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Original Article

Correlation of Internal Jugular Venous Collapsibility Index with Central Venous Pressure to Assess Volume Status in Critically ill Patients

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Mahfuzur Rahaman[1*], Mohammad Mohsin[2], Mohsin Ur Rahman Mamun[3]

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*Corresponding Author

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ABSTRACT

Introduction: *Intravascular volume status assessment and hemodynamic monitoring plays an important role in management of critically ill patients. One of the important parameters in the hemodynamic evaluation of critically ill patients is central venous pressure (CVP). Sonographic evaluation of the Internal Jugular Venous (IJV) Collapsibility Index can be used as an alternative to CVP as an indirect measure of volume status.* ***Objective:*** *To find out the correlation between IJV collapsibility index and CVP for assessment of volume status in critically ill patients.* ***Methods & Materials:*** *This cross-sectional study was carried out in Non-COVID ICU at the Department of Anaesthesia, Pain, Palliative & Intensive Care, Dhaka Medical College Hospital (DMCH), Dhaka from January 2022 to December 2022. A total of 97 study subjects were included as per the inclusion and exclusion criteria. CVP was measured by CVP manometer and IJV diameter with collapsibility index was measured by bedside ultrasonography. Specificity and Sensitivity of IJV collapsibility index was calculated and correlation between CVP and IJV collapsibility index was done. For all statistical tests, p value of <0.05 was considered as statistically significant.* ***Results:*** *The mean age was 38.13±11.83 years, majority of the patients were female (51.5%). This study showed significant negative correlation of IJV collapsibility index with central venous pressure (r = -.553, p<0.001), systolic blood pressure (r = .372, p<0.001) and diastolic blood pressure (r= -.420, p<0.001). In present study showed that CVP of <8 cmH_2O was chosen as a clinically significant cutoff value for low CVP level. Internal jugular venous collapsibility index ≥34% considered as best cut off value of hypovolemia. The diagnostic performance test value was sensitivity 86.1%, specificity 73.8%, PPV 65.9%, and NPV 90.0% and accuracy 78.4%.* ***Conclusion:*** *This study reveals that IJV collapsibility index ≥34% correlates with hypovolemia in critically ill non ventilated patients.*

Keywords: *IJV collapsibility index, CVP, Critically ill Patients*

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1. *Junior Consultant, Department of Critical Care, Divine Mercy Hospital Ltd., Dhaka, Bangladesh*
2. *Associate Professor, Department of Critical Care Medicine, Sir Salimullah Medical College, Dhaka, Bangladesh*
3. *Assistant Professor, Department of Critical Care Medicine, Northeast Medical College Hospital, Sylhet, Bangladesh*

INTRODUCTION

Hypovolemia is a common phenomenon in critically ill patients which may have multiple etiologies, results in hypoperfusion of vital organs, which can lead to organ failure if hypoperfusion is not managed quickly and appropriately. Early therapy for reaching an optimal fluid status has been shown to reduce morbidity and mortality in patients with hypovolemia in case of severe sepsis [1]. Volume status can be evaluated by clinical examination and by using hemodynamic monitoring devices. Hemodynamic monitoring devices are costly and invasive so they are limitedly used. In early stages of shock, blood pressure or heart rate is not a reliable marker due to low volume state [2]. Also the absence of tachycardia or hypotension does not rule out blood loss in the early stages of hemorrhagic shock [3]. Depending fully on clinical examination and vital signs are sometimes misleading and may lead to loss of valuable time in resuscitation [4,5]. Point-of-care ultrasound provides a non-invasive method to physicians to evaluate the intravascular volume status of a patient [6]. This tool helps the physician to rapidly make crucial decisions regarding necessary and perfect treatment of critically-ill patients (volume resuscitation versus the use of vasopressors) [7]. Predicting fluid responsiveness perfectly prevents volume overload which may lead to adverse events like acute pulmonary edema. Previously, dynamic measures like variations in stroke volume (SVV) and pulse pressure variation (PPV) were used to assess fluid responsiveness =. Still now there are risks in obtaining and limitations of interpretation of these measurements, so they are not practical in most patients [8]. In contrast, early sonographic evaluation of the major vessels of a critically ill patient gives a highly sensitive and specific assessment of intravascular

