Editorial

Inferior vena cava collapsibility index: Speculation, mirage, or reality?

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Sukhminder Jit Singh Bajwa, Nishkarsh Gupta[1], Shelly Rana[2], Shikha Sharma[3]
Department of Anaesthesiology and Intensive Care, Gian Sagar Medical College and Hospital, Banur, Patiala, Punjab, [1]Department of Onco-Anaesthesiology and Palliative Medicine, DRBRAIRCH, AIIMS, New Delhi, [2]Department of Anaesthesia, Dr. Rajendra Prasad Government Medical College, Kangra at Tanda, Himachal Pradesh, [3]Department of Anaesthesia, ASCOMS, Jammu, India

Address for correspondence: Dr. Sukhminder Jit Singh Bajwa,
Department of Anaesthesia and Intensive Care, Gian Sagar Medical College and Hospital, Banur, Patiala, Punjab, India.
E-mail: sukhminder_bajwa2001@yahoo.com

Intraoperative hypotension is a common occurrence in patients undergoing surgery under general and spinal anaesthesia and is associated with adverse outcomes.[1] Though its origin is multifactorial, one of the common modifiable causes is absolute or relative fluid deficit which can be treated with a fluid challenge to increase the cardiac output. Though we have clear guidelines for preoperative fasting, patients often do not comply with them and it may result in fluid deficit and possible hypotension following anaesthesia induction. Nevertheless, it is often a challenge to gauge the degree of fluid deficit and the amount of fluid required for resuscitation. The assessment of intravascular volume and fluid responsiveness (FR) in a critically ill patient has long been a dilemma for the anaesthesiologist. It is important for the anaesthesiologist to ascertain the FR, as the likelihood of critically ill patients being in the state of FR amounts to 50% only.[2,3] That means resuscitation will be done in a situation of physiological uncertainty, and while negotiating this situation one has to remember that overenthusiastic fluid administration has often been related to various undesirable patient outcomes including extended hospital stays, increased duration of mechanical ventilation,[4] and increased morbidity and mortality.[5] Therefore, just like any other medication, carefully calculated dosages of intravenous fluids should be administered.

At present, we do not have any gold standard single method having precision in determining the intravascular volume status and FR. The central venous pressure (CVP) monitoring described initially is found to have no significant correlation to the intravascular volume status.[6] The other methods, for example, the passive leg raising test and end-expiratory occlusion test, work practically well; however, it is challenging to execute them in some situations. Recently employed techniques such as pulse pressure variation and stroke volume variation are either invasive or feasible to only a small subset of patients, that is, patients on mechanical ventilation.[7]

Point-of-care ultrasound is the new stethoscope for clinicians, and inferior vena cava (IVC) diameter measurement and respiratory variation in caval diameter expressed as caval index (difference in IVC diameter during expiration and inspiration divided by maximum IVC diameter on expiration) have become a popular method nowadays. It is being used by researchers and clinicians to assess FR in trauma patients, predict hypotension after anaesthesia induction, and in guiding fluid therapy in critically ill patients.[8–10] The changes in IVC diameter are different in spontaneously breathing and mechanically ventilated patients due to opposite changes in the intrathoracic pressure (ITP). During spontaneous breathing, the collapsibility of the IVC is assessed in response to a decrease in ITP depending upon the interaction of the CVP and intrathoracic-abdominal pressure gradient. The change in dimensions of the

