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Iliac venous pressure estimates central venous pressure after laparotomy

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ABSTRACT

Background: Central venous pressure (CVP) is traditionally obtained through subclavian or internal jugular central catheters; however, many patients who could benefit from CVP monitoring have only femoral lines. The accuracy of illiac venous pressure (IVP) as a measure of CVP is unknown, particularly following laparotomy.

Methods: This was a prospective, observational study. Patients who had both internal jugular or subclavian lines and femoral lines already in place were eligible for the study. Pressure measurements were taken from both lines in addition to measurement of bladder pressure, mean arterial pressure, and peak airway pressure. Data were evaluated using paired *t*-test, Bland-Altman analysis, and linear regression.

Results: Measurements were obtained from 40 patients, 26 of which had laparotomy. The mean difference between measurements was 2.2 mm Hg. There were no significant differences between patients who had laparotomy and nonsurgical patients ($P = 0.93$). Bland-Altman analysis revealed a bias of 1.63 ± 2.44 mm Hg. There was no correlation between IVP accuracy and bladder pressure, mean arterial pressure, or peak airway pressure.

Conclusions: IVP is an adequate measure of CVP, even in surgical patients who have had recent laparotomy. Measurement of IVP to guide resuscitation is encouraged in patients who have only femoral venous catheter access.

1. Introduction

Central venous pressure (CVP) is a frequently used clinical parameter for critically ill patients. When used in the appropriate clinical context, CVP is useful in guiding resuscitation and therapy in shock [1–3]. The most common approach to CVP measurement is by central venous catheterization via internal jugular (IJ) or subclavian (SC) venous catheters, with CVP measured in the superior vena cava. However, some patients, especially those who have emergent central line placement, have only femoral venous catheters in place. Central venous catheterization through the femoral vein is technically easier than superior approaches, safe, and reliable for administration of fluids [4]. As a result, placement of a femoral catheter is standard for venous access in acute trauma resuscitation and resuscitation of burn patients [5,6]. Despite the frequency in which femoral lines are placed in acute resuscitation, the use of pressure measurements from femoral-placed lines positioned in the external or common iliac is not routinely performed.

A limited number of studies have evaluated the use of iliac venous pressure (IVP) measured from femoral lines as

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a measure of CVP in preclinical and clinical models and demonstrated no significant difference in the pressure measurements [7–20]. However, no studies have evaluated IVPs measured from femoral lines after laparotomy. This study aims to compare IVP measured from a femoral line to CVP in patients after abdominal surgery to determine if IVP is an adequate measure of CVP. Additionally, we will examine the influence of abdominal compartment pressure on IVP measurements.

2. Methods

This was a prospective, observational study approved by the University of Pittsburgh Institutional Review Board (PRO 11020017). Patients were consented and included in the study under two circumstances: (1) if they had both IJ or SC lines and femoral lines already in place for clinical indications or (2) they had a femoral line in place that was being removed and immediately replaced with an IJ or SC line. The type of catheter in each location (introducer or multilumen catheter) was documented at the time of enrollment. Pressure measurements from both lines were taken for comparison. Measurement of bladder pressure, mean arterial pressure, and peak airway pressure if the patient was on the ventilator was also recorded to analyze for the impact these measurements may have on IVP and the correlation with CVP. For trauma patients, the injury pattern was recorded with particular attention paid to abdominal injuries such as pelvic fractures or retroperitoneal hematomas, which may influence IVP measurements. Data were evaluated using paired *t*-test, Bland-Altman analysis [21], and linear correlation.

3. Results

Measurements were obtained from 40 patients, 26 of which had laparotomy during their admission. All patients were admitted to the trauma or general surgery services. Patient demographics and mechanism of injury are listed in Table 1. Femoral introducers were most commonly used (55%), whereas a multilumen catheter was more commonly used in the IJ or SC. CVP ranged from 3 to 24 with a mean of 12.7 mm Hg. The mean absolute difference between measurements for all patients was 2.2 mm Hg (Table 2). Ninety-five percent of patients had a measurement difference of $\leq$5 mm Hg. The mean absolute difference between CVP and IVP for patients who underwent laparotomy was 2.2 mm Hg. When comparing patients who had laparotomy to the nonsurgical group, there was no significant difference in the CVP and IVP measurements ($P = 0.93$). A Bland-Altman analysis was performed to assess for agreement between the two measurements for all patients, revealing a bias of 1.63 ± 2.44 mm Hg (Fig. A). The 95% limits of agreement ranged from -3.2 to 6.4 mm Hg. There were no trends in CVP and IVP differences throughout the wide range of CVP measurements, as demonstrated by the flat slope of the curve. When analyzing Bland-Altman plot for only patients who underwent laparotomy, the bias was 1.77 ± 2.44 mm Hg, with the 95% limits of agreement ranging from -3.0 to 6.5 mm Hg (Fig. B).

Table 1 – Patient demographics and injuries.

Patient Characteristics	Laparotomy, $n = 26$	Nonsurgical, $n = 14$
Age (y)		
Median	55.5	60.5
Gender, *n* (%)		
Male	20 (77)	10 (71)
Female	6 (23)	4 (29)
Trauma, *n* (%)	16 (61)	10 (71)
MVC	5 (31)	5 (50)
GSW	8 (50)	0 (0)
Fall	1 (6)	4 (40)
MV *versus* Ped	2 (13)	0 (0)
Hanging	0 (0)	1 (10)
Wound vac used	17 (65)	
Operation		
Exploration alone	5	
Pericardial window	3	
Small bowel resection	5	
Colectomy	6	
Splenectomy	2	
Repair bleeding vessel	1	
Nephrectomy	3	
Repair gastrotomy	1	
Repair perforated ulcer	2	
Adrenalectomy	1	
Cholecystectomy	2	
Bladder repair	2	
Hepatorrhaphy	4	
Hepatic lobectomy	1	

GSW = gunshot wound; MVC = motor vehicle crash; MV *versus* Ped = motor vehicle *versus* pedestrian.

A significant number of trauma and acute care general surgery patients have a temporary wound vacuum abdominal closure placed after damage control laparotomy. At our institution, we use the ABThera wound vac system or the standard vac abdominal dressing wound vac (KCI, San Antonio, Tx) at 125 mm Hg suction. We also analyzed pressure measurements in 17 patients who underwent laparotomy and had their fascia left open with temporary wound vac closures (Table 3). The mean difference for patients with a temporary wound vac closure was 2.4 mm Hg. There was no difference between mean CVP and IVP difference in patients who had fascial closure and patients with a wound vac ($P = 0.52$). Ninety-five percent of patients with a wound vac in place had a CVP and IVP difference of <5 mm Hg.

We next analyzed the influence of additional variables, including catheter type, injury pattern, and abdominal and airway pressures on CVP and IVP measurements. The type of catheter (introducer *versus* multilumen) had no influence on the CVP, IVP measurement, or the CVP and IVP correlation. Three patients had pelvic fractures and four had retroperitoneal hematomas that did not influence CVP, IVP measurement, or the CVP and IVP correlation. Abdominal and airway pressures were plotted and linear regression analysis was performed to identify correlations between pressure measurements. Abdominal compartment pressures, measured by bladder pressure, had no correlation on IVP or the CVP and IVP difference for both the nonsurgical and laparotomy groups. There was also no correlation