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● *Clinical Note*

RESPIRATORY VARIATION IN FEMORAL VEIN DIAMETER HAS MODERATE ACCURACY AS A MARKER OF FLUID RESPONSIVITY IN MECHANICALLY VENTILATED SEPTIC SHOCK PATIENTS

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Abstract—Ultrasound (US) is considered the first step in evaluation of patients with shock; respiratory variation of the inferior vena cava (inferior vena cava collapsibility [IVCc]) is an important measurement in this scenario that can be impaired by patient condition or technical skills. The main objective of this study was to evaluate if respiratory variation of the femoral vein (femoral vein collapsibility [FVc]), which is easier to visualize, can adequately predict fluid responsiveness in septic shock patients. Forty-five mechanically ventilated septic shock patients in a mixed clinical–surgical, 30-bed intensive care unit were enrolled in this study. All patients underwent assessments of FVc, IVCc and cardiac output using a portable US device. The passive leg raising test was used to evaluate fluid responsiveness. FVc presented an area under the receiver operating characteristic curve of 0.678 (95% confidence interval: 0.519–0.837, $p = 0.044$) with a cutoff point of 17%, yielding a sensitivity of 62% and specificity of 65% in predicting fluid responsiveness. IVCc had greater diagnostic accuracy compared with FVc, with an area under the receiver operating characteristic curve of 0.733 (95% confidence interval: 0.563–0.903, $p = 0.024$) and a cutoff point of 29%, yielding a sensitivity of 47% and specificity of 86%. In conclusion, FVc has moderate accuracy when employed as an indicator of fluid responsiveness in spontaneously mechanically ventilated septic shock patients. (E-mail: wagnernedel@uol.com.br) © 2017 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Fluid responsivity, Septic shock, Mechanical ventilation, Inferior vena cava collapsibility, Femoral vein collapsibility.**

INTRODUCTION

Decisions regarding volume expansion are challenging but frequently required in critically ill patients (Muller et al. 2012). Treatment of hypovolemia requires prompt fluid infusion, but excessive fluid loading can induce peripheral and pulmonary edema and compromise microvascular perfusion and oxygen delivery (Ferguson et al. 2002; Wang et al. 1992). Hemodynamic monitoring techniques can be used to help determine appropriate therapeutic interventions and evaluate a patient's response to therapy (Cecconi et al. 2014).

Respiratory variation in inferior vena cava (IVC) diameter has been investigated extensively for its usefulness in the evaluation of volume status, with excellent accuracy in the first studies exploring this measurement (Barbier et al. 2004; Feissel et al. 2004). Zhang et al. (2014) performed a systematic review and meta-analysis and presented an adequate pooled diagnostic odds ratio and diagnostic performance-to-fluid-responsiveness prediction. Despite its potential advantages, visualization of the sonographic inferior vena cava collapsibility index (IVCc) can be impaired by various factors, such as abdominal distension, bowel gas overlying the IVC, overlying tissue edema, complex abdominal wounds, masses causing external compression, elevated intra-abdominal pressure and morbid obesity, thus limiting its use in a great number of patients (Stawicki et al. 2009).

The main objective of this study was to evaluate if respiratory variation of the femoral vein (femoral vein collapsibility [FVc]), a proposed technique in a vein peripheral to the IVC with easier visualization and with fewer technical limitations, could adequately predict fluid responsiveness in mechanically ventilated (MV), critically ill patients.

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METHODS

In a prospective, observational study, we studied 45 consecutive MV patients with a diagnosis of septic shock (according to the Surviving Sepsis Campaign 2012 criteria [Dellinger et al. 2013]) for whom a fluid response test was indicated by an attending physician. Exclusion criteria included age <18 y; ventilatory asynchrony during the procedure or intense respiratory effort with accessory respiratory muscle use; pregnancy; femoral deep venous thrombosis; ascites or intra-abdominal mass; enrollment in palliative care; known aortic or pulmonary disease, ascending aortic aneurysm and acute or chronic cor pulmonale; contra-indication to the passive leg raising (PLR) test for any reason; and presence of a difficult acoustic window that resulted in an inability to obtain interpretable ultrasound images. The main clinical characteristics of our study population are summarized in Table 1. This study was approved by the local ethics committee under Study Registration No. 50559115.2.0000.5530, and written informed consent was obtained from the patients' next of kin.