IVC depends entirely on fluctuations in ITP; therefore, in spontaneously breathing patients, the degree and the rate of the respiratory effort is an important and difficult-to-quantify variable. Thus, a patient who is dyspnoeic will tend to have a disproportionate collapse of the IVC, contrary to a patient who is hardly breathing, resulting in minimum collapse of an 'empty' IVC. A caval index of >50% in spontaneously breathing patients is thought to be associated with low volume status and fluid responsiveness. However, the cutoffs for these parameters are variedly reported and using a universal cutoff for the caval index may result in missing events. The IVC index predictability is thus physiologically dependent on the interplay of ITP, abdominal pressure, vessel compliance, and CVP. Any change in these parameters due to variability of demographics, measurement method, environmental condition, fasting status of patients, pre-existing heart disease, and anaesthesia technique affects the overall test results and their interpretation. There are studies[11,12] evaluating the predictive value of ultrasound-guided IVC measurements wherein the authors have commented that the 'IVC cannot reliably predict FR' and 'caval index does not reliably predict FR' in spontaneously breathing patients, respectively. Millington suggested that the literature does not support the use of variability of the IVC with respiration (ΔIVC) to predict FR in spontaneously breathing patients.[13] Similarly, Chowdhury *et al*.[14] assessed the role of IVC collapsibility index (IVCCI) and carotid artery peak velocity variation (CAPVV) in the prediction of post-spinal anaesthesia hypotension (PSH) in spontaneously breathing patients and concluded that both IVCCI and CAPVV have poor diagnostic accuracy in predicting post-spinal hypotension in adult patients undergoing elective infraumbilical surgery. On the contrary, Ayyanagouda *et al*.[15] found a positive correlation between IVCCI and pre-spinal fluids and concluded that ultrasound assessment of the IVC reduces spinal induced hypotension and the requirement of vasopressors in hernia and hydrocoele surgeries.

In a study being published in this issue of the *Indian Journal of Anaesthesia*, 110 patients were studied in order to determine the correlation of preoperative IVC diameter in expiration (dIVCmax) during spontaneous ventilation and IVCCI, with general anaesthesia associated hypotension (GAAH). A significant positive correlation was found to be present between patient height and dIVCmax. The study concludes that both dIVCmax and IVCCI have poor diagnostic accuracy, with good specificity and low sensitivity in predicting GAAH. Also, these preoperatively assessed US guided parameters were not significantly correlated with temperature of the environment, humidity and preoperative fasting.[16]

An intriguing fact is that several studies on the effectiveness of the IVC index do not specifically report the important variables like intra-abdominal pressure, tidal volume used during mechanical ventilation, inspiratory effort, positive end expiratory pressure used, and IVC compliance that can affect the caval index.

Another point of concern is that there is no standardised and best approach for measuring intravascular volume status or FR by ultrasound of the IVC, leading to arguments regarding its usefulness in estimation of the intravascular volume and FR.[17] Finnerty *et al*.[18] suggested that the B-mode, subxiphoid long axis (LA) 2–3 cm caudal to the right atrial junction is the most reliable means of IVC acquisition. IVC measurement is less reliable and less accurate in M-mode when compared to B-mode.[19] The reliability is poorer in spontaneously breathing patients as it is difficult to standardise the tidal volume and respiratory efforts across spontaneously breathing patients. The results have been varied because of heterogeneity in studies with respect to demographics, the respiratory parameters used, the formula applied and the patient's underlying condition.[20] This is due to the fact that IVC is a high capacitance vessel and the diameter may be different in patients of different age, gender, and body mass index. The usefulness has been shown to be better in patients with a higher American Society of Anesthesiologists physical status and those with higher fluid shifts due to major resection and volume disturbances.

A major challenge with the use of US for clinical decision-making is difficult visualisation due to lack of operator skill and/or the patient's characteristics that hinder appropriate visualisation (morbid obesity, abdominal distension due to gas, dressing etc.). These technical factors may lead to inter-rater variability and affect the overall reliability.[21] However, this can be overcome by appropriately training the caregivers and identifying alternative ways to visualise the IVC.

Measurement of ultrasound-guided IVC diameter currently appears to be an upcoming non-invasive tool that can be useful for the measurement of FR in

experienced hands to assess the changes early before the appearance of clinical manifestations. However, the data available is currently inconclusive with respect to its effectiveness. It is important to know the cutoffs for assessment, along with the clinical scenarios which may reduce its effectiveness. We need several large multicentric studies across populations with the same criteria for assessment to have valid cutoffs adjusted for age and demographic parameters for meaningful assessment. Nevertheless, only the IVC index may not be appropriate to be used as a surrogate marker for fluid management and predicting hypotension. All this leaves one wondering as to whether IVC ultrasound is a mirage. Will it remain a speculation or will it become a routine procedure in real-time clinical practice?

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