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Original Research Article

Correlation Between Internal Jugular Vein/Common Carotid Artery Ratio And Central Venous Pressure

Internal Juguler Ven/Karotis Arter Oranının Santral Venöz Basınç ile İlişkisi

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ABSTRACT

Aim: *The aim of this study was to evaluate a rapid and non-invasive method for estimating central venous pressure (CVP) by comparing ultrasound measurements of the internal jugular vein and common carotid artery to CVP measured by central venous catheter.*

Materials and Method: *A portable ultrasound machine was used to determine cross-sectional areas of the internal jugular veins (IJV) and common carotid arteries (CCA). The measurements were performed on patients lying in the supine position at a 45 degree angle, with ratios of the IJV area to CCA area recorded as ratio 1(lying position) and ratio 2(45˚ position). The patients were categorized into 3 groups according to CVP, specifically; group1: CVP<10mmHg, group2: CVP 10-20mmHg, and group3: CVP>20mmHg.*

Results: *Forty intensive care unit patients who were mechanically ventilated with a central venous catheter in place were enrolled during the study period. No statistically significant differences detected in ratio 1. Ratio 2 showed a mean ratio of 1.18 for group 1(min-max 0.72-1.64), 2.64 for group 2 (min-max 1.73-3.55) and 3.00 for group 3 (min-max 0.97-5.03). For ratio 2, it was observed that group 1 had a lower value than group 2 (p=0.020) and group 3 (p=0.021).*

Conclusions: *Ultrasound measurement of internal jugular to common carotid area ratio at a position of 45 degrees showed that a low ratio was correlated with a low central venous pressure as measured by central venous catheter.*

Keywords: *ultrasound; central venous pressure; non invasive; intensive care*

ÖZET

Amaç: *Çalışmanın amacı santral venöz basıncı (SVB) karotis arter ve internal juguler venin ultrason ölçümlerini santral venöz kateter yoluyla ölçülmüş SVB ile karşılaştırarak hızlı ve non invaziv bir yöntemle değerlendirmek.*

Yöntem ve Gereçler: *Ultrason ile internal juguler ven (IJV) ve karotis arterin (KA) alan ölçümleri yapıldı, oranları hesaplandı. Ölçümler hastalar supin ve 45º yatar pozisyondayken yapıldı ve ölçüm sonuçları supin pozisyonda yatanlar için 'oran1' ve 45º yatar pozisyon için 'oran2' olarak kaydedildi. Hastalar SVB değerlerine göre üç gruba ayrıldı : Grup 1 : SVB < 10 mmHg, Grup 2 SVB 10-20 mmHg, Grup 3: SVB > 20 mmHg.*

Sonuç: *Çalışmaya çalışma sürecinde yoğun bakım ünitesinde yatmakta olan , invaziv mekanik ventilatörde takipli santral venöz kateteri olan 40 hasta dahil edildi. Oran1'de gruplar arası anlamlı fark tespit edilmedi. Oran2 'de grup 1'de ortalama 1.18 (min-max 0.72-1.64), grup 2'de 2.64 (min-max 1.73-3.55) ve grup 3'de 3.00 (min-max 0.97-5.03) izlendi. Oran2'nin grup 1'de grup 2 ve 3'e göre daha anlamlı olduğu izlendi.*

Tartışma: *45º yatar pozisyonda yapılan ultrason ölçümleriyle elde edilen İJV/KA oranının (oran2) santral venöz basıncı düşük ölçülmüş hasta grubunda (grup1) korelasyonunun daha iyi olduğu tespit edildi.*

Anahtar Kelimeler: *ultrason; santral venöz basınç; noninvaziv; yoğun bakım*

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INTRODUCTION

Nearly 80 years ago, Sir Thomas Lewis first described a technique for estimating central venous pressure (CVP) by measuring the height of jugular veins (1). Central venous pressure (CVP) can be an important parameter for estimating the fluid status of critically ill patients in the emergency department (ED) or intensive care unit (ICU). Estimation of CVP can help identify low preload conditions where early fluid resuscitation can improve outcome including sepsis, trauma, shock; also can identify high preload in patients suffering from congestive cardiac failure or other fluid overload conditions. Measuring CVP via central venous catheter (CVC) is the gold standard technique but placement of a central venous catheter is invasive and may result in iatrogenic complications.

Using bedside ultrasound to augment the physical examination has increased in recent years as it is non-invasive, rapid, and readily performed at the bedside. Ultrasound training is included in emergency medicine training programs, often with a focus on trauma assessment, focused echocardiography, pulmonary assessment, procedural guidance (2, 3). Fast and reliable measurement of central venous pressure noninvasively is of paramount importance in cases of emergency medicine or critical care practice. Ultrasound can provide a noninvasive estimation of central venous pressure. Many research papers use collapsibility of the inferior vena cava (IVC) as an initial tool for early detection of hypovolemic shock or as an indicator of acute blood or volume loss exclude intubated patients (4-7). May be correlation of internal jugular vein/common carotid artery ratio more accurately reflects CVP value in critical patients.