All patients in this study underwent serial assessment of their FV, IVC and cardiac output (CO) with a portable ultrasound device (M Turb by Sonosite Fuji Film, Bothell, WA, USA). Measurement of cardiac output and IVC diameter has been outlined in detail elsewhere (Feissel et al. 2004; Seif et al. 2012). The first step in FV diameter measurement was visualization of a cross-sectional, B-mode window of the short-axis view of the vessel with a high-frequency linear array transducer. After the target vein was localized (just above the great saphenous junction), the dynamic diameter change was recorded over time using the M-mode setting to identify and measure the minimum and maximum FV diameter over a respiratory cycle. FV diameter variation was calculated as the difference between the maximum and minimum FV diameter values; two separate measurements were taken and averaged, and the result was expressed as a percentage. A 2-D echographic sector was used to visualize the IVC (sub-xyphoidal, long-axis view), and its M-mode cursor was used to generate a time–motion record of the IVC diameter approximately 3 cm from the right atrium. IVC diameter variation was calculated as the difference between the maximum and minimum IVC diameter values; two separate measurements were taken and averaged, and the result was expressed as a percentage. CO was evaluated using echocardiography by measuring the diameter of the left ventricular outflow tract just below the aortic orifice and the velocity time integral of the aortic blood flow during end-expiration, as previously described (Feissel et al. 2001).

Table 1. Characteristics of patients

Variable	Median (IQR)
Age (y)	64 (25.0)
Male sex (%)	44
Simplified acute physiology score III (points)	68 (13.2)
Body mass index (kg/m^2)	21.9 (9.0)
Intra-abdominal pressure (mm Hg)	8.4 (6)
Noradrenalin dosing (μg/kg/min)	0.14 (0.07)
Mean arterial pressure (mm Hg)	
Pre	80 (19.5)
Post	83.6 (24.3)
Heart rate (beats/min)	
Pre	96 (31)
Post	97 (32)
Cardiac index (L/min/m^2)	
Pre	2.19 (1.46)
Post	2.63 (1.81)
Positive end-expiratory pressure (cm H_2O)	7 (2.0)

IQR = interquartile range.

After the first panel of measurements (IVCc, FVc and CO), a PLR maneuver was performed using proper methodology as previously described (Monnet and Teboul 2015; Thiel et al. 2009). If the PLR suggested fluid responsivity, a second CO measurement and a fluid challenge were performed, but only one measurement of FVc was performed in each patient for study purposes. An increase of 10% in the CO after the PLR maneuver was considered to be a positive fluid responsiveness test.

All patients were MV in the assisted mode (pressure support ventilation) with a tidal volume between 6 to 8 mL/kg and were well adapted to mechanical ventilation without ventilatory asynchrony. Two sets of measurements (mean arterial pressure and heart rate) were performed: the first before volume expansion and the second immediately after the PLR maneuver. Ventilatory settings and vasopressor dosing were held constant throughout the study, and an intra-abdominal pressure measurement was performed posteriorly by intravesicular pressure, as described by existing guidelines (Malbrain et al. 2006).

The primary objective was to evaluate if FVc could predict fluid responsiveness and determine its diagnostic accuracy. Secondary objectives were to evaluate IVCc accuracy as a fluid responsiveness marker in this clinical scenario and to determine if there was agreement between the FVc and IVCc measurements.

Results were expressed as the mean ± standard deviation or median ± interquartile range, according to the presence of a normal distribution, as determined by the Kolmogorov–Smirnov test. Assuming that a 10% change in CO was required for clinical significance post-PLR test (Thiel et al. 2009), patients were separated into responders and non-responders. Agreement between IVCc and FVc was assessed using a paired Student *t*-test. A p value < 0.05 was considered to indicate statistical significance. Continuous variables were tested with the Mann–Whitney or Student *t*-test, according to the absence or presence of a normal distribution, respectively.