Critical Review Form
Diagnostic Test

Respiratory changes in inferior vena cava diameter are helpful in predicting fluid responsiveness in ventilated septic patients, *Intensive Care Med* 2004; 30: 1740–1746

Objective: **"To test the hypothesis that respiratory changes in IVC diameter in mechanically ventilated patients could predict the efficacy of volume expansion". (p. 1741)**

Methods: **Retrospective study from January-July 2003 of ventilated patients over age 18 years with circulatory failure (systolic arterial pressure < 90 mg Hg and/or vasopressor infusion) related to severe sepsis in the medical-surgical ICU of Poissy-Saint-Germain-en-Laye hospital (France). All patients had volume mode ventilations with the following settings: VT= 8.5 ± .5 mL/kg, rate 15 ± 2 breaths/minute, PEEP 4 ± 2 cm H_20, and plateau pressure < 30 cm H_20. All patients had arterial line pressure monitoring, pulse, oxymetry, and CVP monitoring. The last six subjects also had respiratory change in abdominal pressure measured (Fusco 2001).**

Transthoracic Doppler echocardiography was performed in synchronization with the ventilatory cycle. IVC was measured just upstream of the origin of the suprahepatic vein in the M-mode coupled to two-dimensional mode. IVC was measured subcostally in longitudinal section in order to compute the distensibility index (d IVC) which reflects the ↑ diameter with inspiration.

$$\text{d IVC} = \frac{\text{maximum inspiratory diameter} - \text{maximum expiratory diameter}}{\text{minimum diameter on expiration}}$$

The cardiac index (CI) was calculated from the right ventricular outflow tract by measuring the velocity timed integral (VTI) via pulsed Doppler mode at the pulmonary annulus. The diameter (D) of the pulmonary annulus was also measured to compute:

$$\text{CI} = (\text{VTI} \times \pi \times D^2 / 4 \times \text{HR}) \div \text{body surface area}$$

All clinical and echocardiographic measures were obtained before and after a 30-minute volume expansion using 4% modified fluid gelatin. Responders were defined by CI increase ≥ 15%. A ROC was constructed to determine the d IVC threshold which provided the optimal sensitivity and specificity for predicting fluid responsiveness.

Guide		Comments
I.	**Are the results valid?**	
A.	**Did clinicians face diagnostic uncertainty?**	Yes. "Measurements were recorded on videotape for later review by a second operator not aware of fluid responsiveness". (p. 1741) Inter-observer variability in the measurement of IVC diameter was 8.7 ± 9%.
B.	**Was there a blind comparison with an independent gold standard applied similarly to the treatment group and to the control group? (Confirmation Bias)**	The criterion standard is not clearly stated but responsiveness was judged by ≥ 15% increase in CI. All subjects had CI measured by Doppler echo but echocardiographers were not blinded to the IVC diameter or other clinical parameters.
C.	**Did the results of the test being evaluated influence the decision to perform the gold standard? (Ascertainment Bias)**	No, all subjects had Doppler echocardiography performed.
II.	**What are the results?**	

A.	**What likelihood ratios were associated with the range of possible test results?**	• 20 patients were included in this analysis with 75% male and mean age 63 years with mean SAPS II score 60. The vast majority (14/20) had pneumococcal lung injury or inhalational lung injury. • 50% of patients were volume responders. • Comparing responders to non-responders, initial heart rate, SBP, CI, CVP, and vasopressor dose did not predict volume responsiveness (Table 3, p. 1742) but dIVC did (40% in responders vs. 8% in non-responders, p = 0.0019). • There were no differences in plateau pressure, PEEP, or respiratory system compliance between responders and non-responders. • A dIVC value > 18% provided the optimal sensitivity (90%) and specificity (90%) to predict the efficacy of volume expansion (Fig 2, p. 1744)
III.	**How can I apply the results to patient care?**	
A.	**Will the reproducibility of the test result and its interpretation be satisfactory in my clinical setting?**	Uncertain. Who performed the IVC ultrasound? What training did they have and how does that equate to average EP? Can EPs standardize vent settings as they did in their study? How does one assess and control for differences in right heart function and intra-abdominal pressure changes that can confound the measurement of dIVC?

B.	**Are the results applicable to the patients in my practice?**	The ventilated, septic subset (very few).
C.	**Will the results change my management strategy?**	No, not until outstanding questions in III-A addressed in future research.
D.	**Will patients be better off as a result of the test?**	Not in the ED (for now). The settings and methods of this research leave too many questions about external validity and controlling for confounding variables to permit confidence for widespread implementation.

Limitations

1) **Who performed the IVC ultrasound? What training did they require and how was expertise maintained?**
2) **Limited external validity for EM since non-ED setting regimented vent settings and entirely ventilated patients with sepsis.**
3) **No control for confounding variables (RV function, intra-abdominal pressure changes).**
4) **Unable to perform IVC measurement via Echo in subset of patients (morbidly obsess, post- laparotomy).**
5) **No conflict of interest statements.**

Bottom Line

In ventilated ICU patients with sepsis the IVC distensibility index is superior to initial heart rate, blood pressure, CI, or CVP in identifying likely fluid responders. Future studies will need to verify that EPs with heterogeneous sonographic skills and skill maintenance can reliably and accurately measure dIVC in hemodynamically unstable patients with possible sepsis and that the dIVC provides similar prognostic test characteristics in this subset before this technology can be recommended for widespread EM utilization.