FOCUS 3: UTRASUONI - PER LA VOLEMIA

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Disclosures

Type	Company
Travel expenses and registration for meetings and congresses	Vygon

Fluid therapy in critically ill patients

- **Early resuscitation**
  - ECHO to avoid mistakes
  - ECHO to confirm diagnosis /reduce uncertainity
- **Late resuscitation**
  - ECHO to assess fluid responsiveness
  - ECHO to target fluid therapy

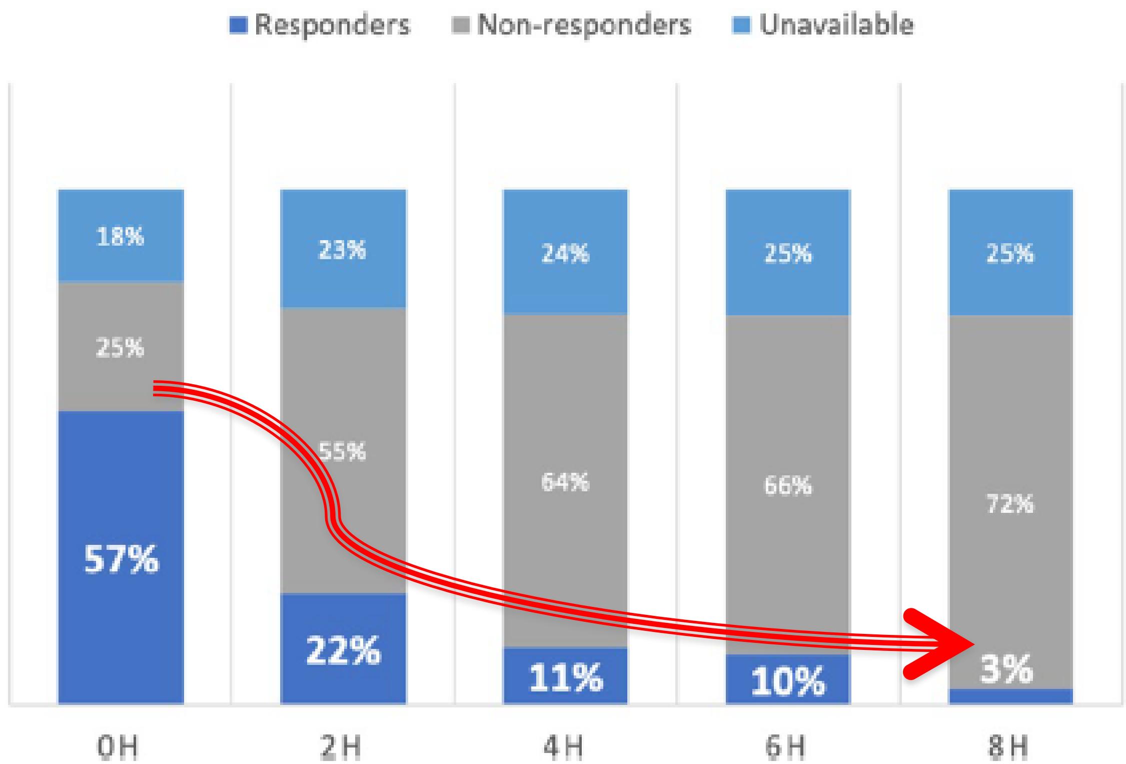


Fig. 1 Fluid responsiveness (in %) over time in 424 patients with sepsis Adapted with permission from Hernandez et al. [5]

Intensive Care Med
https://doi.org/10.1007/s00134-019-05713-y

What should I use next if clinical evaluation and echocardiographic haemodynamic assessment is not enough?

Antonio Messina, Massimiliano Greco, and Maurizio Cecconi

Curr Opin Crit Care 2019, 25:259–265

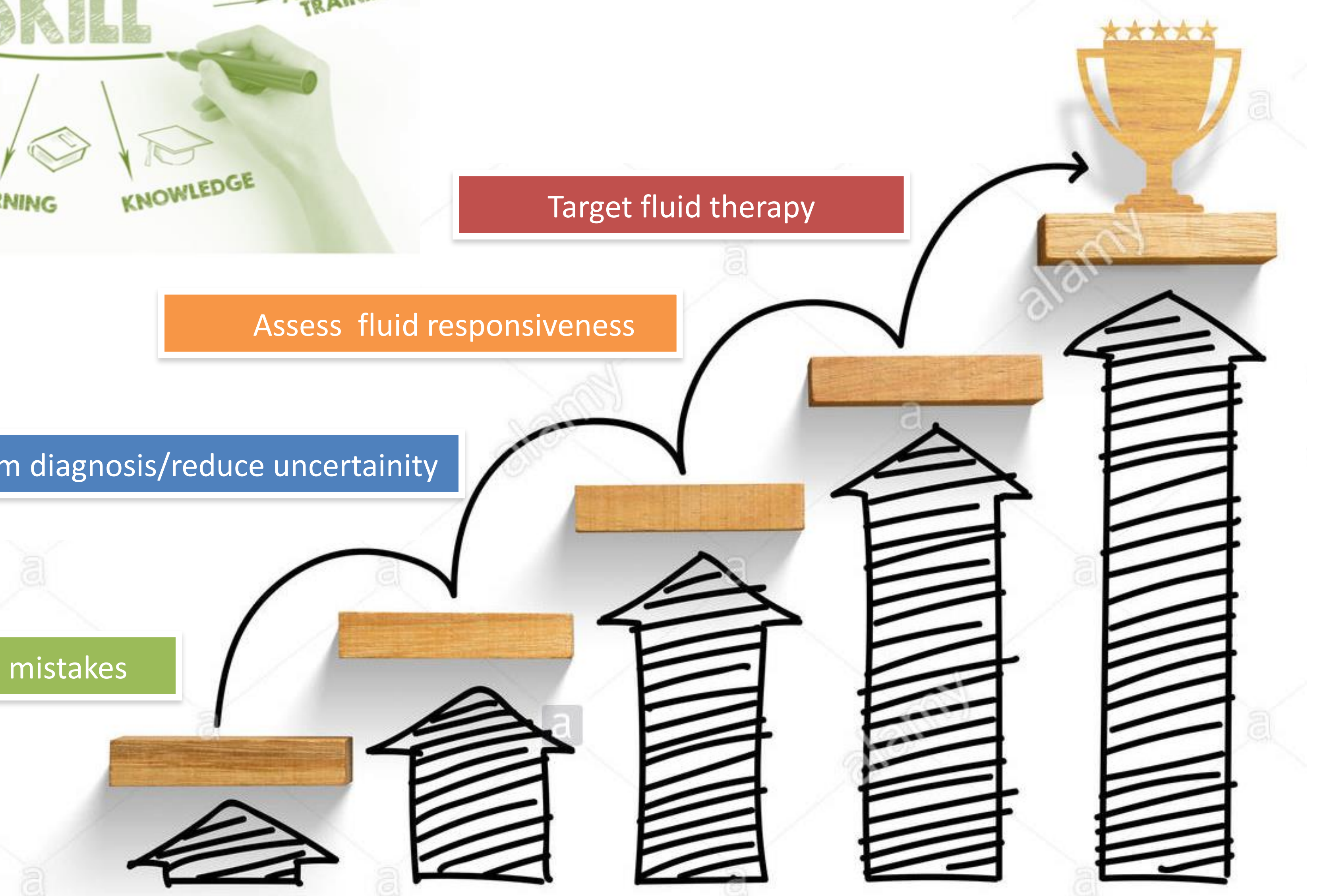
- Goal-directed echocardiography is not a comprehensive echocardiogram performed by highly skilled and certified echocardiographers. In fact, its scope at bedside **is to provide images instead of numbers, and a qualitative evaluation of cardiac structure and function.**
- For this reason, the key challenge of the goal-directed echocardiography is obtaining the **most informative pictures**, using very few, echocardiographic views in very complex clinical scenarios.