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volume status and response to fluid administration [9]. Central venous pressure is the most commonly used measure for assessing volume status. Considering the need to establish a precise diagnosis of hypovolemia in ICU patients, mainly those with circulatory shock, and the difficulty to establish that diagnosis based only on clinical assessment, the use of invasive measures is required. High central venous pressure (CVP) is known to be associated with volume overload states while low CVP is associated with volume depleted states. A lot of evidence indicates that extra thoracic veins can reflect intrathoracic venous pressure and volume changes [10]. Based on this association, hypothesis of this study is internal jugular venous collapsibility index (IJV-CI) could be an alternative option to CVP. Study shows the IJV collapsibility index ≥39% correlated best with hypovolemia, a sensitivity of 87.5% and specificity 100%. The area under ROC curve for IJV collapsibility index was 0.938 [5]. Prospective examination of the efficacy of the IJV-CI as an alternative in the absence of CVP will be performed. Some studies have been done on the IJV diameter, cross-sectional area, and their corresponding CI (collapsibility index) by ultrasonography as an indirect measure of CVP. Therefore aim of this study is to evaluate the accuracy, sensitivity & specificity of IJV-CI and it's correlation with CVP to assess volume status in critically ill non ventilated patients.

METHOD & MATERIALS

Study design: A Cross-sectional study.

Place of study: The Non-COVID ICU in the Department of Anaesthesia, Pain, Palliative & Intensive Care, Dhaka Medical College Hospital, Dhaka, Bangladesh.

Period of study: 12 months (January 2022 to December 2022).

Study populations: All critically ill patients aged 18-65 years of both gender and not on mechanical ventilation admitted in ICU.

Sample size: Sample size is 97.

Selection criteria

Inclusion criteria

- Patients aged 18-65 years old of both gender & critically ill and not on mechanical ventilation with central venous line.

Exclusion criteria

- Patients <18 years old or >65 years old
- Patients with pulmonary hypertension, valvular heart disease, ischemic heart disease, right ventricular dysfunction and superior venacaval obstruction.
- Patients with injury in cervical region or with cervical collar

Study procedure: This was a cross-sectional study conducted in Non-COVID ICU, Department of Anaesthesia, Pain, Palliative & Intensive Care, DMCH for 12 months. Ethical approval was taken from the DMC ethical review committee prior to the study. After matching the inclusion and exclusion criteria total 97 patients were included in the study by purposive sampling method. Informed written consent was taken from patient's legal guardian before enrollment in study. Moreover, they were clearly informed that they were not get any financial benefits from this study and they can withdraw their patient from the study. A total of 97 sample size has been estimated by using statistical formula. Before measuring central venous pressure and internal jugular venous collapsibility index, bed-side echocardiography was done to exclude right ventricular dysfunction, valvular heart disease, or any wall motion abnormalities due to ischemic heart disease.

Central venous pressure measurement:

- Here, a 3-way tap is used to connect the manometer to an intravenous drip set on one side, and, via extension tubing filled with intravenous fluid, to the patient on the other. First, lined up the manometer arm with the phlebostatic axis. Made sure that no air bubbles are present in the tubings. Also, checked if the tubings are either kinked or blocked.
- Zeroing of the manometer done by moving the manometer scale up and down. This procedure allows the bubble to be aligned with zero on the scale.
- The 3-way tap is then turned so that it is open to the fluid bag and the manometer but closed to the patient, allowing the manometer column to fill with fluid. Overfilling of the manometer column is carefully prevented. Then, turned off the flow from the fluid bag and opened the three-way tap from the manometer to the patient. The fluid level within the manometer column fall to the level of the CVP, the value of which is taken on the manometer scale which is marked in centimeters, therefore giving a value for the CVP in centimeters of water (cmH2O)
- When the fluid stopped falling, the CVP measurement is taken.

