

Central venous pressure versus inferior vena cava collapsibility index measurement to assess the intravascular status

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Assessment of intravascular volume is very crucial to manage critically ill and hypotensive patients; however, predicting fluid responsiveness can be challenging, particularly in children. Numerous hemodynamic (static and dynamic) variables have been proposed as predictors of fluid responsiveness [1]. The central venous pressure (CVP) remains the most commonly used variable for this purpose; although studies have shown its poor predictive value and concluded that CVP should not be used to make clinical decisions regarding fluid management [2]. Routine use of CVP is not always practical, is costly, and carries risks of vascular access. The imaging modality, ultrasonography (USG), has had mixed results predicting CVP measurement to assess the intravascular status by assessing the inferior vena cava collapsibility index (IVC-CI) [3,4]. Good non-invasive modalities, to assess the cardiac function and fluid status, elude the pediatric intensivist.

This issue of the Indian Journal of Child Health has published a research by Ali *et al.* where authors have evaluated the relation between CVP and IVC-CI in cases of pediatric shock [5]. The author's asked the question, "does IVC collapsibility in children with fluid refractory shock, predict CVP?" It is a prospective observational study on consecutive patients, with IVC measurements performed by PICU fellows blinded to CVP during the ultrasound measurements, with an independent review later performed by a pediatric cardiologist. This is the largest pediatric study done to date reviewing IVC size and caval index (CI) on pediatric intubated patients in shock. No sample size calculation was reported, but using "difference in proportion" equation for ultrasound/CVP sensitivities, 107 patients were an adequate sample to show a difference. Additional strengths were the blinding of sonographers, confirmation of CVP catheter position, the use of a standardized protocol limiting interobserver bias, the independent review done, and the exclusion of patients with raised intra-abdominal pressures.

This study has added to the current literature of pediatric USG, repeating what has been documented in very few numbers of patients; a step in the scientific method often overlooked. This has been studied a handful of times in the literature, but illustrates a practice many pediatric intensivists may be used

to aid clinical judgment. Previous studies comparing USG to CVP have shown contradictory results as some reported similar results [3] and some contrary [4]. Echocardiography, by experienced sonographers, can evaluate stroke volume (SV) and predict fluid responsiveness; however, the typical pediatric intensivist does not have this extensive training or experience. Leaving us wanting to prove fluid status or responsiveness through the methods we know.

Trying to find a better, non-invasive measure is important in the current setting of fluid resuscitation in septic shock. Too little and too much fluid is bad and high CVP is an independent risk factor for mortality in pediatric septic shock patients [6]; therefore, maybe, just enough is what we need. Despite data in favor of CVP and CI not having a high correlation [7], the negative predictive value (NPV) and positive predictive value of the extremes of measurement have a good correlation to fluid status. This current study has a high NPV with CVP >12 mmHg and IVC-CI >25%. Common sense dictates when the IVC is fully collapsed, CVP is likely very low and when fully distended with minimal respiratory variability, adequate left ventricular filling, and SV, the patient does not need fluid.

We must be cautious in applying adult studies to pediatric patients. We cannot bring all our patients to a cath lab, a straight leg raise is not physiologically informative in children with leg:body ratios different from adults [8], and disposable single-use catheters and monitoring are not available in all settings. Mugloo *et al.* showed that IVC-CI correlates with CVP measurement through umbilical vein catheter in neonates ($r^2=-0.937$). However, the ability of IVC-CI to predict surrogate markers of tissue perfusion in shock was not studied [9].

Limitations of this study affecting outcomes include it was a single-center study with a restrictive inclusion/exclusion criteria; it employed convenience sampling, measurements were only done when a trained fellow was available, with no specific time interval from initial presentation of shock; and while there was independent review, inter- and intra-observer variability was not reported. The authors describe good cardiac function in patients, the majority in cold shock, indicating shock from decreased intravascular volume, and vasopressors or inotropes would not improve the IVC measurements/CVP. Without scanning at a

standardized time in the resuscitation, inferences are moot, limiting the studies applicability.

Correlation to age normal IVC measurements was not done and should be considered in future studies. Kutty *et al.* measured the IVC in 120 health pediatric patients and developed nomograms based on body surface area (BSA) for IVC diameter and IVC-IC in healthy spontaneous breathing children [10]. Age, weight, or BSA-specific norms can help assess abnormal findings.

The authors reported inclusion of only ventilated patients as a limitation to which we disagree. Spontaneously, breathing patients would introduce even more unknown variables due to variability in chest volumes and pressures in spontaneously breathing patients and lead to a very little correlation between CVP and IVC-CI [11]. The study population was specific: Intubated patients in septic shock requiring >40 ml/kg fluid, ventilated with a tidal volume of 6 ml/kg, PEEP of 5. Studies validating fluid responsiveness predictors have used a tidal volume of 8–10 mL/kg. Ventilators deliver positive pressure increasing the right atrial resistance distending the IVC and increase intrathoracic pressure reducing venous return to the right atrium, all returning to baseline following exhalation. Smaller tidal volumes, as in this study, have less circulatory effects and may not be measured reliably or be diagnostic [12].

The take-home message is, in patients refractory to fluid administration, intubated, ventilated with lung protective volumes, on no inotrope/vasoactive medications, IVC-CI is moderately correlated to the CVP.

Non-invasive approaches are better for the patients. Correlating IVC-CI to minimally invasive cardiac output monitoring instead of CVP is a potential for future pediatric studies. Technology is rapidly advancing, and skepticism persists regarding bedside ultrasound. The thought that we could soon use smartphone ultrasound with the quality needed to make the diagnostic decisions can significantly improve delivery of care in remote landscapes and quaternary centers. A dose of healthy skepticism should be used toward any technology used by poorly or untrained practitioners; we should promote appropriate training in basic ultrasound measurements, adding to the patient assessments, providing the best care.

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