Target fluid therapy

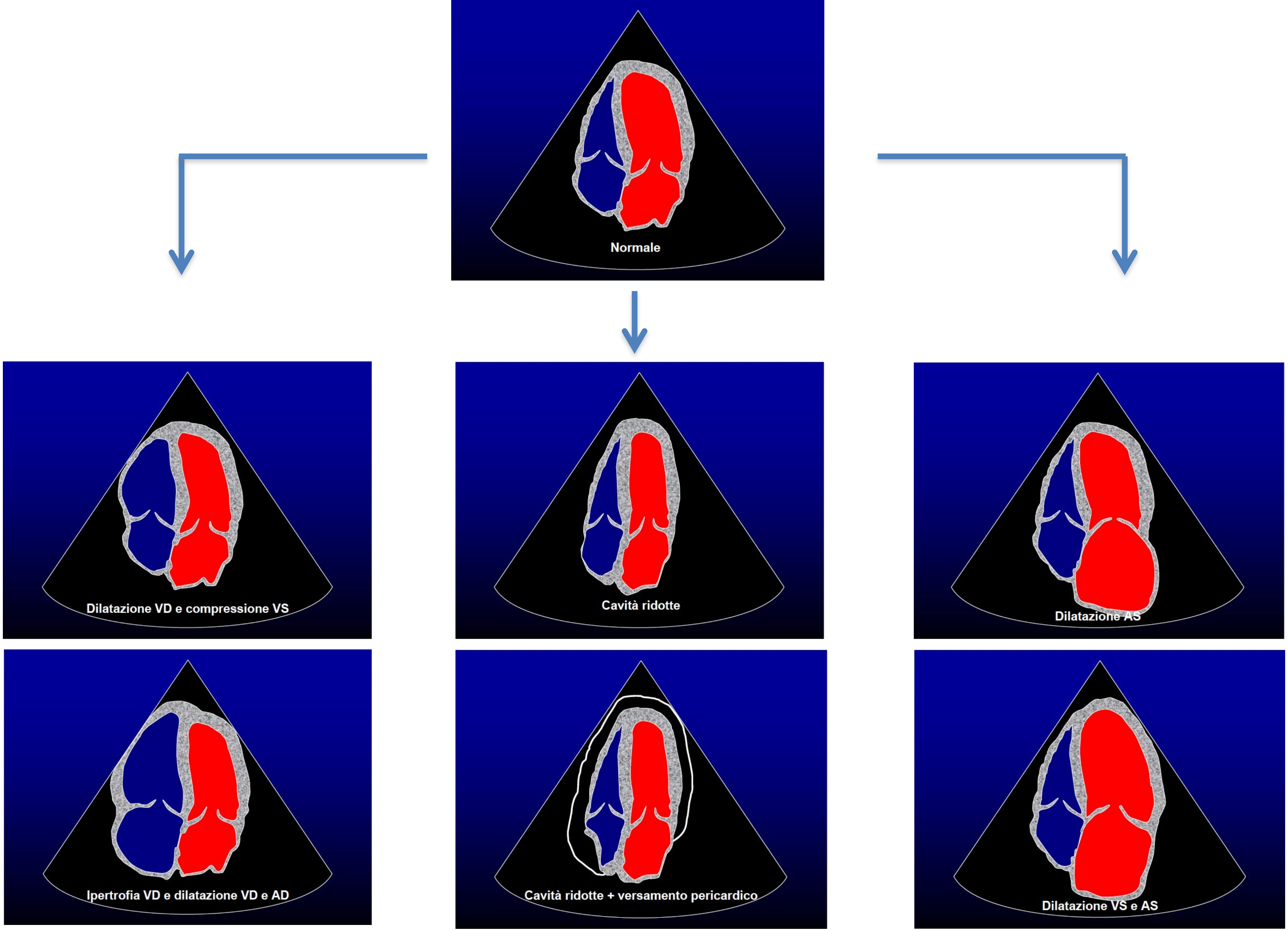
Assess fluid responsiveness

Confirm diagnosis/reduce uncertainity

Avoid mistakes



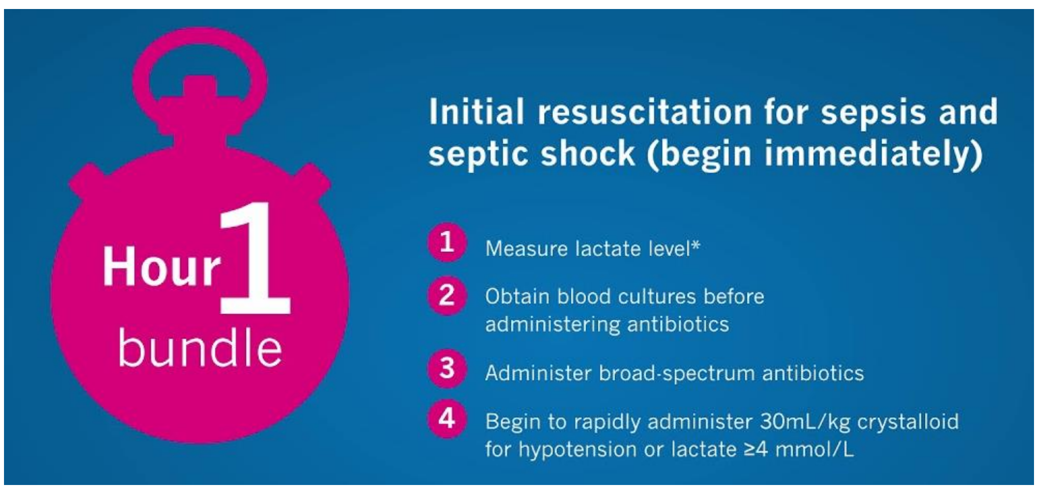
Early fluid resuscitation

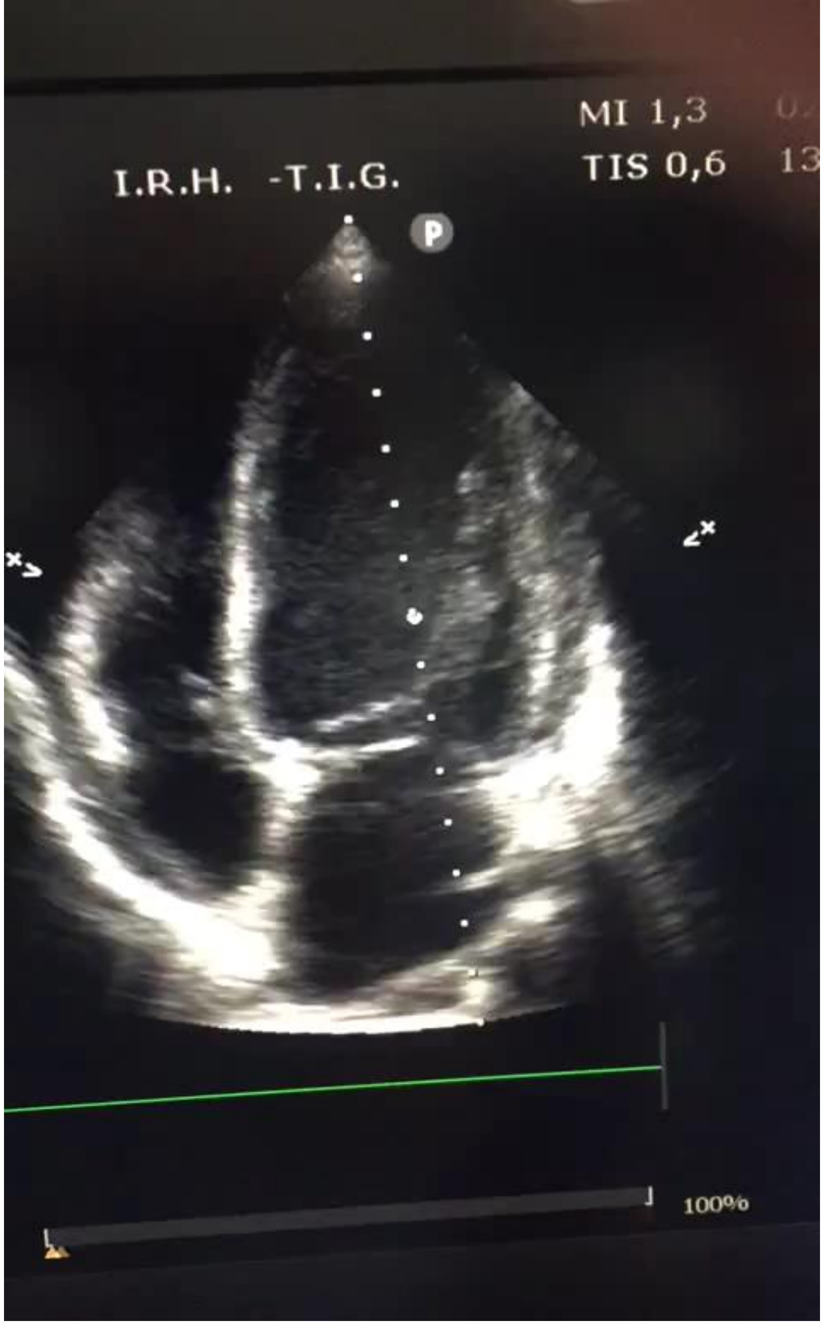

Normale
Dilatazione VD e compressione VS
Cavità ridotte
Dilatazione AS
Ipertrofia VD e dilatazione VD e AD
Cavità ridotte + versamento pericardico
Dilatazione VS e AS

Early fluid resuscitation

ECHO to avoid mistakes

- 20 y.o lady.
- Admitted to the ED for fever (39.1)r and tachycardia (TPSV?)
  - Received 2 cardiological examinations – treated with adenosine and verapamil
- History of asthenia and weight loss
- Confused and sweaty



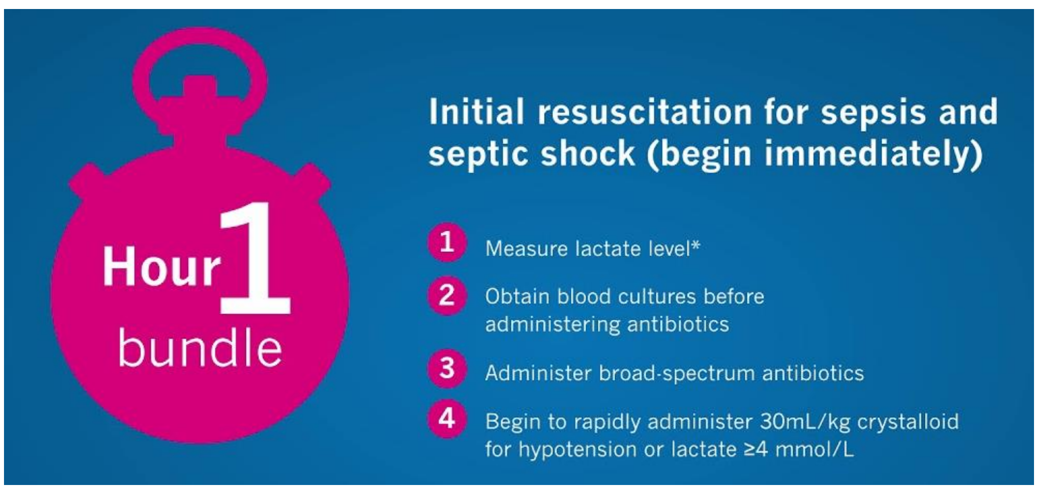

MI 1,3
TIS 0,6
I.R.H. -T.I.G.
P
100%


MI 1,3
TIS 0,6
I.R.H. -T.I.G.
P
100%

Early fluid resuscitation

ECHO to avoid mistakes

- 68 y.o mand. History of Hypertension; COPD? (smoker).
- Admitted to the ED for fever started at home (38.6)r and tachycardia (115 bpm)
- Confused and sweaty
- WBC 25.000; PCR 40 mg/L, PA 80/40, CRT 4 sec; Lactates 6 mmol/L
- Pyuria



- After 2 L of Crystalloids, still hypotensive.
- Norepinephrine up to 0.5 mcg/kg/min


04 GIU 2019 20:29
P 80%
MI
TIS
35 %
C2/--
1
0
5
10
48 Hz
0/1
17%
2"
esaote

Late fluid resuscitation

Without echo

- **Static evaluation:**

  Static pressure measurements

- **Dynamic evaluation:**

  Dynamic indexes (PPV/SVV)

  Functional Hemodynamic Tests (PLR, EEOT, mini-FC)

With echo

- **Static evaluation:**

  Intracardiac Volumes

  Static pressures estimation

- **Dynamic evaluation:**

  Dynamic indexes (IVC collapsibility, VTI/SV changes)