Data analysis plan: Following collection of the data, all data were edited and encoded into a statistical software named 'Statistical Package for Social Science' (SPSS) version 22.0. Data were inputted into the software (termed as variable) according to the prior analysis plan. Categorical and continuous variables, CVP and IJV diameters, were presented as frequency (percentage) and mean ± SD respectively. Descriptive statistics were used to summarize all demographic and other clinical characteristics of the patients. The relationship between two quantitative variables was examined using Pearson's correlation coefficients. Various measures of diagnostic accuracy, such as sensitivity, specificity, positive, and negative predictive values were calculated to determine the diagnostic and predictive accuracy of the IJV collapsibility index. A receiver operating characteristic (ROC) curve was then computed to derive best suitable cutoff values for the IJV collapsibility index and to assess model discrimination and predictive accuracy. Pearson's correlation test was done to see the correlation between IJV-CI and CVP. A p value <0.05 considered as a level of significance.

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RESULTS

A total of 97 patients not on mechanical ventilation were selected after matching inclusion and exclusion criteria.

Table – I: Distribution of the study patients by age group and gender (*n*=97)

Variables	Frequency	Percentage (%)
Age group (years)		
<30	35	36.1
31-40	29	29.9
41-50	16	16.5
51-60	10	10.3
>60	7	7.2
Mean±SD	38.13±11.83	
Range (min – max)	(18 – 65) years	
Gender		
Male	47	48.5
Female	50	51.5
Male : Female ratio	1:1.1	

In Table I is showing majority of the patient's age is below 30 years which is 36.1% of total participants. The mean age was 38.13±11.83 years with range 18-65 years. Male patients were 48.5% and female 51.5%. The male: female ratio was 1:1.1.

Table – II: Distribution of the study patients by comorbidities (*n*=97)

Comorbidities	Frequency	Percentage (%)
Diabetes mellitus	29	29.9
Chronic lung disease	26	26.8
Renal disease	2	2.1

In Table II, the study patients' comorbid disease was listed. 29.9% of them had diabetes mellitus, 26.8% had Chronic lung disease, 2.1% patients had renal disease.

Table – III: Distribution of the study patients by central venous pressure (cm H_2O) (*n*=97)

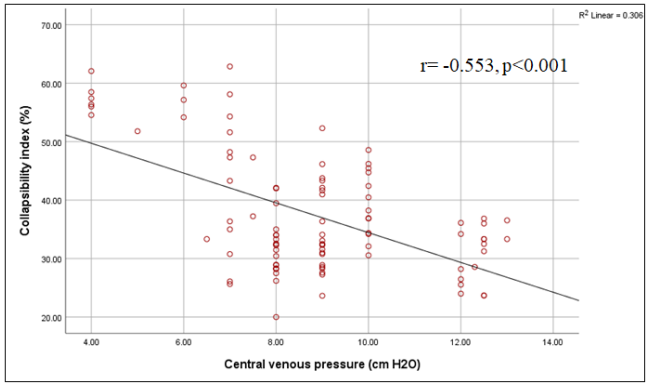
CVP	Frequency	Percentage
Hypovolemia (CVP < 8 cm H_2O)	36	37.1
Euvolemia (CVP 8-12 cm H_2O)/ Hypervolemia (CVP > 12 cm H_2O)	61	62.9

Table III showed the central venous pressure (CVP) of the study subjects. Maximum patients had euvolemia/hypervolemia (62.9%) followed by hypovolemia 37.1%.

