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The sensitivity and specificity of ultrasound estimation of central venous pressure using the internal jugular vein☆

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Abstract

Purpose: The fluid volume status of a patient is difficult to assess clinically. The aim of this study was to compare the ultrasound estimation of the height of the right internal jugular vein (CVP_{IJV}) with direct estimation of central venous pressure (CVP) (CVP_{CVC}).

Materials and Methods: A portable ultrasound machine defined the "top" of the right internal jugular vein in 44 patients from a single tertiary hospital. The vertical height from this point to the sternal angle was used to estimate CVP_{IJV}. A central venous catheter was then inserted and direct measurement of CVP was made with a pressure transducer. A normal CVP was defined as 3 to 6 mm Hg.

Results: For overloaded patients, CVP_{IJV} correlated well with CVP_{CVC}, $P = .004$, sensitivity of 64.3%, specificity of 81.3%, and positive predictive value of 85.7%. The area under the curve for the receiver operating characteristic curve was 0.73 (95% confidence interval, 0.59-0.86). For undervolumed patients, the correlation remained statistically significant, $P < .001$, sensitivity of 88.9%, specificity of 77.1%, and negative predictive value of 96.4%. The area under the curve was 0.83 (95% confidence interval, 0.70-0.96).

Conclusion: Ultrasound estimation of CVP using a portable ultrasound machine and the internal jugular vein is simple, noninvasive, and accurate.

1. Introduction

Estimation of the central venous pressure (CVP) has been frequently used in clinical practice to assess volume status and cardiac preload [1,2]. Knowledge of the CVP has been helpful in the diagnosis and management of a variety of critical illnesses including acute kidney injury, trauma, burns, sepsis, heart failure, shock, and others [1,3].

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Sir Thomas Lewis [1] first described traditional noninvasive estimation of the CVP by measuring the height of the column of blood in the internal jugular veins (IJVs). Limitations of the physical examination in estimating volume status and CVP have been demonstrated to result in a lack of precision and accuracy, especially in the obese and elderly populations [4-6]. Invasive measurement of the CVP via a central venous catheter (CVC) is still the criterion standard.

Some of the limitation in physical examination of the IJVs is due to uncertainty of the true "top" of the venous pulsation. Estimation of the height of the IJV using a portable ultrasound, which allows visualization of the IJV lumen, has been described but has not been well validated [7]. We performed a prospective assessment of the height of the right IJV using portable ultrasonography with the aim of comparing its accuracy with CVP measurement via a CVC.

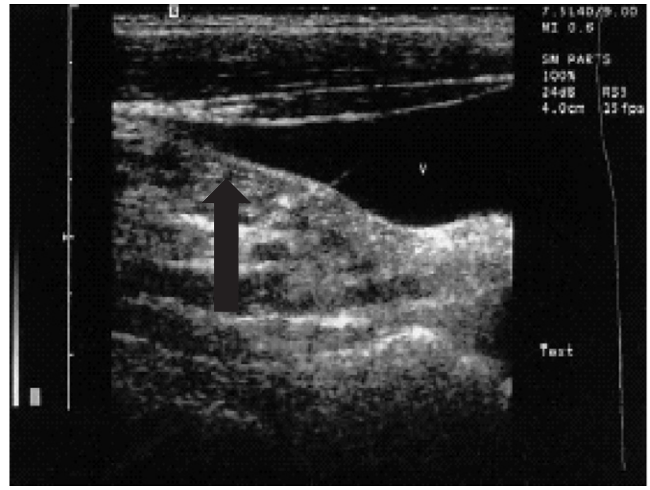

Fig. 1 Longitudinal view of the IJV showing the tapering portion (arrow) of the vein (V).

2. Materials and methods

This study was performed at Sir Charles Gairdner Hospital, in Perth, Australia. In this institution, the insertion of most CVCs for ward patients was performed by the department of anesthetics, in the postoperative recovery room. The investigators were advised on an ad hoc basis of CVC insertions that were being performed for clinical reasons, and patients were subsequently approached for consent into this study. Patients were excluded if they were younger than 18 years; currently undergoing invasive or noninvasive ventilation; had tricuspid regurgitation, pulmonary hypertension, and actively changing fluid status (eg, active bleeding and aggressive fluid resuscitation); and were unable to hold their breath or unable to visualize the right IJV with an ultrasound. The local human research and ethics committee approved this study.

Ultrasound estimation of the height of the right IJV was done by identifying the "top" of the "a" wave of the venous pulsation when the patient was lying at 45°, on both longitudinal and transverse views (Figs. 1 and 2), using a Site-Rite 3 (Bard Access Systems, Salt Lake City, Utah) ultrasound machine with a 7.5-mHz probe [8]. The height of the IJV was measured by the vertical distance between the "top" of the jugular venous pulse and the sternal angle, with the patient holding their breath at the end of expiration. Minimal pressure was applied with the ultrasound probe to ensure that it did not directly result in venous occlusion. The average of 3 measurements was used as the height of the IJV. The CVP was estimated by the addition of 5 cm to the measured height of the IJV (CVP_{IJV}) [9].

A CVC was inserted under guidance of real-time ultrasound. A direct measurement of the CVP was made after the CVC position was checked with a chest radiograph, and the transducer zeroed to the level of the heart. The CVP values obtained via a pressure transducer (CVP_{CVC}) were converted from millimeters of mercury to centimeters of water (1 mm Hg = 1.36 cm H_2O). The patients were then divided into 2 groups, firstly dependent upon whether they were volume depleted, then dependent on whether they were volume overloaded. The classification was based on the assumption that the normal jugular venous pressure (JVP) is a vertical height of 0 to 3 cm above the sternal angle, which corresponds to a CVP of 3 to 6 mm Hg (or 5-8 cm H_2O) [1,10]. All measurements were performed by 1 of 2 investigators AH or BS.

Correlation of ultrasound-estimated CVP (CVP_{IJV}) with CVC-estimated CVP (CVP_{CVC}) was assessed using Spearman rank correlation. χ^2 analysis assessed the 2-by-2 contingency tables constructed, and the specificities, sensitivities, and predictive values were calculated based on the available data. A receiver operating characteristic (ROC)

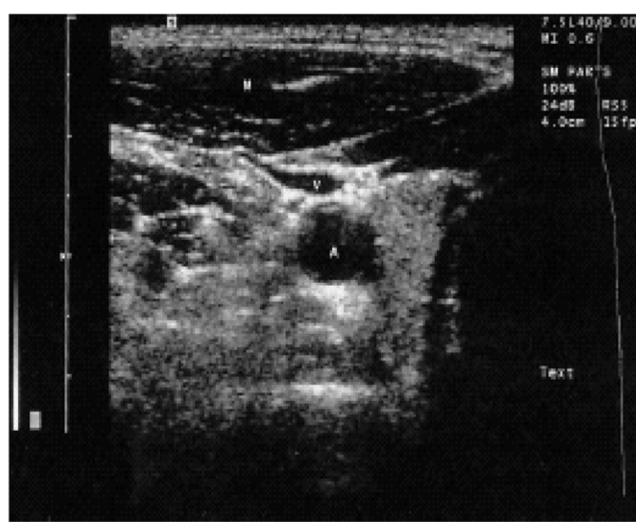

Fig. 2 Transverse view of the collapsed IJV (V), which corresponds to the tapering portion of the vein seen on the longitudinal axis. A indicates internal carotid artery; M, sternocleidomastoid muscle.