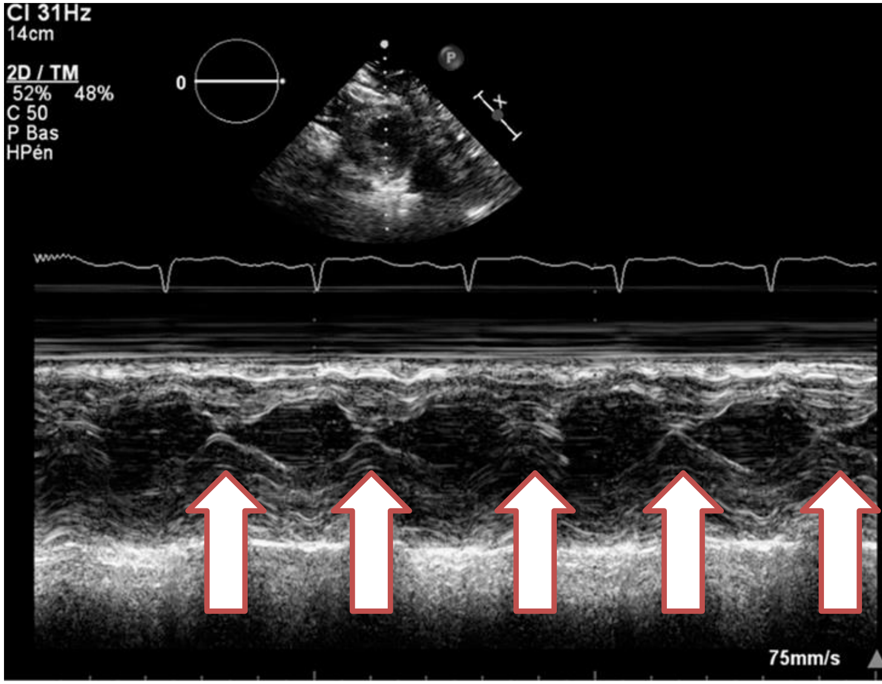
  Functional Hemodynamic Tests (PLR, EEOT, mini-FC)

Static echo evaluation

Left ventricle size

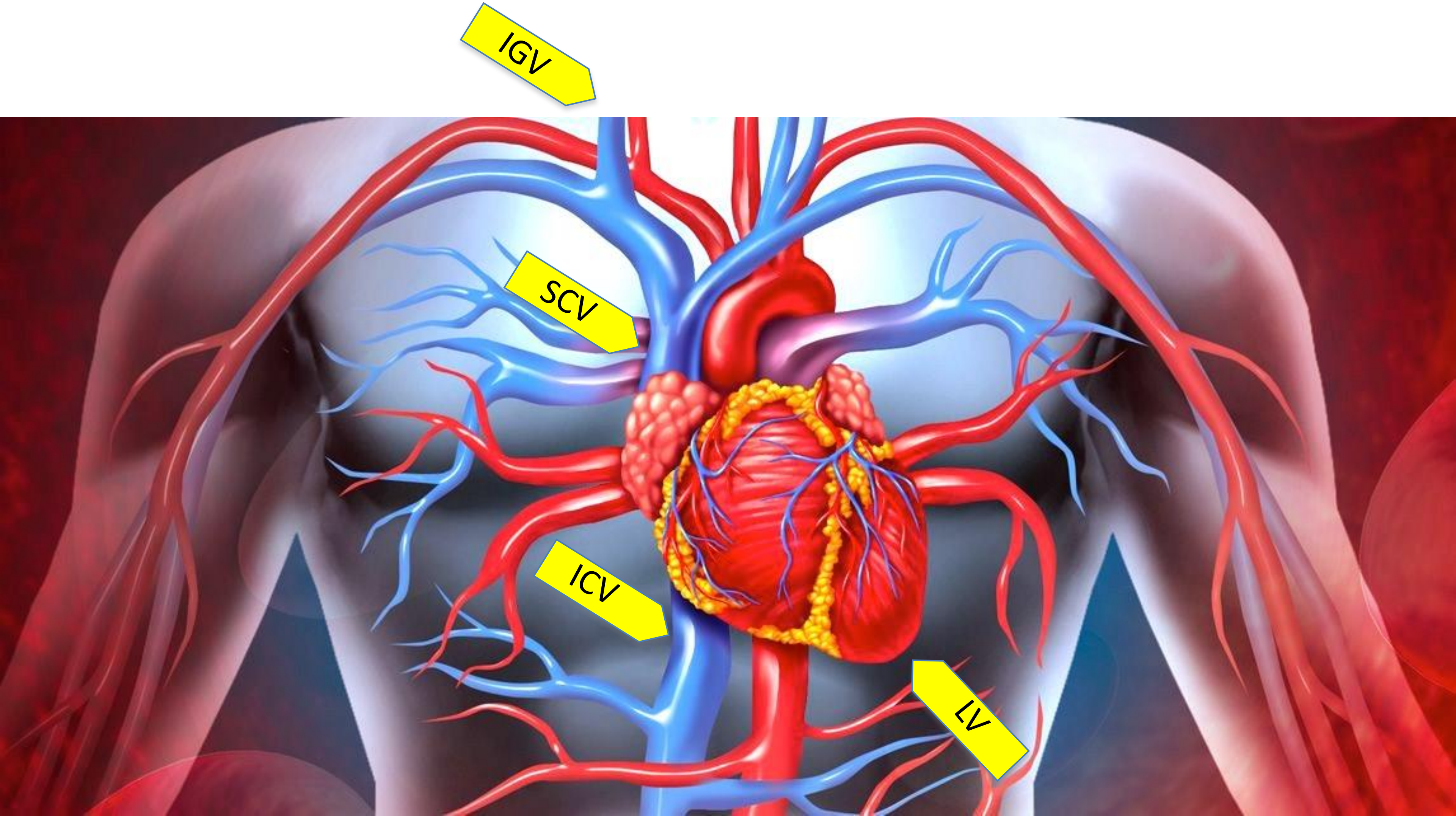
- **No clear cut-off can be proposed** for reliable prediction of fluid responsiveness.

- Response to fluids is often observed in patients with very small ventricular cavities, especially when associated with **kissing papillary muscles** whereas it is unlikely in patients with **dilated left or right ventricles.**



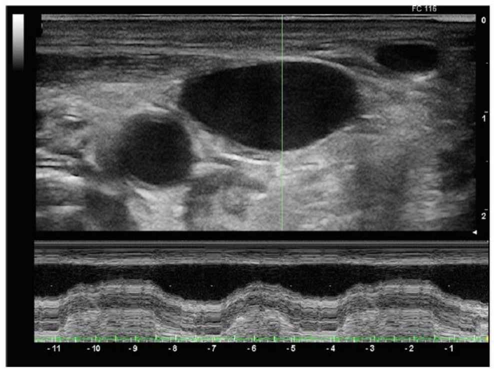
Ann Am Thorac Soc Vol 11, No 1, pp 129–136, Jan 2014

Dynamic echo evaluation


IGV
SCV
ICV
LV

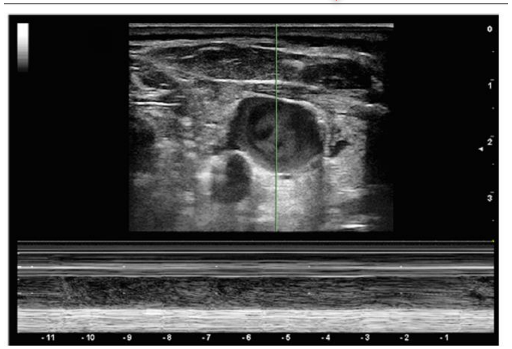
Jugular vein distensibility predicts fluid responsiveness in septic patients

Guarracino *et al. Critical Care* (2014) 18:647
DOI 10.1186/s13054-014-0647-1

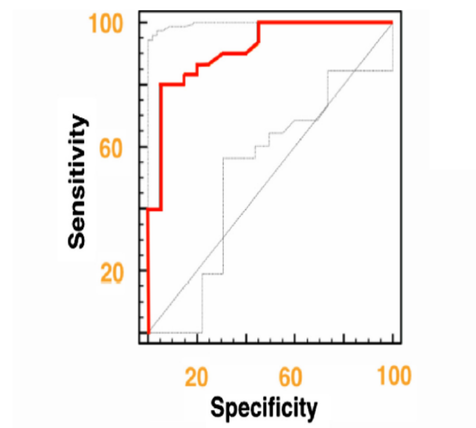


>18%

Figure 1 Ultrasound probe position for internal jugular vein detection at the cricoid cartilage level. The patient is in the supine position at 30° with head rotation of 30°.



< 12%



Best Criterion values and coordinates of the ROC curve for IJV distensibility

Criterion	Sensitivity	95% CI	Specificity	95% CI
>9,9	100,00	88,4 - 100,0	55,00	31,5 - 76,9
>12,3	90,00	73,5 - 97,9	60,00	36,1 - 80,9
>15	83,33	65,3 - 94,4	80,00	56,3 - 94,3
>18	80,00	61,4 - 92,3	95,00	75,1 - 99,9
>25,5	40,00	22,7 - 59,4	100,00	83,2 - 100,0

Figure 4 Receiver operator characteristic (ROC) curve of internal jugular vein (IJV) distensibility before fluid administration to predict fluid responsiveness. The gray lines represent 95% confidence bounds.

