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Original Article

The efficacy of inferior vena cava diameters and the jugular vein in assessing fluid resuscitation

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Abstract

Objective: Fluid resuscitation is necessary in almost all critical patients. The central venous pressure (CVP) is a well-established method of assessing resuscitation. Recently, there have been attempts to investigate less invasive methods like the diameters of inferior vena cava (IVC) or the jugular vein. We aimed to investigate this method in our research.

Methods: Seventy eight critical patients admitted to the emergency department from April 2018 to December 2018 were studied. The CVP was measured along with the diameters of the two mentioned veins before and during resuscitation. The urinary output was also recorded after administering the fluid. The minimum p-value that would illustrate a significant association was equal to 0.05.

Results: Findings showed that 53.8% of patients were males and 46.2% were females with an average age of 71.48 years. The causes of the critical state were 25.6% hemorrhagic shocks, 30.8% septic shocks and 43.6% hypovolemic shocks. The mean diameter of the jugular vein before and during resuscitation was 27.21 mm and 25.38 mm, respectively ($P=0.1$). The mean of IVC diameter before and during resuscitation was 63.33 mm and 57.98 mm, respectively ($P<0.001$). The CVP was 4.23 mmHg before resuscitation and 5.61 mmHg after resuscitation ($P<0.001$). With an average urine output of 201.28 cc, a significant correlation was observed with the increase in the CVP, while no such correlations were observed with the decreasing state of the diameters of the IVC or the jugular vein.

Conclusion: Both the IVC diameter and the jugular vein diameter are unable to assess fluid resuscitation independently from respiratory factors.

Keywords: Inferior vena cava, Jugular vein, Central venous pressure, Fluid resuscitation, Emergency medicine

Introduction

The replenishing of the fluids of the body which are lost through various processes is called fluid resuscitation in the medical practice. In most of the cases of septic or hypovolemic shocks, fluid resuscitation is necessity (1-3). Crystalloid and colloid solutions are utilized for fluid resuscitation (4). Although the central venous pressure (CVP) is a well-established measure of assessing the efficacy of fluid resuscitation, it is an invasive method. Recent studies have attempted to suggest alternative measures like the inferior vena cava (IVC) diameter or the diameter jugular vein diameter (3, 5). This study was performed on 78 critical patients to further investigate the efficacies of the mentioned methods, using the most recent and relevant literature.

Methods

The sample size was equal to 78 people. Any patient admitted on account of the critical care due to the necessity of fluid resuscitation and those requiring the measurement of CVP met the inclusion criteria. Patients suffering from cervical deformities and/or traumas or patients with abdominal traumas or those unable to be measured due to tympanites faced the exclusion criteria and were omitted from the study.

This descriptive-analytic study was conducted at the Emergency Department from April 2018 to December 2018. A checklist was prepared and completed by each patient. This checklist included the following information:

- Age
- Sex
- Etiology
- Diameter of the jugular vein before resuscitation
- Diameter of the jugular vein during resuscitation
- Diameter of the IVC before resuscitation
- Diameter of the IVC during resuscitation
- CVP
- Urinary output

After inserting the central venous catheter, the diameter of the jugular vein on one side was measured simultaneously with the diameter of the IVC on the opposite side. The CVP was also recorded during insertion. The numerical value of the CVP was measured from the terminal part of the superior vena cava with a unit of mmHg (equal to 1.3 cmH2O) and equivalent to the pressure at the surface of the right atrium. At any point during resuscitation, the CVP was measured so that the resuscitation procedure could be conducted based on it. The diameters of the jugular vein and the IVC were recorded utilizing ultrasonography at the moment of insertion and after administering 500 cc of fluid. In addition, the amount of urinary output after administering the fluid was measured, and its association with the jugular and IVC indices was evaluated.

The analysis was performed using SPSS software version 17. For the continuous numerical variables, the average, median, mode, range and standard deviation (SD) were computed; while for the categorical variables, the absolute and relative frequencies were calculated. In order to evaluate an association, considering that other variables were categorical, the chi-squared test along with the independent *t* test were utilized; and in order to determine an association between other variables under the study, logistic regression was used and the Pearson correlation coefficient was calculated. *P* value less than 0.05 was considered as statistically significant. This study was approved by the Committee of Ethics in Research of Tabriz University of Medical Sciences (ethical code 54/22231). The patients' contributions were completely voluntary and confidential, and their anonymity was guaranteed.

Results

Among the study population, 42 cases (53.8%) were males and 36 cases (46.2%) were females. The mean of age was 71.48±16 years (minimum 19 and maximum 101). Based on the cause of the critical state, 20 cases (25.6%) had hemorrhagic shocks, 24 cases (30.8%) had septic shocks and 34 cases (43.6%) had hypovolemic shocks.

The mean of jugular vein diameter was 27.21± 16.62 mm before resuscitation (Figure 1) and 25.38± 15.11 mm during resuscitation (Figure 2). The decrease in the diameter of jugular vein was not statistically significant (*P* value = 0.1). The mean of IVC diameter was 63.33± 16.55 before resuscitation (Figure 3) and 57.98 ± 18.56 during resuscitation (Figure 4). The decrease in the diameter of the IVC was statistically significant (*P* value <0.001). The CVP was 4.23± 3.34 mmH2O before resuscitation and 5.61±3.64 mmH2O after receiving 500 cc of fluid. This difference was statistically significant (*P* value <0.001).

The average of urine output was 201.28± 29.87 cc, with a partially significant correlation discovered with the increase in CVP (*P* value =0.069, r=0.2). There was no significant correlation between the urine output and the decrease in the diameter of the IVC (*P* value =0.239, r=-0.13). There was no significant correlation between the urine output and the decrease in the jugular vein diameter either (*P* value =0.53, r=0.71).