The aim of this study was to evaluate the accuracy of a non-invasive, rapid, ultrasound guided method for estimating intravascular fluid status by comparing the ratio of measurements of internal jugular vein (IJV) and common carotid artery (CCA) area to invasively determined CVP.

METHODS

This was a prospective study and approved by the local ethical committee. Patients hospitalized in University Faculty of Medicine Intensive Care Unit (ICU) during a 6 months period were enrolled in the study on a convenience basis. Eligible patients were had CVP monitoring via central venous catheter measurements and were mechanically ventilated. Reasons for ICU admission included conditions such as malignancy, congestive heart failure, acute coronary syndrome, chronic obstructive pulmonary disease, pneumonia, sepsis, renal failure, stroke, trauma and venous thromboembolism. Patients with infectious neck lesions or prior history of neck surgery were excluded.

Patient demographic features (age, sex), weight, hemodynamic parameters (blood pressure, heart rate) and APACHE scores were recorded before measurements.

A portable ultrasound machine, the M7 Diagnostic Ultrasound System (Mindray, Shenzen, China) with a 7 MHz linear probe was used for comparing measurements of IJV and CCA area. Measurements were performed with patients in a supine position and lying at an angle of 45˚. The data was recorded as ratio 1 (lying position) and ratio 2 (45˚ position) respectively. Positive pressure ventilation was interrupted briefly and end expiratory diameter area values were measured. The ultrasound probe was placed 2 cm above the clavicle on the opposite side of the central venous catheter. In order to prevent vein compression resulting in underestimation of IJV area, the, amount of pressure applied to skin was investigated by coordinating daily practice and reviewing studies measuring IJV–CVP correlation (8, 9). We determined that the most appropriate way to avoid compressing the vein was to inspect subcutaneous tissues during compression. Measurements were performed using the ‘area measurement’ option on the ultrasound device and images were recorded on the device.

CVP was measured via CVC by ICU physicians, within an hour of ultrasound measurements and blinded to the ultrasound results. Physicians performing ultrasound exams were also blinded to CVP measurements.

The patients were categorized into 3 groups according to CVP, group 1: CVP <10 mmHg (n=19) , group 2: CVP 10-20 mmHg (n=14), and group 3: CVP >20 mmHg (n=7).

Sonographic measures were performed by a single emergency physician to avoid interobserver variability. This emergency physician had undergone a 40 hour ultrasound training course and performed at least 4 vascular imaging studies per week. This study was planned and performed as a double blind study. Ultrasound and CVP measurements were performed close to each other to prevent variability in the hemodynamic states of patients during CVP and sonographic measurements.

To prevent differences during both CVP and sonographic measures, positive pressure was interrupted temporarily in patients who were ventilated in PEEP mode.

Statistical analysis was done using SPSS 16.0 (IBM, Armonk, New York, United States). One way ANOVA followed by Tukey and Bonferroni multiple comparison tests were used to determine the significance of the differences between groups. ANOVA and Student's t test were used to investigate the significance of differences observed between group pairs.

RESULTS

Forty patients were enrolled in the study that were admitted to the intensive care unit during the study period and mechanically ventilated with central venous catheters in place.

Out of the 40 patients with central venous catheters, 65 percent were subclavian, 22.5 percent were jugular, and 12.5 percent were femoral catheters. 60 percent of patients were male. The mean age was 65.10±18.70 years.

The reasons for being admitted to intensive care unit was are shown in Table 1.

Malignancy detected as most common disease (n=13) in 40 patients. Cardiac disorders (n=12), Chronic Obstructive Pulmonary Disease (COPD)-pneumonia (n=8) were other common disorders. Some patients had multiple diseases.

Mean arterial blood pressure was 86.80±20.40 mmHg; mean heart rate was 90.77±12.57 beats/minute.

In the evaluation of all cases mean APACHE score was 17.59±7.4.

Mean CVP values for the three groups were: 3.71±2.42mmHg for group 1 (n=19), 14.67±2.67mmHg for group 2 (n=14), and 26.43±5.38mmHg for group 3 (n=7).

Distribution of hemodynamic values, APACHE scores, age, sex, and weight by group are shown in Table 2. There was no statistically significant difference between these groups.

The correlation between the ratio of IJV: CCA sonographic area measurements were evaluated through CVP groups based on ratio 1 and ratio 2. For ratio 1 the mean ratio was 2.26 for group 1 (min-max 1.53-2.99), 3.18 for group 2 (min-max 2.30-4.05), and 2.87 for group 3 (min-max 2.32-3.44) with no statistically significant differences. For ratio 2 the mean value was 1.18 for group 1 (min-max 0.72-1.64), 2.64 for group 2 (min-max 1.73-3.55), and 3.00 for group 3 (min-max 0.97-5.03). For ratio 2, group 1 had a lower value than group 2 (p=0.020) and group 3 (p=0.021). No significant differences were observed between groups 2 and 3 (Table 3). There was no statistically significant difference between groups in relation with three different types of CVCs (subclavian, jugular, and femoral) were used.