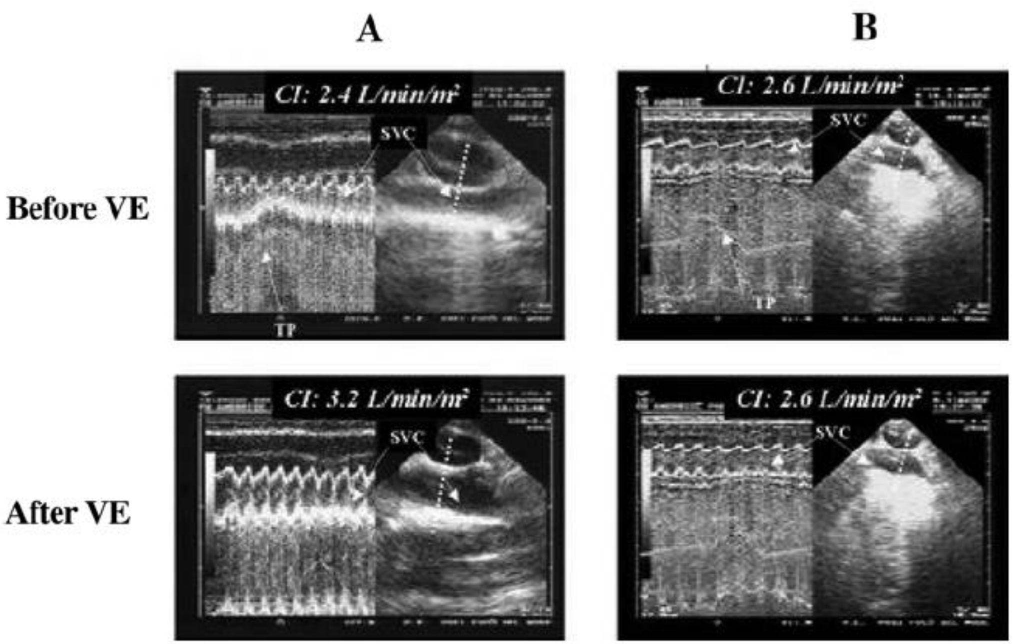
Intensive Care Med (2004) 30:1734–1739
DOI 10.1007/s00134-004-2361-y

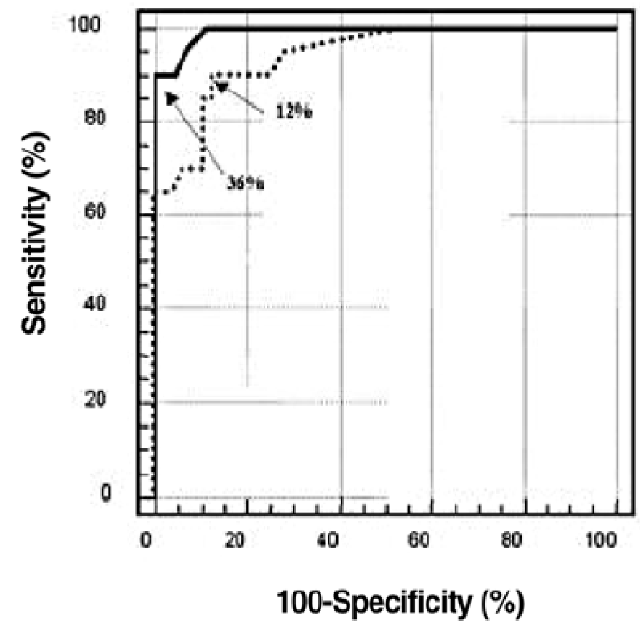
ORIGINAL

Only TEE

Antoine Vieillard-Baron
Karim Chergui
Anne Rabiller
Olivier Peyrouset
Bernard Page
Alain Beauchet
François Jardin

Superior vena caval collapsibility as a gauge of volume status in ventilated septic patients





The threshold SCV collapsibility of **36%** allowed discrimination between responders (defined by an increase in cardiac index of at least 11% induced by volume expansion) and nonresponders, with a **sensitivity of 90% and a specificity of 100%.**

IVC echographic evaluation

The good

The bad

Intensive Care Ultrasound: VI. Fluid Responsiveness and Shock Assessment

Daniel De Backer and David Fagnoul

Ann Am Thorac Soc Vol 11, No 1, pp 129–136, Jan 2014

IVC Measurement

1. The cardiac probe in a subxiphoid position perpendicular to the skin (a transverse plane)
2. The probe is then rotated by 90° to obtain a longitudinal plane (to identify the hepatic veins and entrance of the IVC into the right atrium)
3. The probe centered on the vessel in the same location during the entire respiratory cycle, preventing motion artifact (Three measurements should be averaged)
4. The IVC diameter can be measured either close to its entrance to the right atrium (influenced more by contraction of the diaphragm but less susceptible to motion artifact) or 1 to 2 cm caudal to the hepatic vein–IVC junction (approximately 3–4 cm from the junction of the IVC and the right atrium).
5. Whatever the location, the measurement is valid only when there are no active contractions of abdominal wall muscles or raised intraabdominal pressure .

Intensive Care Ultrasound: VI. Fluid Responsiveness and Shock Assessment

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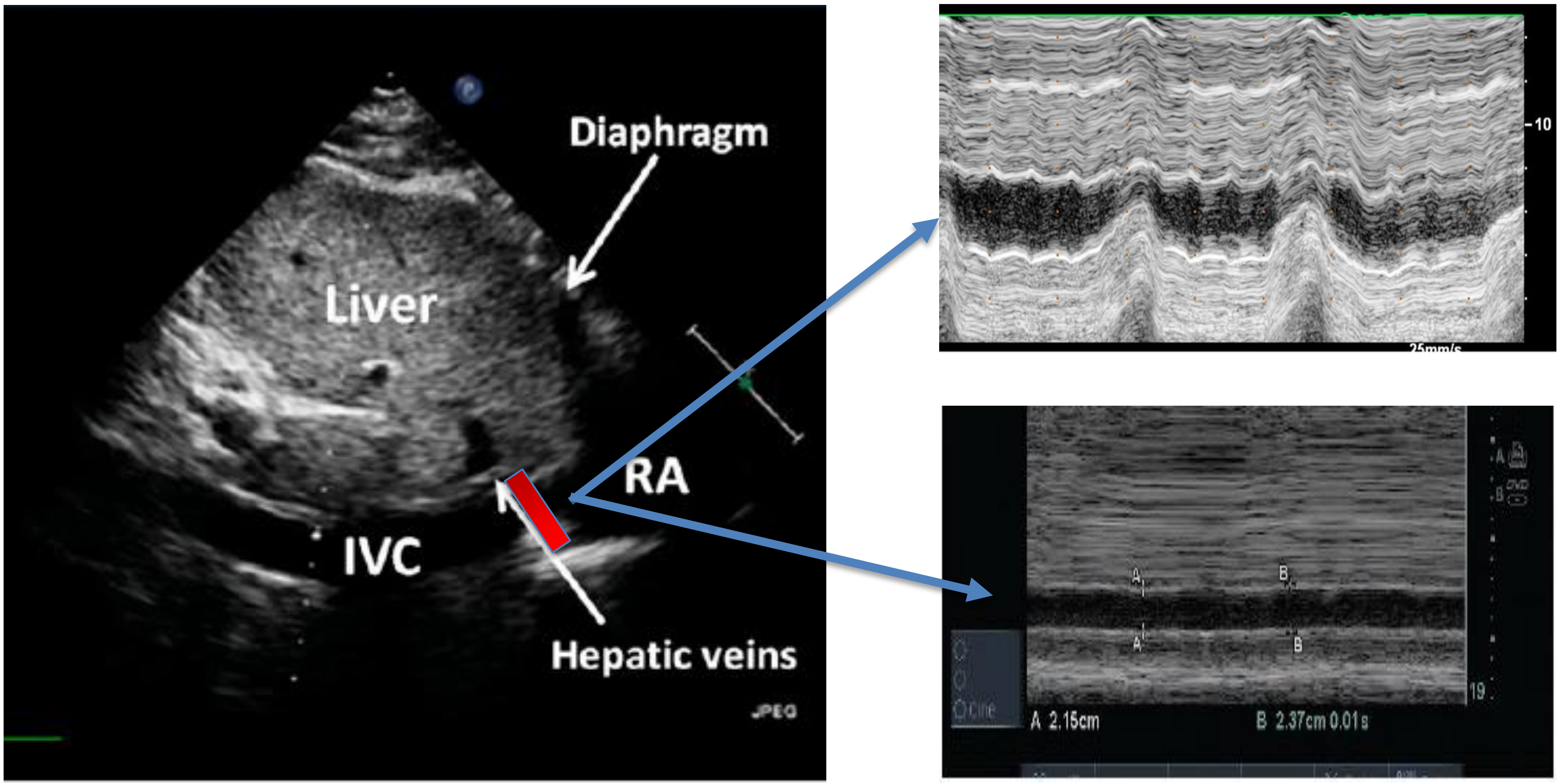
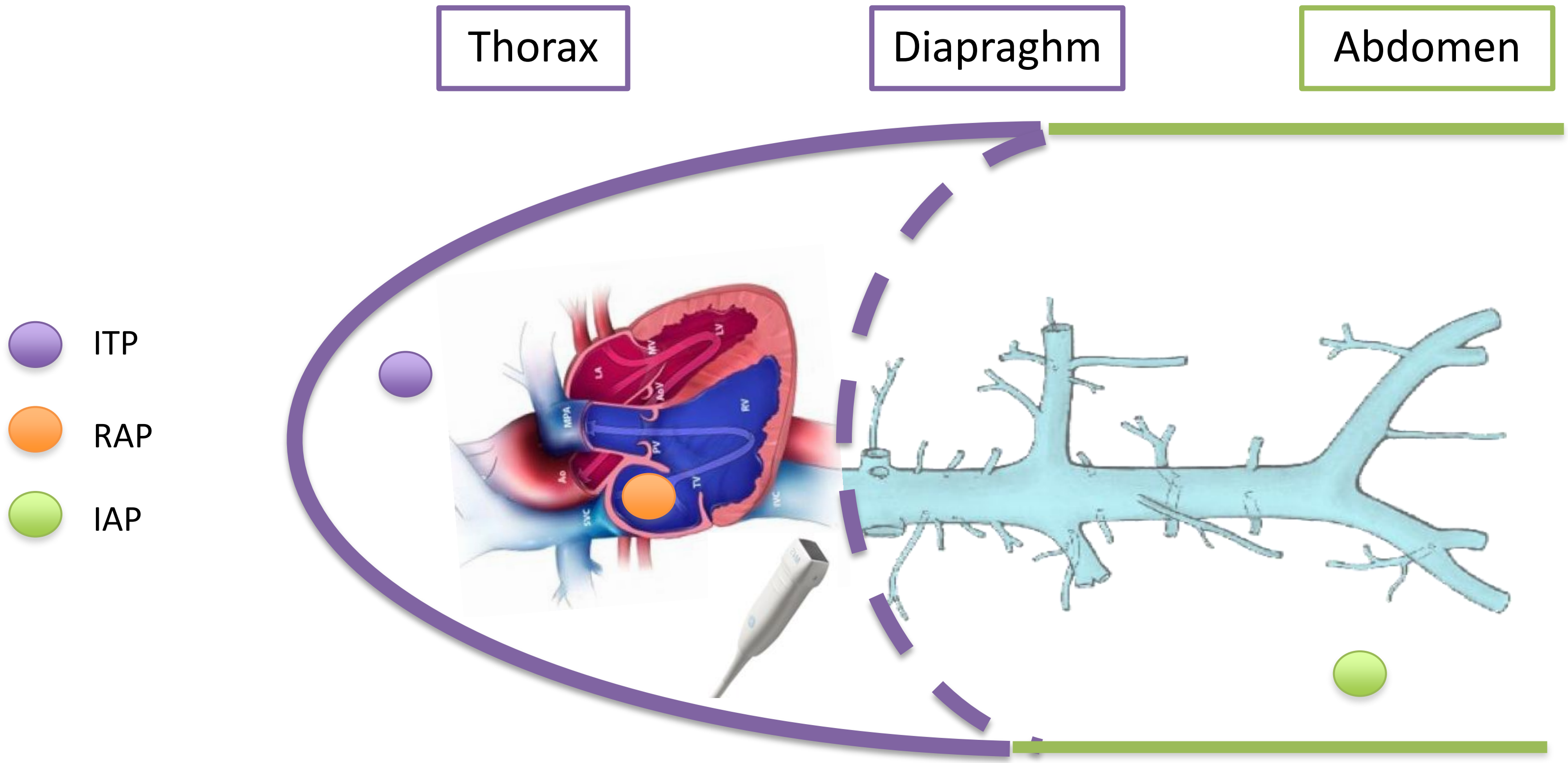
IVC Measurement