Table – IV: Distribution of the study patients by internal jugular venous collapsibility index (*n*=97)

Internal jugular venous collapsibility index	Frequency	Percentage
Hypovolemia (≥ 34)	47	48.5
Euvolemia/hypervolemia (<34)	50	51.5

Table IV showed the internal jugular venous collapsibility index of the study subjects. Maximum patients had euvolemia/hypervolemia (51.5%) followed by hypovolemia 48.5%.



p-value obtained by Pearson's correlation test

Figure – 1: Correlation between internal jugular venous collapsibility index and central venous pressure

In Fig-1 showed that significant negative correlation of internal jugular venous collapsibility index with central venous pressure (r = -.553, p<0.001).

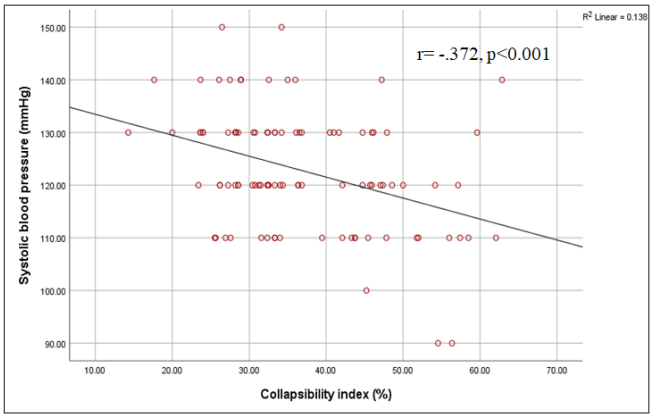


Figure – 2: Correlation between internal jugular venous collapsibility index and systolic blood pressure

In Fig-2 showed that significant negative correlation of internal jugular venous collapsibility index with systolic blood pressure (r= -.372, p<0.001).

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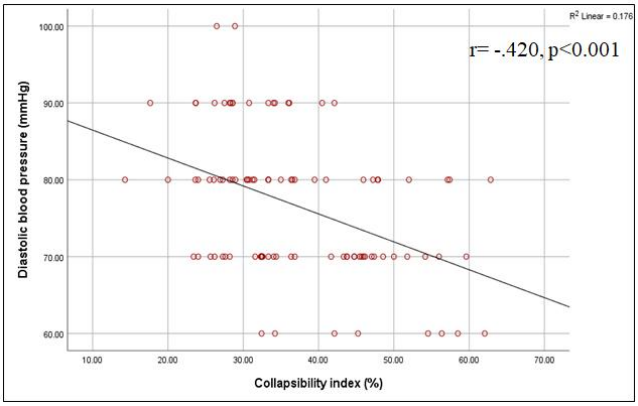

Figure – 3: Correlation between internal jugular venous collapsibility index and diastolic blood pressure

In Fig-3 showed that significant negative correlation of internal jugular venous collapsibility index with diastolic blood pressure (r= -.420, p<0.001).

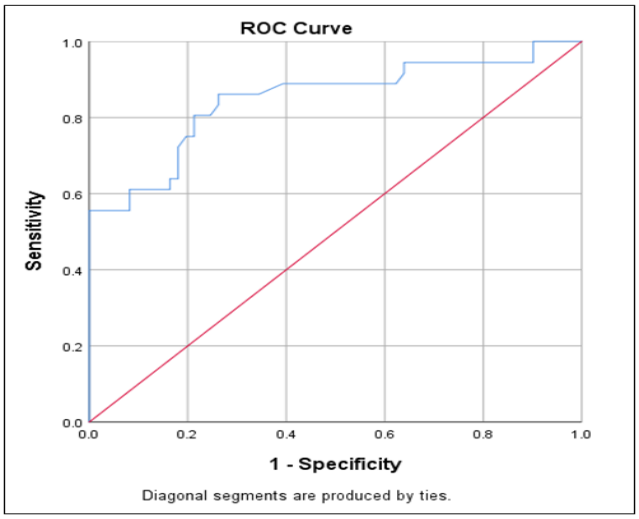

Figure – 4: ROC curve analysis performed to predict the best cut off value of internal jugular venous collapsibility index

