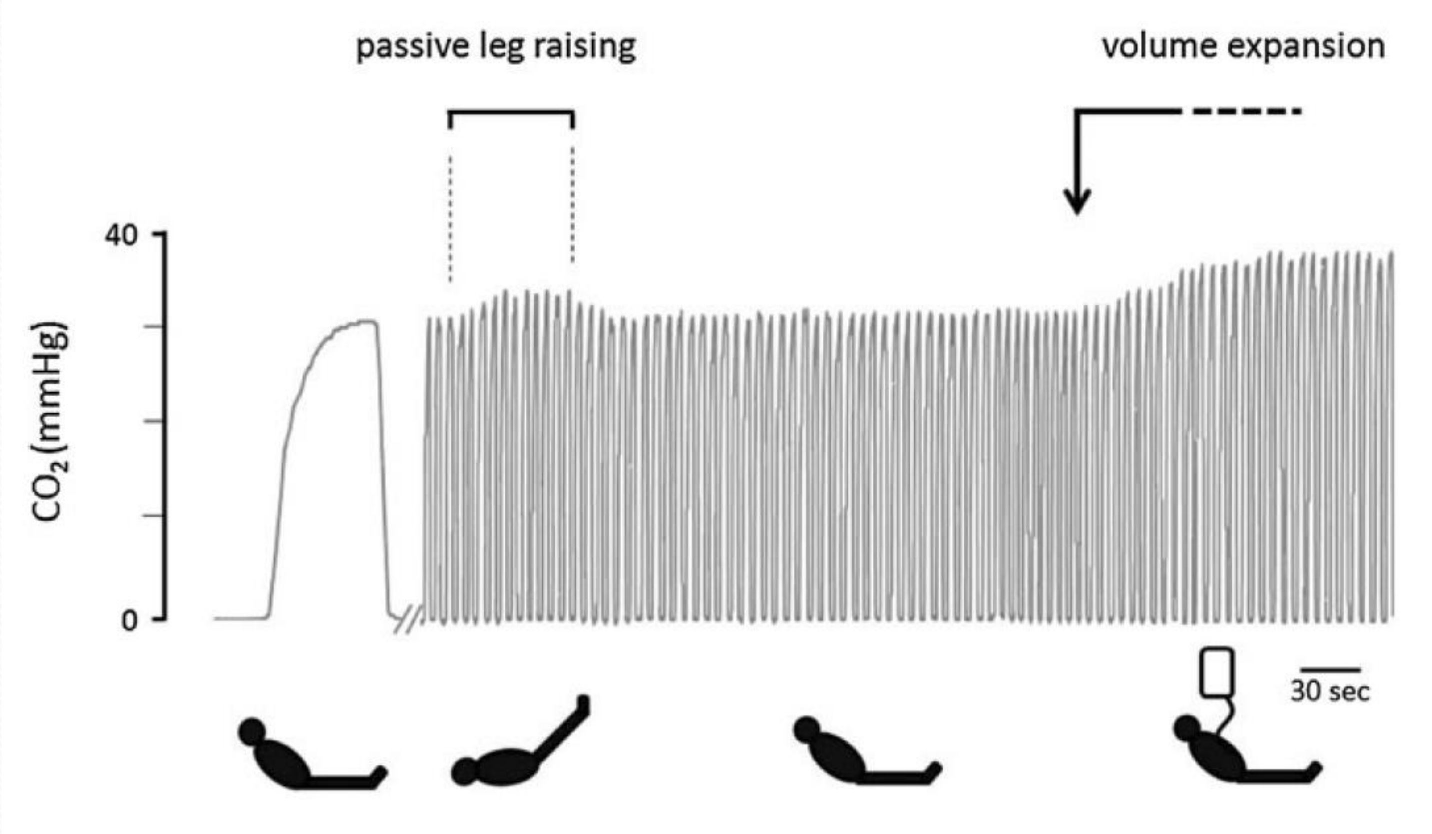


# Passive Leg Raising




- Readily reversible
- Assess impact: change in Qt, PP, echo (aortic flow), ET $CO_2$
- Predictive threshold: 10-12%
- Timing: 1-5 min after PLR

# PLR and ET-$CO_2$




*Monnet X, et.al: Intensive Care Med 2013; 39:93*

| | Invasive | Intermittent CO | Contin. CO | Addit'l Variables | Limits |
|---|---|---|---|---|---|
| PiCCO Plus | Femoral thermistor-tipped catheter | Transpulm. thermodilution | Every 3s | GEDV, EVLW, SVV, PPV | Severe Vasc. Disease, IABP, arrhythmias |
| PulseCO/ LiDCO | Regular a-line | Transpulm. thermodilution | Beat to Beat | SVV | SVV/PPV, IABP, arrhrythmias |
| FloTrac/ Vigelo | Regular a-line | None | Every 20s | SVV | Spont. Breathing, IABP arrhythmias |

# The End Expiratory Occlusion Test....

Cyclic impediment in preload during inspirium

↓

Cyclic increase in preload with end expiratory occlussion

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Increase in preload in patients with fluid responsiveness