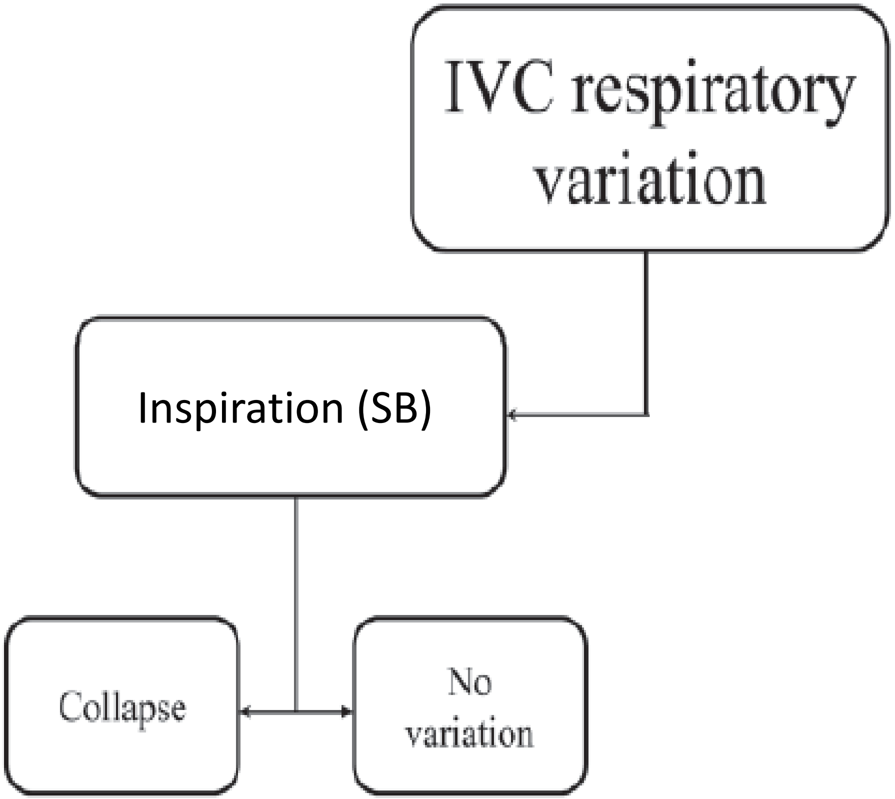


Inspiration (SB) — IVC COLLAPSE

Inspiration (MCV) — IVC DILATATION

Factors acting on IVC collapse:

1) Intra-abdominal pressure
2) Venous retourn
3) Cardiac function


IVC respiratory variation
Inspiration (SB)
Collapse
No variation

Diagnostic Accuracy of the Inferior Vena Cava Collapsibility to Predict Fluid Responsiveness in Spontaneously Breathing Patients With Sepsis and Acute Circulatory Failure

CCM March 2017 • Volume 45 • Number 3

Patients: 90 Non intubated patients without mechanical ventilation presenting with sepsis-induced acute circulatory failure

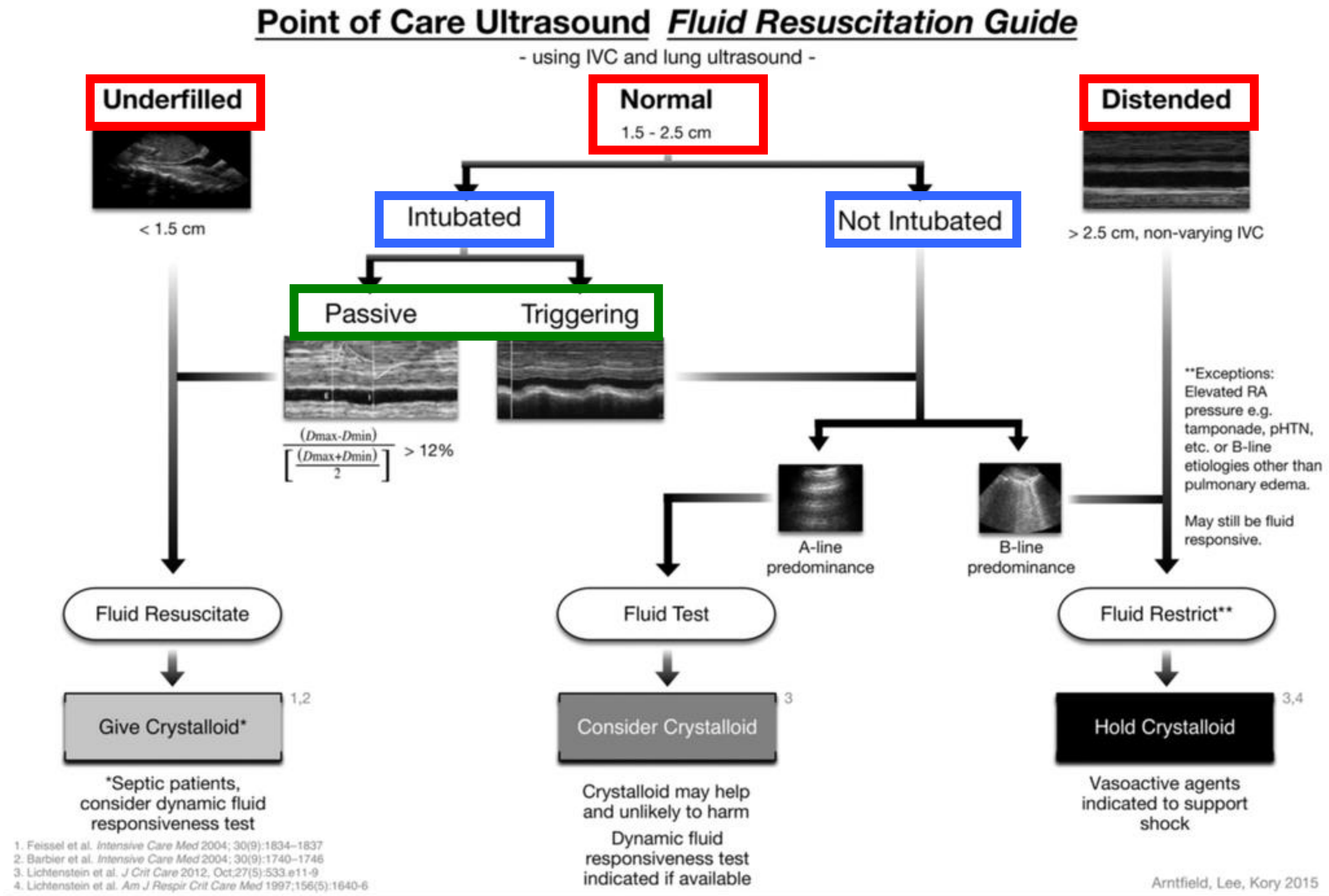
Interventions: We assessed hemodynamic status at baseline and after a volume expansion induced by a 30-minute infusion of 500-mL gelatin 4%.

Oral cavity pressures were recorded with commercially available MP101 micromanometers (KIMO Instrument, Montpon, France). The deep standardized inspiration consisted of a brief (< 5 s) and continuous inspiration strain that did not go beyond a maximum inhalation. Patients were orally guided to generate a minimum buccal pressure from −5 to −10 mm H2 O without any respiratory resistor.

Hemodynamic Parameters	Area Under Receiver Operating Characteristic Curve [95% CI]	Threshold	Sensitivity [95% CI]	Specificity [95% CI]
C_{index} man	0.89 [0.82–0.97]	> 48	0.84 [0.71–0.93]	0.90 [0.76–0.97]
		> 39	0.90	
		> 48		0.90
C_{index} st	0.82 [0.73–0.91]	> 31	0.76 [0.62–0.87]	0.88 [0.73–0.96]
		> 13	0.90	
		> 41		0.90
Dia_{exp} man	0.68 [0.57–0.80]	< 19	0.76 [0.62–0.87]	0.68 [0.51–0.81]
		< 24	0.90	
		< 12		0.90
Dia_{exp} st	0.73 [0.62–0.84]	< 20	0.78 [0.64–0.88]	0.65 [0.48–0.79]
		< 22	0.90	
		< 13		0.90

Functional hemodynamic test on IVC in SB ICU patients

C.W.C. Lee et al. / Journal of Critical Care 31 (2016) 96–100



ORIGINAL ARTICLE

Comparison of Echocardiographic Indices Used to Predict Fluid Responsiveness in Ventilated Patients

Philippe Vignon[1,2,3], Xavier Repessé[4*], Emmanuelle Bégot[1,2*], Julie Léger[5], Christophe Jacob[6], Koceila Bouferrache[7], Michel Slama[8], Gwenaël Prat[6], and Antoine Vieillard-Baron[4,9,10]