A CVP of <8 (cm H_2O) was chosen as a clinically significant cutoff value for hypovolemia. The test characteristics of ultrasound findings in predicting volume status are given in Fig-4. The area under the ROC curve (AUC), along with sensitivity, specificity, and PPV, and NPV for IJV collapsibility indices to determine a low CVP (<8 cm H_2O). The most suitable cutoff value determined for collapsibility index for IJV at 30 degree was 34.0 with AUC =0.849 with sensitivity 86.1% and specificity 73.8% in predicting low CVP.

Table – V: Diagnostic performance test performed between internal jugular venous collapsibility index and central venous pressure for volume status

Internal jugular venous collapsibility index	CVP (cm H_2O)		Total
	Hypovolemia (<8) (n=13)	Euvolemia/ hypervolemia (≥8) (n=84)	
Hypovolemia (≥34)	31 (True positive)	16 (False positive)	47
Euvolemia/ hypervolemia (<34)	5 (False negative)	45 (True negative)	50
Total	36	61	97
Diagnostic performance test values			
	Values	**95% CI**	
Sensitivity	86.1%	70.50% to 95.3%	
Specificity	73.8%	60.93% to 84.2%	
Positive Predictive Value	65.9%	55.5% to 75.1%	
Negative Predictive Value	90.0%	79.7% to 95.4%	
Accuracy	78.4%	68.8% to 86.1%	

A CVP of <8 cmH_2O was chosen as a clinically significant cutoff value for low CVP level. The test characteristics of ultrasound findings in predicting volume status. Internal jugular venous collapsibility index ≥34% considered as hypovolemia. The diagnostic performance test value were sensitivity 86.1%, specificity 73.8%, PPV 65.9%, and NPV 90.0% and accuracy 78.4% (Table-V).

DISCUSSION

This was a cross sectional study carried out in Non-COVID ICU, Department of Anaesthesia, Pain, Palliative & Intensive Care, DMCH for 12 months. After achieving the inclusion and exclusion criteria total 97 patients were included in the study by purposive sampling method. The purpose of the study was to see the correlation between internal jugular venous collapsibility index and central venous pressure for volume status assessment in critically ill patients who are not in mechanical ventilation. In present study showed the mean age was 38.18±11.83 years, majority of the patients were female (51.5%). Jassim et al., [4] showed the mean age 54.34±16.61 years with 81% male predominance in his study. Chawang et al., [11] reported mean age 49±15.6 years with 63% male in study. In this study patient's co-morbidities were diabetes mellitus, chronic lung disease and renal disease 29.9%,26%, and 2.1% respectively. Chawang et al., [11] showed comorbidities, where type 2 diabetes being the most common 21.9%. This was followed by hypertension 12.3%, chronic obstructive pulmonary disease 0.09%, chronic kidney disease 0.06%. In this study CVP of <8 cmH_2O was chosen as a clinically significant cutoff value for hypovolemia.Here in this study 37.1% patients are hypovolemic and 62.9% patients are euvolemic/hypervolemic according to CVP. Killu et al., [5]