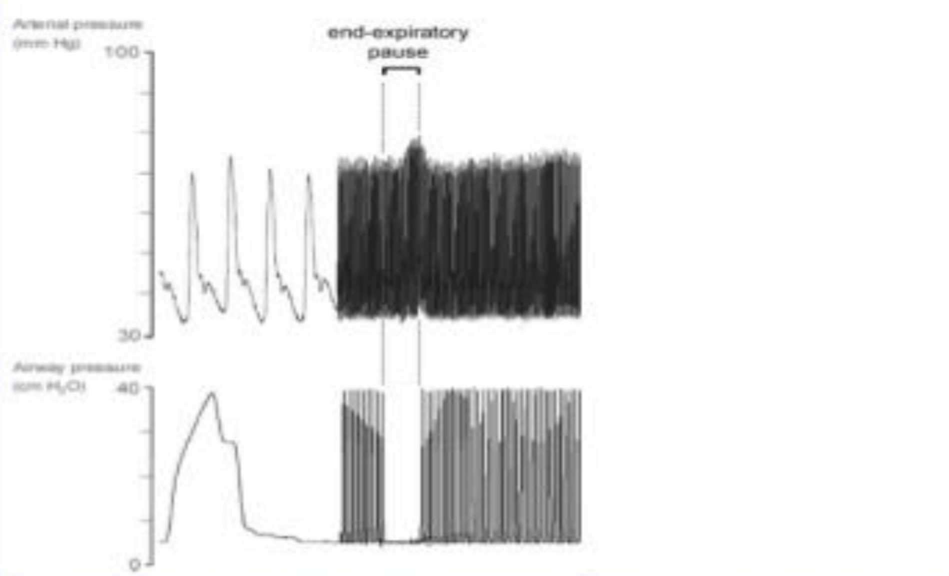



Figure 1. Typical recording of the arterial pressure curve before and during an end-expiratory occlusion and then before and during fluid expansion. The increase in arterial pulse pressure induced by fluid expansion was preceded by an 11% increase in arterial pressure during the end-expiratory occlusion.

Crit Care Med 2009; 37:951–956

# Predicting volume responsiveness by using the end-expiratory occlusion in mechanically ventilated intensive care unit patients

Xavier Monnet, MD, PhD; David Osman, MD; Christophe Ridel, MD; Bouchra Lamia, MD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD

Crit Care Med 2009 Vol. 37, No. 3

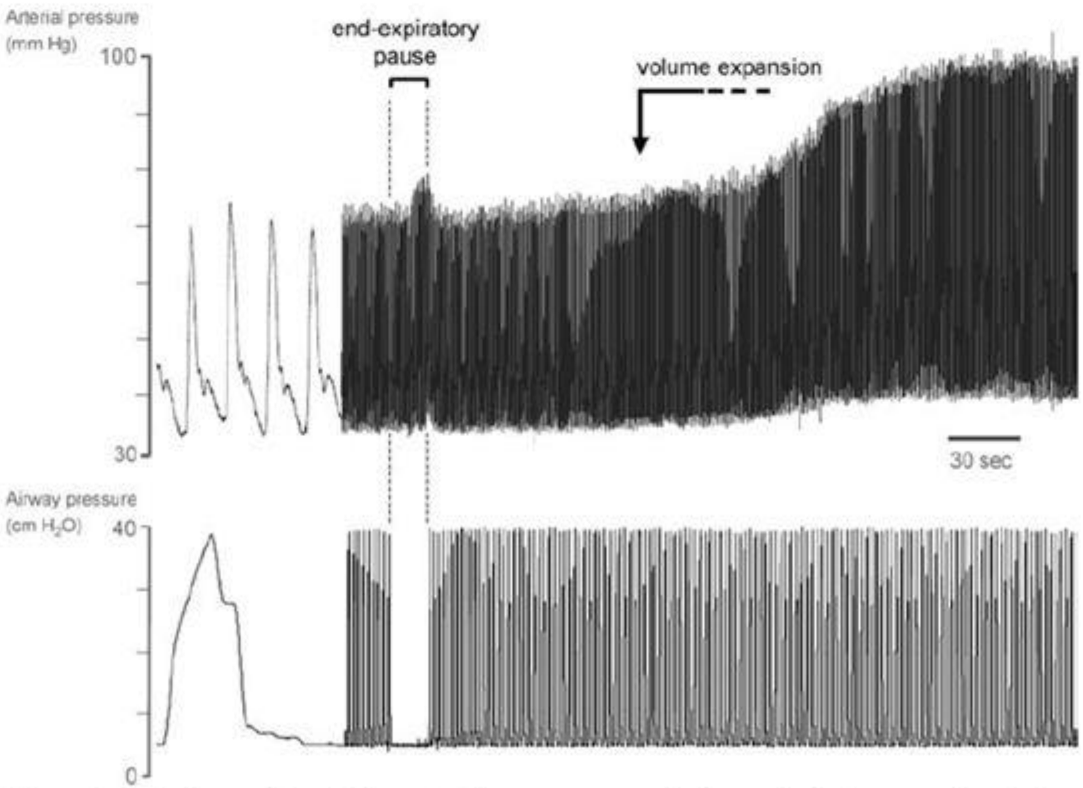
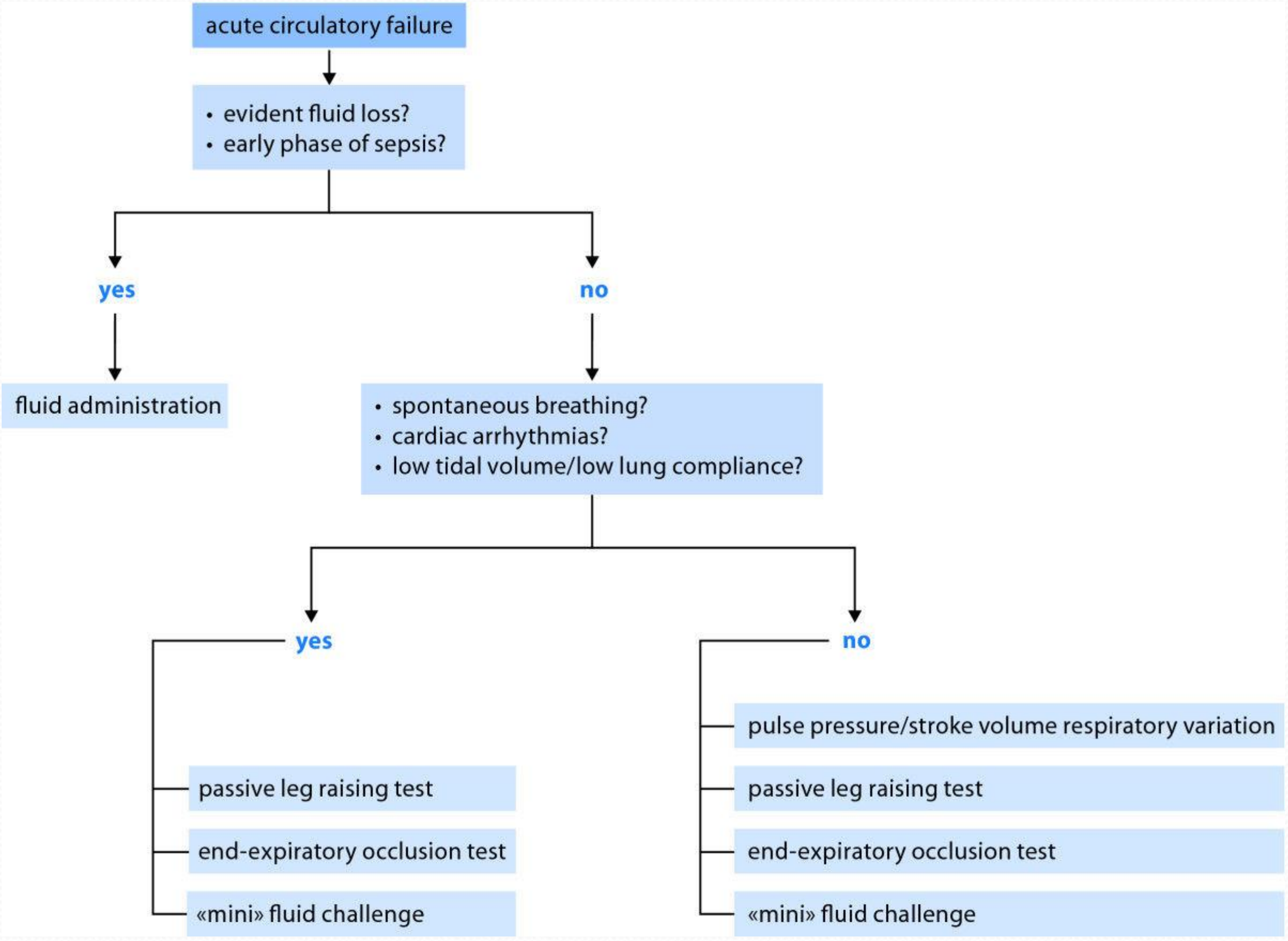



**Figure 1.** Typical recording of the arterial pressure curve before and during an end-expiratory occlusion and then before and during fluid expansion. The increase in arterial pulse pressure induced by fluid expansion was preceded by an 11% increase in arterial pressure during the end-expiratory occlusion.

**The hemodynamic response to a 15-second end-expiratory occlusion can predict volume responsiveness in mechanically ventilated patients.**

# Summary


acute circulatory failure
• evident fluid loss?
• early phase of sepsis?
yes
no
fluid administration
• spontaneous breathing?
• cardiac arrhythmias?
• low tidal volume/low lung compliance?
yes
no
passive leg raising test
end-expiratory occlusion test
«mini» fluid challenge
pulse pressure/stroke volume respiratory variation
passive leg raising test
end-expiratory occlusion test
«mini» fluid challenge