AJRCCM Vol. 195, No. 8 | Apr 15, 2017

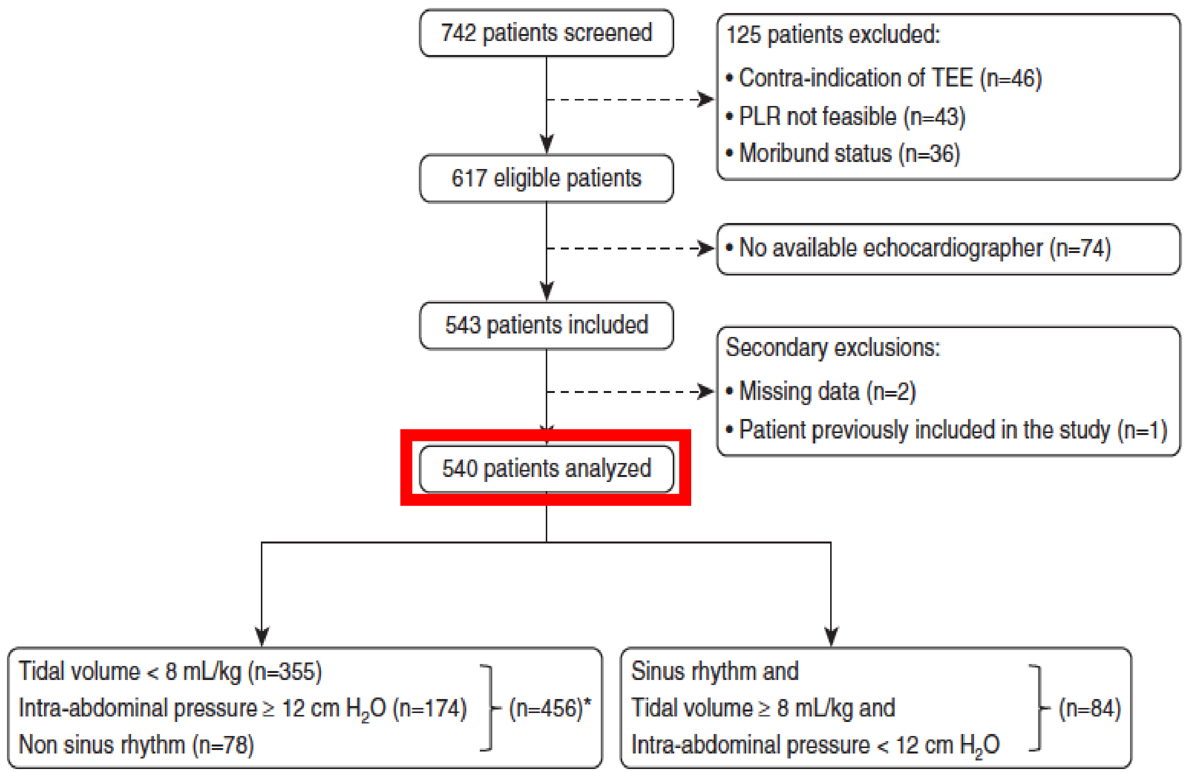
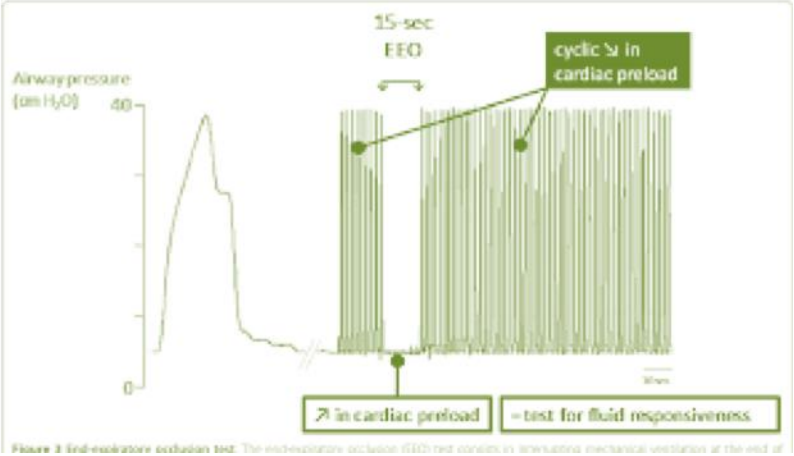


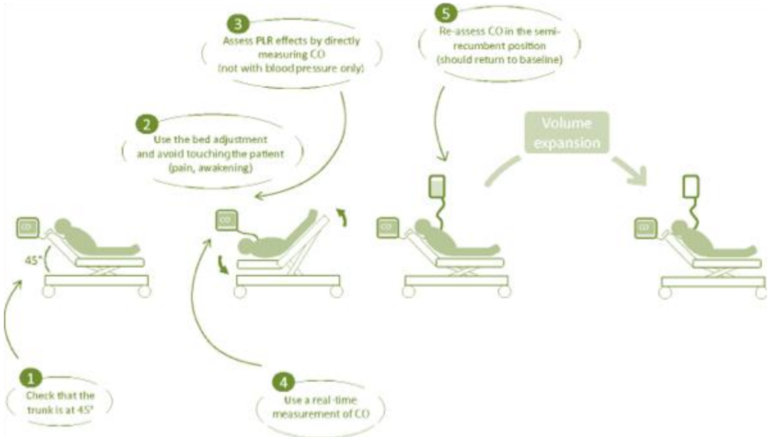
Figure 1. Flow chart of the study. *A single patient may cumulate different criteria. PLR = passive leg raise; TEE = transesophageal echocardiography.

Dynamic Parameters	Threshold Value (%)	Sensitivity [% (95% CI)]	Specificity [% (95% CI)]	Area under the Curve
Study population (n = 540)				
ΔPP (n = 424)	⩾11	58 (53–62)	72 (68–76)	0.675
ΔVmaxAo (n = 421)	⩾10	79 (75–83)	64 (59–69)	0.752
ΔSVC (n = 538)	⩾21	61 (57–66)	84 (81–87)	0.755
ΔIVC (n = 422)	⩾8	55 (50–59)	70 (66–75)	0.635
Subset of patients with all dynamic parameters available (n = 319)				
ΔPP	⩾11	55 (49–60)	73 (68–78)	0.657
ΔVmaxAo	⩾9.4	78 (74–83)	60 (55–66)	0.720
ΔSVC	⩾21	63 (58–68)	81 (77–86)	0.742*
ΔIVC	⩾13	44 (39–49)	85 (81–89)	0.653

Dynamic Parameters	Threshold Value for Optimized Sensitivity (%)	Optimized Sensitivity (Associated Specificity) (%)	Threshold Value for Optimized Specificity (%)	Optimized Specificity (Associated Sensitivity) (%)
ΔPP (n = 424)	4	92 (19)	18	89 (28)
ΔVmaxAo (n = 421)	7	90 (39)	18	90 (29)
ΔSVC (n = 538)	4	89 (25)	31	90 (43)
ΔIVC (n = 422)	3	74 (36)	18	90 (28)