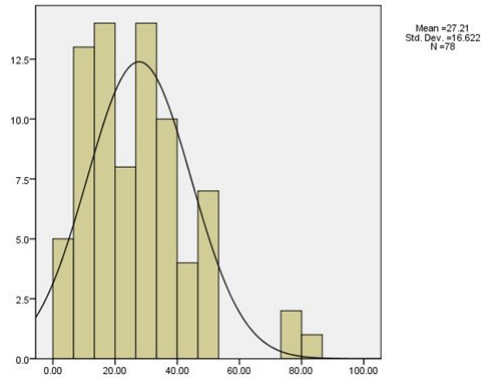

Figure 1. The diameter of the jugular vein before resuscitation (horizontal) by frequency (vertical).

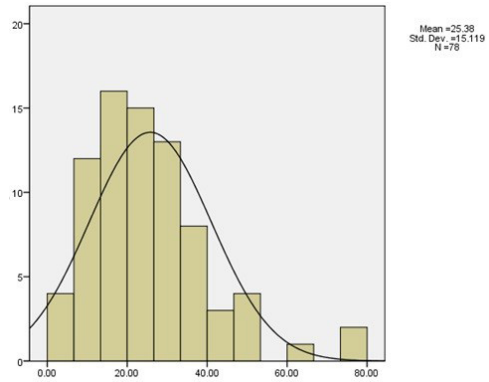

Figure 2. The diameter of the jugular vein during resuscitation (horizontal) by frequency (vertical).

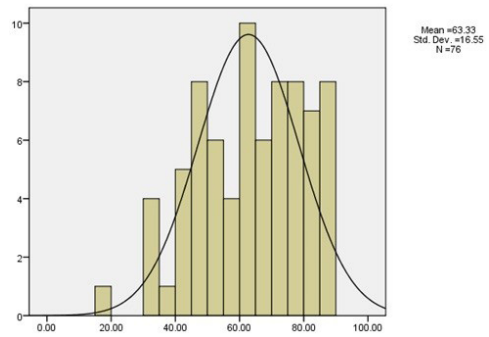

Figure 3. The diameter of the inferior vena cava before resuscitation (horizontal) by frequency (vertical).

Discussion

The percentage of the male patients was somewhat higher than the number of the females. Similar results were observed in a study by Lall et al (6). However, an international case review showed a larger portion of male patients equal to 64.3% (7). The percentage was 77.6%

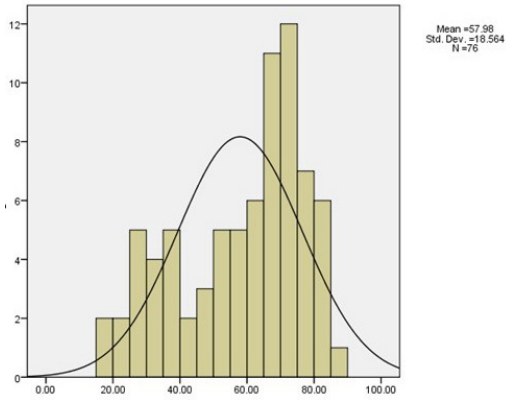

Figure 4. The diameter of the inferior vena cava during resuscitation (horizontal) by frequency (vertical)

in a study about assessing the hydration status in fluid management (8). The cause of the critical state in most of our cases was hypovolemic shock. A study on the Chinese population with 70 subjects illustrated similar results, with 50% of the cases being hypovolemic (3). However, in a reassessment by Hartog et al (9), the populations of most of the clinical studies were septic, though the studies about hypovolemia in the meta-analyses and systematic reviews had larger samples. The difference could be due to the recent decrease in the prevalence of infectious diseases in Iran as a result of improved lifestyle and the rather successful management programs by the health system.

While our study did not show a statistically significant association between the changes in the jugular vein diameter and fluid resuscitation, other studies have revealed a high efficacy (3, 10). However, the mentioned studies were conducted using positive pressure ventilation along with the jugular vein diameter. It seems that the jugular vein diameter is unable to determine the outcome of fluid resuscitation independently. In contrast, the decrease in the IVC diameter was statistically significant. The IVC diameter was found as an effective indicator of health in a prospective study on normal population (5). However, Airapetian et al (11) conducted a study on 59 patients and identified that IVC diameter was not an appropriate indicator of fluid responsiveness unless collapsibility due to inhalation is considered. The finding is similar to our results concerning the diameter of the jugular vein. Since both veins are anatomically connected to the right heart, which supply the lungs, it is logical to state that changes in the pressure during inhalation and exhalation will influence the decreases in the diameters of IVC and jugular vein. The CVP significantly increased in our study. But, a retrospective study on 40 patients suffering from septic shock stated that CVP may not be a consistent marker of the preload of the left ventricle for fluid management (12). The mentioned study did indicate that CVP was not appropriate for septic shock. The majority of our cases had hypovolemic shocks and not septic shocks.

Conclusion

Both septic and hypovolemic shocks are indications of fluid resuscitation. The diameters of IVC and the jugular vein will be effective markers of fluid resuscitation only if utilized along with respiratory markers. In the future studies, it is suggested that the sensitivities and specificities of the diameters of IVC and the jugular vein be measured and analyzed comparing with the CVP, which is currently an acceptable method of evaluating hydration.

Ethical issues

An approval was obtained from the Committee of Ethics in Research of Tabriz University of Medical Sciences (ethical code 54/22231). All actions undertaken were consistent with the diagnosis, treatment or follow-up that is usually performed for a disease; thus, no extra payments were demanded from patients. The patients' chaperones were assured that the contributions were completely voluntary and confidential, and their anonymity was guaranteed.

Authors' contributions

SSV designed and conducted the study. NZM performed data collection. HH analyzed data and wrote the manuscript

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