SONOGRAM OF THE INTERNAL JUGULAR VEIN: A FEASIBLE NON-INVASIVE TOOL FOR VOLUME ASSESSMENT OF PATIENTS UNDERGOING CARDIAC SURGERY?

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Background: Intraoperative volume status assessment is important for guiding fluid therapy and optimizing hemodynamic management. Traditional accepted methods of volume assessment include measurements of left ventricular end-diastolic volume (LVEDV), central venous pressure (CVP), and pulmonary artery diastolic pressure (PAD). However, these methods are invasive, expensive, and can potentially subject the patient to complications and therefore, are not applicable in all surgical populations. Instead, less invasive and more reliable methods of evaluating a patient's volume status are being sought. A recent pilot study reports the successful utilization of ultrasonography of the internal jugular vein (IJV) as a noninvasive tool to predict CVP in spontaneously breathing critical care patients (1). No study to date has performed ultrasound assessment of the IJV as a possible tool in the operating room to assess volume status and guide fluid management in the surgical patient under general anesthesia. This study aims to compare correlations of sonographic measurements of the IJV, CVP, and PAD to LVEDV in this population subset. Additionally, current literature suggests positive correlations between pulse pressure variation percent (PPV%) and left ventricular end-diastolic area as a reliable measure of fluid responsiveness (2). Thus, as a secondary endpoint, we will also evaluate the correlation between PPV% and LVEDV.

Methods: After IRB approval, 18 patients scheduled for cardiac surgery were consented for this prospective observational study. Routine anesthetic management for these patients included invasive hemodynamic monitoring (arterial line, CVP, PA catheter) and transesophageal echocardiography. Echocardiographic and hemodynamic data were collected at two time points: baseline and immediately prior to initiation of cardiopulmonary bypass. We considered LVEDV the gold standard for volume status assessment, against which all other measurements were compared (IJV diameters, IJV cross sectional area (CSA), PPV%, CVP, and PAD).

The IJV was measured by placing a linear-phased array transducer on the patient's left neck, avoiding compression of the vessel during image acquisition. The LVEDV was calculated using Simpson's formula with measurements of the left ventricle obtained in the mid-esophageal four chamber and two chamber views. All measurements of IJV and LVEDV were performed under general anesthesia with the patient supine and the ventilator off. Hemodynamic data were collected and stored via electronic medical record. The derived PPV% was calculated as the pulse pressure modulation at the respiratory frequency divided by mean pulse pressure. All echocardiographic, sonographic, and PPV% data were interpreted offline by a blinded investigator.

Statistical analysis was performed as described by Bland and Altman in which the correlation coefficient between different variables was calculated after removing differences between subjects and looking at changes within individual subjects (3). $P < 0.05$ was considered significant.

Results: Of 18 consented patients, only ten were included in the study analysis of IJV diameters/CSA, and only five subjects were included in PPV% analysis. Patients were excluded from the study due to the development of hemodynamically unstable arrhythmias, presence of IJV clot, ventricular aneurysm, or severe aortic insufficiency. Average intravenous fluid administration and blood loss between the two time points was 950 ml and 400 ml, respectively. The average decrease in LVEDV between the two time points was 27%. The relative variation of the other parameters as compared to LVEDV is shown in the Table. The best correlation was shown between LVEDV:IJVCSA and LVEDV:IJVAP ($p = 0.01$), while the lowest correlation was between PPV% and LVEDV.

Table 1

Correlation Coefficient between LVEDV and Measured Variables						
	IJV AP	IJV Lat	IJV CSA	CVP	PAD	PPV%
LVEDV	R=0.72 (p=0.01)	R=0.51 (p=0.12)	R= 0.76 (p=0.01)	R=0.72 (p=0.02)	R=0.42 (p=0.19)	R= 0.01 (p=0.98)

To test the reliability of IJV image acquisitions we used the intra-class correlation coefficient (ICC) as a measure of intra-rater reliability. This test was performed on a separate study group of 10 healthy volunteers in whom the IJV was imaged and measured 3 consecutive times. The interclass correlation coefficient between the investigator's images was 0.94 (95%CI: 0.84 to 0.98).

Discussion: The data confirm our hypothesis that the sonographic measurement of the IJV correlates with the gold standard for volume assessment, LVEDV, as well as other parameters such as CVP. This preliminary study offers insight into the possibility of using ultrasound as a non-invasive, inexpensive, and user-friendly tool to reliably identify changes in the volume status of surgical patients. It appears to be as accurate, if not more accurate, than some other more invasive measures of volume status (CVP, PAD). In contrast the PPV% had the least correlation with LVEDV and was prone to much artifact from arrhythmias, which are frequently seen in the cardiac surgical population. In conclusion, these preliminary results show that IJV CSA and AP diameter can be reliably used to track changes in volume status in patients undergoing general anesthesia.

References:

1. Donahue S, Wood J, Patel B, Quinn J. Correlation of sonographic measurements of the internal jugular vein with central venous pressure. *Amer J of Emergency Med* 2009; 27: 851-855.
2. Preisman S, Kogan S, Berkenstadt H, and Perelz A. Predicting fluid responsiveness in patients undergoing cardiac surgery: functional haemodynamic parameters including the Respiratory Systolic Variation Test and static preload indicators. *British Journal of Anaesthesia* 2005; 95(6): 746–55.
3. Bland JM, and Altman DG. Statistics notes: Calculating correlation coefficients with repeated observations: Part 1-correlation within subjects. *BMJ* 1995; **310** (6977): 446.