Functional hemodynamic tests



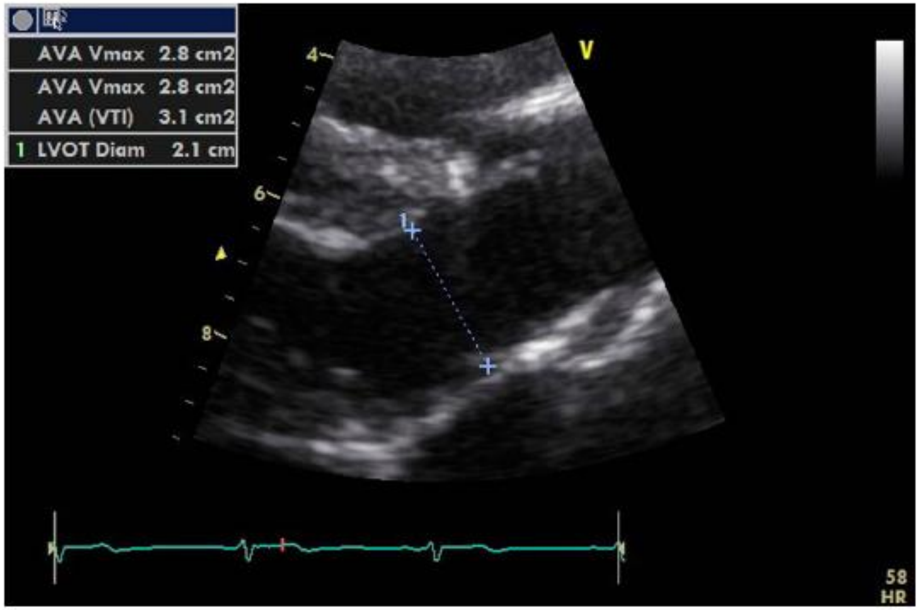


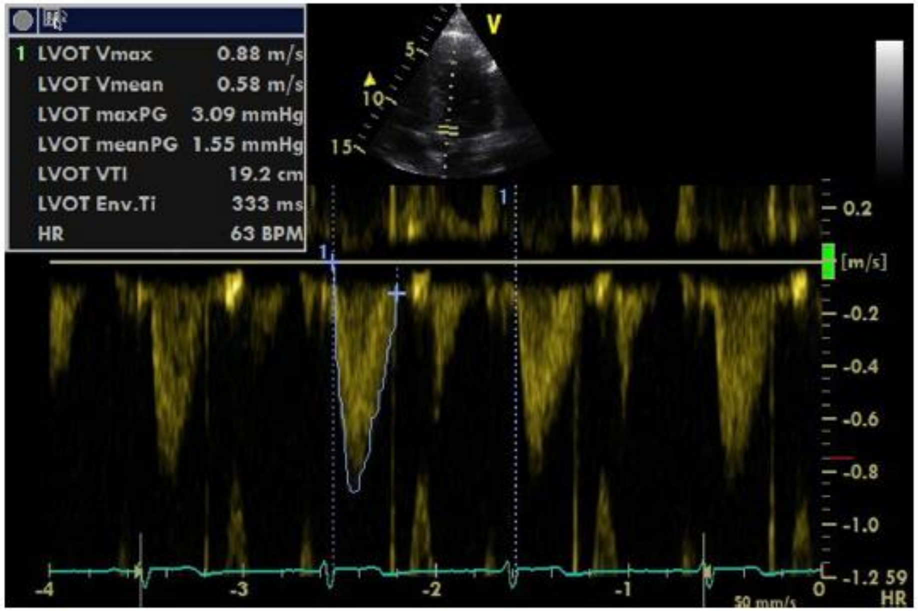
GUIDELINES AND RECOMMENDATIONS

Predicting and measuring fluid responsiveness with echocardiography

$$\text{flow volume (SV)} = \text{SD (or VTI)} \times \text{CSA}$$

$$\text{CSA} = \pi r^2$$

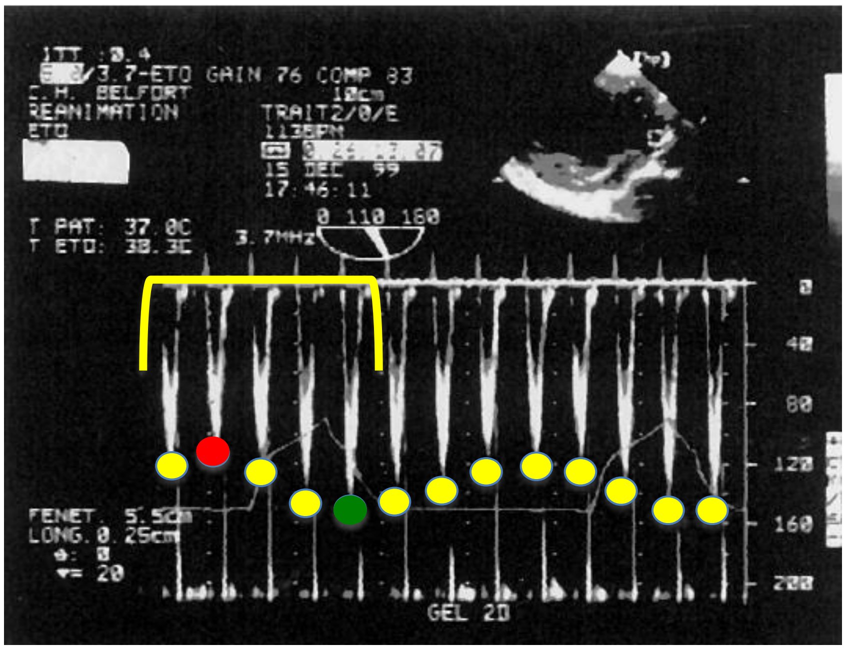


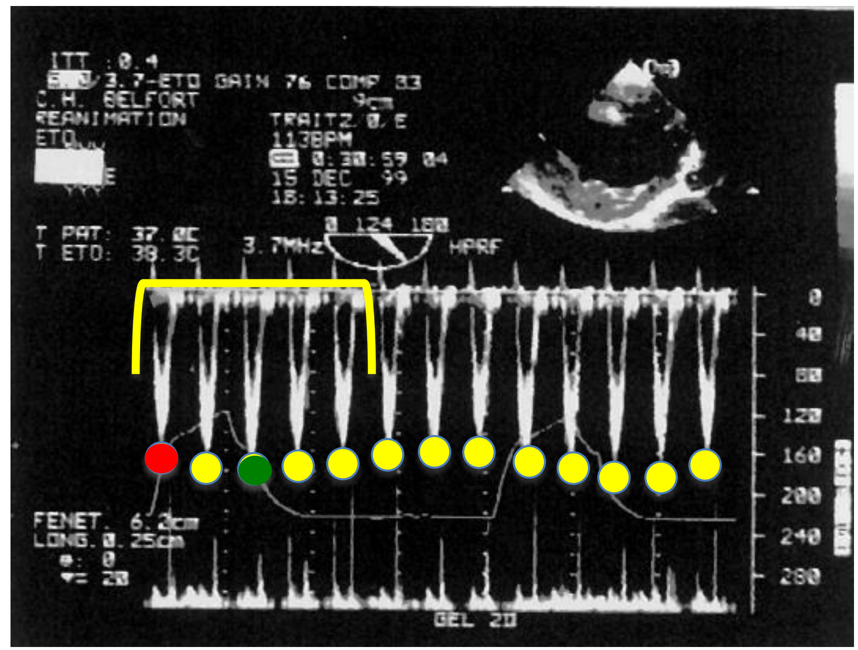


Respiratory Changes in Aortic Blood Velocity as an Indicator of Fluid Responsiveness in Ventilated Patients With Septic Shock*

Marc Feissel, MD; Frédéric Michard, MD; Isabelle Mangin, MD; Olivier Ruyer, MD; Jean-Pierre Faller, MD; and Jean-Louis Teboul, MD, PhD

(CHEST 2001; 119:867–873)





$$\Delta Vpeak\ (\%) = 100 * \frac{(Vpeakmax - Vpeakmin)}{[(Vpeakmax + Vpeakmin)/2]}$$

ΔVpeak threshold value of 12% allowed discrimination between responders and nonresponders with **a sensitivity of 100% and a specificity of 89%.**

Intensive Care Med
DOI 10.1007/s00134-015-4134-1

ORIGINAL

Xavier Monnet
Paul Marik
Jean-Louis Teboul

Passive leg raising for predicting fluid responsiveness: a systematic review and meta-analysis

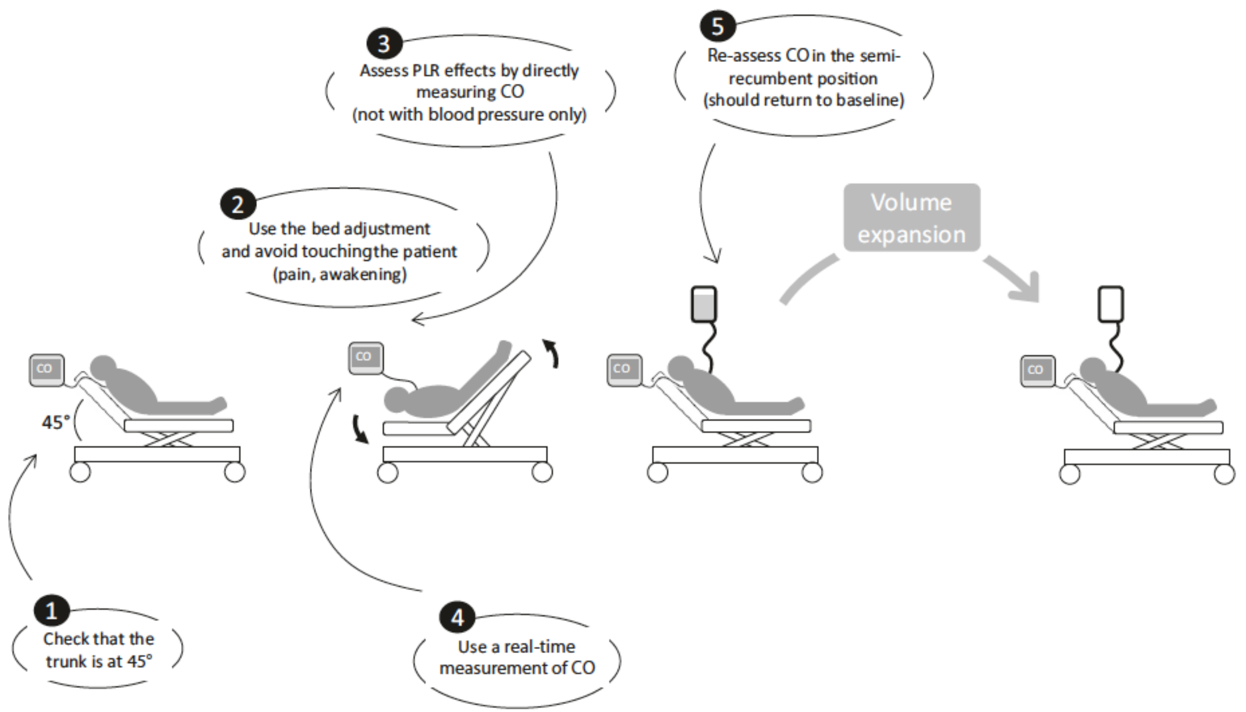


Figure 1 The best method for passive leg raising, indicating the five rules to be followed. CO, cardiac output; PLR, passive leg raising.

Table 1 Main characteristics of included studies

	Setting	Main device used to estimate cardiac output	Indication for volume expansion	No. of included patients	No. of fluid challenges	Type of patients	Spontaneous breathing	Cardiac rhythm
Monnet et al. [34]	ICU	Calibrated PCA	ACF	34	34	Adults	SB and non-SB	Sinus and arrhythmias
Monnet et al. [18]	ICU	Calibrated PCA	ACF	54	54	Adults	Non-SB	Sinus
Dong et al. [12]	ICU	Calibrated PCA	Severe sepsis and septic shock	32	32	Adults	Non-SB	Sinus
Kupersztych-Hagège et al. [13]	ICU	Calibrated PCA	ACF	48	48	Adults	SB and non-SB	Sinus and arrhythmias
Silva et al. [14]	ICU	Calibrated PCA	ACF	20	20	Adults	SB and non-SB	Sinus and arrhythmias
Monnet et al. [17]	ICU	Calibrated PCA	ACF	40	40	Adults	Non-SB	Sinus/arrhythmias
Lamia et al. [32]	ICU	Echocardiography	ACF	24	24	Adults	SB	Sinus and arrhythmias
Maizel et al. [37]	ICU	Echocardiography	ACF	34	34	Adults	SB	Sinus only
Biais et al. [35]	ICU	Echocardiography	ACF	30	30	Adults	SB	No mention
Préau et al. [36]	ICU	Echocardiography	ACF (sepsis or pancreatitis)	34	34	Adults	SB	Sinus
Guinot et al. [16]	ICU	Echocardiography	ACF (under ECMO)	25	25	Adults	Non-SB	No mention
Brun et al. [19]	ICU	Echocardiography	Pre-eclampsia	23	23	Adults	SB	Sinus
Monnet et al. [9]	ICU	Esophageal Doppler	ACF	71	71	Adults	SB and non-SB	Sinus and arrhythmias
Lafanechère et al. [31]	ICU	Esophageal Doppler	ACF	22	22	Adults	Non-SB	Sinus only
Monge-Garcia et al. [15]	ICU	Esophageal Doppler	ACF	37	37	Adults	Non-SB	Sinus
Kang et al. [23]	ICU	Bioreactance	ACF (after cardiac surgery)	34	34	Adults	Non-SB	Sinus
Benomar et al. [22]	ICU	Bioreactance	ACF (after cardiac surgery)	75	75	Adults	No mention	No mention
Marik et al. [20]	ICU	Bioreactance	ACF	34	34	Adults	SB and non-SB	Sinus only
Duus et al. [11]	ED	Bioreactance	ACF	109	100	Adults	SB	No mention
Lakkhal et al. [21]	ICU	PAC + TPTD	ACF	102	102	Adults	Non-SB	Sinus
Thiel et al. [33]	ICU	Suprasternal Doppler	ACF	89	102	Adults	SB and non-SB	Sinus and arrhythmias

Intensive Care Med
DOI 10.1007/s00134-015-4134-1

Orde et al. Critical Care (2017) 21:279
DOI 10.1186/s13054-017-1866-z

Critical Care

REVIEW Open Access

Pearls and pitfalls in comprehensive critical care echocardiography

Sam Orde[1*], Michel Slama[2], Andrew Hilton[3], Konstantin Yastrebov[4] and Anthony McLean[1]

1. Anchor your hand on the patient to keep the same position pre- and post-PLR to ensure efficient imaging and the same pulsed Doppler gate position and angle of Doppler interrogation (Fig. 4a inset)
2. Optimise the LVOT Doppler profile for stroke volume assessment (as per the "Accurate stroke volume assessment" section) with appropriate gain, scale and sweep speed. Assess stroke volume pre-PLR, 1 minute post-PLR and again once supine [11], at the *same time* in the respiratory cycle, using an increase (and subsequent decrease to baseline once supine again) of 15% as a marker of a responder [8].