In group 1, the evaluation of ratio 1 and ratio 2 values showed that they were significantly lower as compared to the other groups (f (2,37)=4,454, p=0,018).

Correlation Coefficient (r) evaluated of the groups, the r values were determined as; group 1: -0.241, group 2: -0.078 and group 3: 0.420. As this results suggest, the most meaningful relationship of ratio 1 and ratio 2 was observed in group 3. However, there was no significant differences between them.

Table 1. The number of the patient's diagnosis.

Diagnosis	No (n=)
Malignancy	13
CHF£, Acute coronary syndrome	12
COPD¥, Pneumonia,	8
Sepsis	7
Renal failure	4
Stroke	4
Trauma	3
Pulmonary thromboembolism	2

£CHF: Congestive Heart Failure
¥COPD: Chronic Obstructive Pulmonary Disease

Table 2. Distribution of hemodynamic values, APACHE scores, age, sex, weight data's into the groups.

	Group 1	Group 2	Group 3
Age	64.74±21.72	66.82±9.45	69.14±13.51
Sex (m/f) %	57.9/42.1	64.3/37.7	57.1/42.9
Weight (kg)	72.21±21.31	76.45±15.08	78.57±35.67
BP MAP(mmHg)	86.93±16.57	76.80±21.90	96.66±25.10
Pulse(beats/min)	87.95±13.95	96.08±8.32	88.86±14.51
APACHE	14.79±7.3	22.55±6.5	19.43±6.7

Table 3. IJV/CCA area ratio in the groups in supine and 45˚ lying position.

	Ratio 1		Ratio 2	
	Mean	**Minimum-maximum**	**Mean**	**Minimum-maximum**
Group 1	2.26	1.53-2.99	1.18£	0.72-1.64
Group 2	3.18	2.30-4.05	2.64	1.73-3.55
Group 3	2.87	2.32-3.44	3.01	0.97-5.03

£ p =0.020 between group 1 and group 2; p=0.021 between group 1 and group 3 in ratio 2.

DISCUSSION

There are a great number of studies in the literature which describe the use of ultrasound to estimate CVP. These studies showed positive correlation but did not establish a normal range using a standardized measuring method. Inferior vena cava and internal jugular vein have been used to evaluate volume status in prior studies; however these studies have not compared these veins in order to identify the optimal vessel. In 1999, Lipton et al. first described the measurement of IJV for determining CVP and claimed that 'bedside US of the IJV, performed by emergency physicians, provides immediate and important information' (8). IJV diameter measurements have been shown to correlate with CVP: if anteroposterior diameter is between 5.7-8.3mm CVP is less then 10mmHg, if diameter is between 11.2-13.8 mm CVP is greater than 10 cm H_2O (9). Ultrasound estimation of central venous pressure by IJV diameter was determined to be 64.3% sensitive and 81.3% specific for high CVP and 88.9% sensitive and 77% specific for low CVP (10). Accuracy of these results may be hindered because of the variable diameter results depending on the amount of pressure applied. An observational clinical study performed by Raksamani et al. (11) described a correlation between cross-sectional area of the internal jugular vein and central venous pressure in January 2014. Based on this literature review we believe there is still not an optimal ultrasound measurement technique for the IJV. In 2012 a pilot study used internal juguler vein/ common carotid artery ratio in 8 pediatric burn patients to estimate CVP (12).

In previous studies, researchers have encountered problems in diameter measurements due to the collapsibility of vessels. Specifically, interobserver and intraobserver differences were high (8-10). Using area measurement rather than diameter may provide more accurate and valid results. In our study we compared central line CVP measurements with IJV: CCA area ratio in 40 adult patients. We measured IJV: CCA ratios in both supine and in a 45˚ lying position, allowing us to analyze the relation between position and IJV diameter-area. All patients were mechanically ventilated allowing us to avoid fluctuations in diameter during expiration and inspiration. During the measurements, mechanical ventilation support to the patients was never interrupted under any circumstances. Considering the potential fluctuations in the measurements with the effect of the positive pressure (PEEP), in mechanical ventilators the measurements were taken in durations of 10 seconds between each PEEP application.

In the evaluation of correlation of area to CVP measurements, we observed that measurements in the 45˚ lying position showed the most significant correlation. Although this correlation increased proportionally to the increase in CVP ratio, the obtained values were more significant in the normal CVP range. Further investigations are necessary for analyzing the significant area ratio relation to CVP values.

In conclusion, ultrasound measurements of internal jugular vein to common carotid artery area at a position of 45 degrees were significantly correlated with low central venous pressure as measured by central venous catheter.

Limitations of this study are being intensive care patients, and a small number of patients in each disease group. A correlation between ratios, CVP and kind of disease would be searched if more patients would be in group of each disease.

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