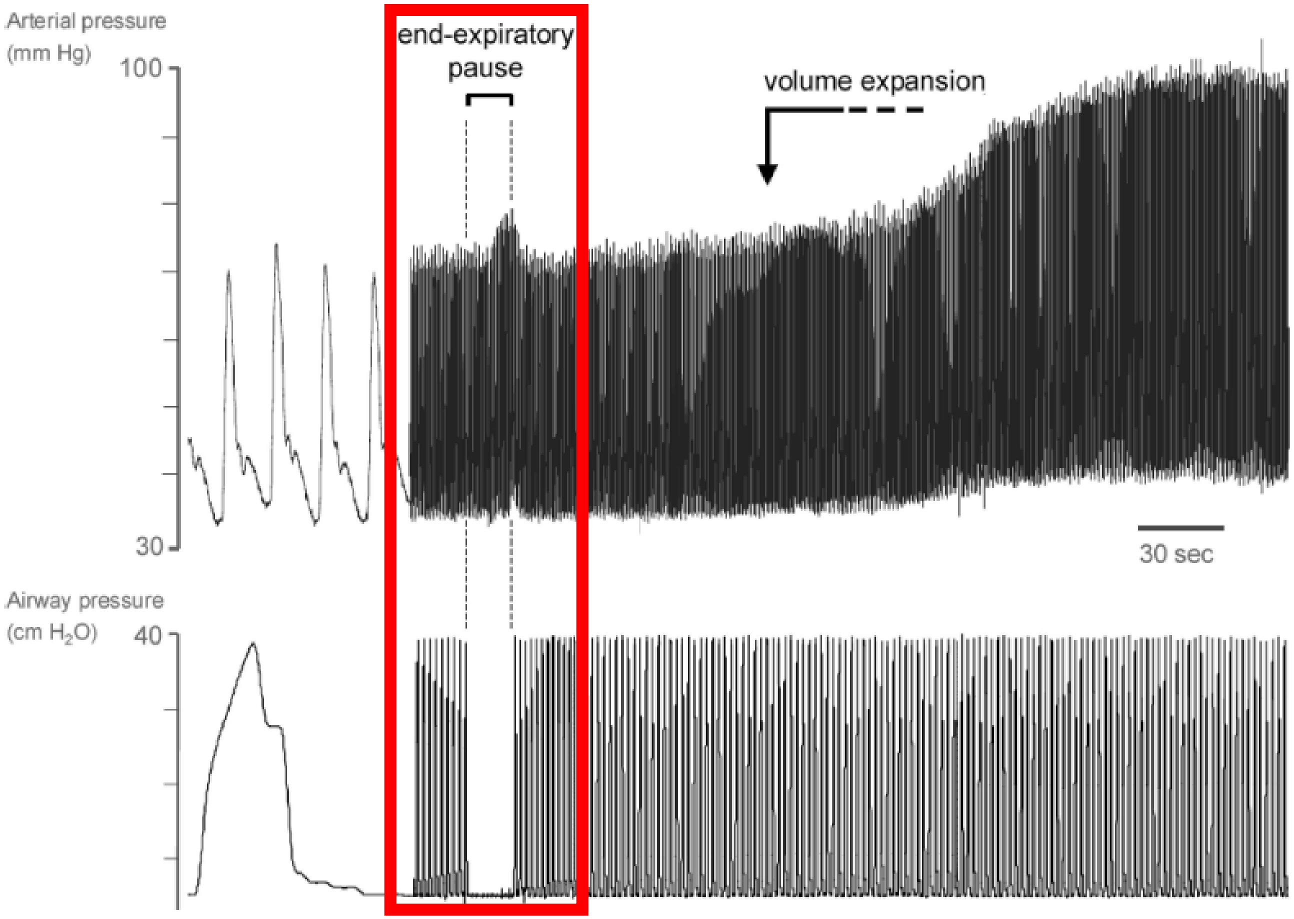
Same position

Same time

Crit Care Med 2009 Vol. 37, No. 3

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



RESEARCH Open Access

End-expiratory occlusion maneuver to predict fluid responsiveness in the intensive care unit: an echocardiographic study

Delphine Georges[1], Hugues de Courson[1], Romain Lanchon[1], Musa Sesay[1], Karine Nouette-Gaulain[1,2,3] and Matthieu Biais[1,3,4*]

- 50 mechanically ventilated critically ill patients. **Velocity time integral and peak velocity** were assessed using transthoracic echocardiography before and at the end of a 12-sec end-expiratory-occlusion maneuver.
- A third set of measurements was performed after volume expansion (500 mL of saline 0.9% given over 15 minutes).
- Patients were considered as responders if cardiac output increased by 15% or more after volume expansion.

Table 3 Ability to predict increase in cardiac output ≥15% after infusion of 500 mL saline over 15 minutes

Index	Best threshold	Gray zone	Patients whose measurements were in the gray zone	AUROC (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	Youden index J
ΔVTI	>9%	6–10%	20%	0.96 ± 0.03	89% (72–98%)	95% (77–100%)	0.85
ΔVmax	>8.5%	1–13%	62%	0.70 ± 0.07	64% (44–81%)	77% (55–92%)	0.42

Best threshold value was determined using the Youden index. Youden Index J = Sensitivity + Specificity – 1. ΔVTI represents changes in velocity time integral induced by end-expiratory occlusion. ΔVmax represents changes in peak velocity induced by end-expiratory occlusion

AUROC area under receiver operating characteristics curves. *CI* confidence interval

ID: 16-0008; June 2016
DOI: 10.1530/ERP-16-0008

Fluid responsive?

Signs of overt hypovolaemia:
LV small (LVED area PSAX <10cm2)
LV hyperdynamic* (HR >100, EF >65%, walls 'kissing')
RV small and hyperdynamic
IVC small (<10mm)
Dynamic LVOT obstruction

*Appearances can be mimicked by LV hypertrophy and vasodilatation

No

No

Yes

Invasively Ventilated
and
Sinus rhythm
and
TV >7mls/kg
and
No spontaneous breaths
and
No ventricular failure

Fluid challenge*:
Measure VTI or SV before and immediately after 250 ml bolus

* If clinically indicated

Spontaneously breathing
or
Arrhythmia
or
Spontaneous breaths during IPPV
or
LV or RV severely dilated or impaired

Yes

VTI or SV increase > 15%

Aortic respiratory variation (SV, VTI, peak velocity)
and/or
IVC respiratory variation

>12%

100 x (max - min) / ((max + min) x 0.5)

Passive leg raise

Measure VTI or SV before and 1 minute after PLR

(average over > 3 consecutive beats)

No

Assess for other causes of shock

LV / RV failure
PE
Tamponade
Severe valve disease

Do not give fluid challenge

Consider false negatives:

Demonstrate increase in E and E/A with fluid challenge or PLR to ensure preload has increased.

A
B

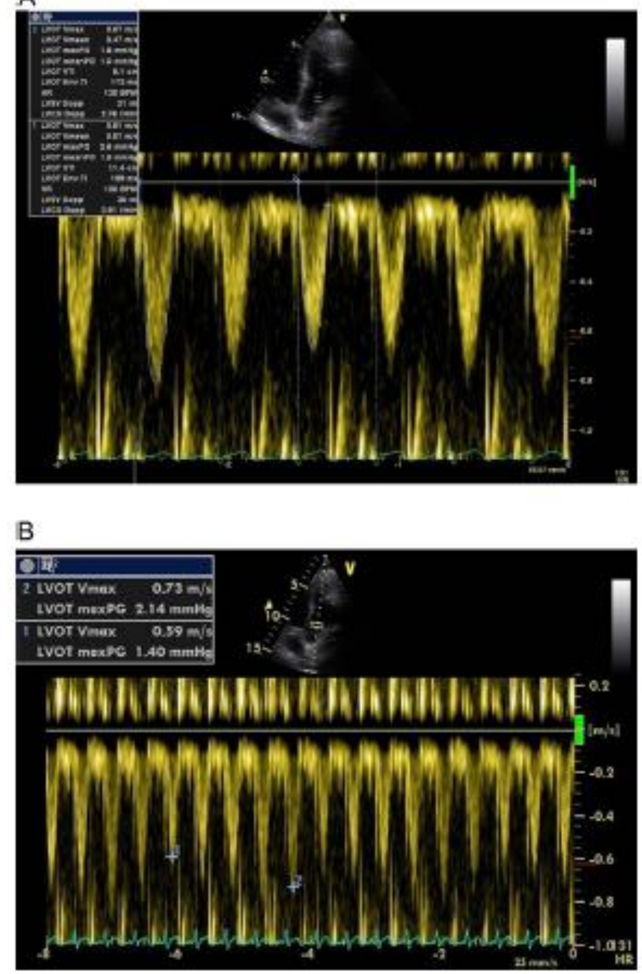


Figure 7
(A) PWD in the LV outflow tract. VTI measurement of the smallest and largest envelope within the respiratory cycle. (B) Measuring V_{max} variation with appropriate sweep speed.

danke

спасибо

شكرا

merci

शुक्रिया

Grazie

HUMANITAS
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Thank you

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¡gracias

谢谢

хвала

ありがとう

Ευχαριστώ