reported 52% patients were hypovolemic and 48% were euvolemic according to CVP. Jassim et al., [4] showed 62% patients were hypovolemic according to CVP and 38% were hypervolemic/euvolemic. In present study 48.5% patients are hypovolemic according to IJV-CI, where as 51.5% patients are euvolemic/hypervolemic. Here the difference of volume status found between others study with this study may be due to patient's clinical condition and available resources during data collection. Like here data was collected from almost settled patients who got treatment for their acute organ failure. But in other hand others took their data from the patients with almost acute crisis condition in emergency department as they had available resources and facilities. Here in this study relationship of co-morbidities with CVP is shown. Like 30.6% diabetic patients were hypovolemic and 29.5 % were euvolemic/hypervolemic. Patients with chronic lung disease 30.6% and 24.6% were hypovolemic and euvolemic/hypervolemic respectively. Patients with renal disease 3.3% were euvolemic/hypervolemic. Again according to IJV-CI 27.7% diabetic patients were hypovolemic and 32.0% were euvolemic/hypervolemic. In chronic lung disease 25.5% & 28% were hypovolemic and euvolemic/hypervolemic respectively. In renal disease case 2.1% were euvolemic and 2% were euvolemic/hypervolemic. In this study there is significant negative correlation between systolic blood pressure and IJV-CI (r = -.372, p<0.001) and there is also significant negative correlation between diastolic blood pressure and IJV-CI (r=-.420,p<0.001).As when there is raised volume of fluid in vessels, blood pressure raises and also collapsibility of vessels reduces and vice versa. In present study showed significant negative correlation of internal jugular venous collapsibility index with central venous pressure (r = -.553, p <0.001). Here as CVP raised collapsibility of vessels decreased and vice versa. Kacar et al., [12] reported statistically significant and negative correlation between CVP and IJV-CI (r = -0.374, p=0.001). Jassim et al., [4] reported negative correlations between CVP and IJV-CI at 30° (r = –0.559, P=0.0001) which was consistent with current study. Chawang et al., [11] reported the IJV collapsibility index (CI) has significant negative correlation with CVP (r = -.412, p=0.008). Number of studies were done, where negative correlation between CVP and inferior venacaval collapsibility index (IVC-CI) was found in assessment of volume status in critically ill patients. Kacar et al., [12] also reported statistically significant and negative correlation (r = -0.428, p <0.001) between CVP and IVC-CI. Jassim et al., [4] reported negative correlations between CVP and IVC-CI (collapsibility index) (r = –.540, P=0.0001) which was consistent with current study. Chawang et al. [11] reported the IVC collapsibility index (CI) was in significant negative correlation with CVP (r= -.541, p=0.005). Most of the studies showed negative correlations between IVC-CI and CVP which was in concordance with present study. Internal jugular venous collapsibility index ≥34% considered as hypovolemia in this study. The diagnostic performance test value were area under the ROC curve (AUC) 0.849, sensitivity 86.1%, specificity 73.8%, PPV 65.9%, and NPV 90.0% and accuracy 78.4%. Killu et al., [5] evaluated the correlation between the IJV-CI (diameter) and hypovolemia by POC USG (point of care ultrasonography), they found that a IJV-CI of ≥39% had AUC 0.938 with no significant difference to the CVP AUC 0.87 and a sensitivity of 87.5% and specificity of 100% in identifying hypovolemia in clinically ill patients. Jassim et al., [4] reported Almost similar findings of IJV-CI >10.2% had the AUC is 0.803, sensitivity 80.6%, specificity 68.2%,PPV 80.6%,NPV 68.2%,accuracy 75.9% in identifying hypovolemia. So according to current study internal jugular venous collapsibility index ≥34% is consistent with hypovolemia which is correlated with low CVP <8 cmH_2O.Thus it can be said that IJV-CI is negatively correlated with CVP for assessment of volume status in critically ill patient.

CONCLUSION

This study showed most of the patients are below 30 years with female predominance. Diabetes mellitus was the commonest co-morbid disease. According to IJV-CI and CVP most of the patients are of euvolemic/hypervolemic group. Internal jugular venous collapsibility index (IJV-CI) is negatively correlated with central venous pressure. Ultrasonographic measurement of IJV-CI is simple, faster, safer and non-invasive than CVP in evaluating volume status of critically ill non-ventilated patients. So it may be an effective method for estimating volume status.

Limitations

Internal jugular venous collapsibility index was measured only for one time. Serial measurement of IJV-CI and CVP was not done, so dynamic changes of collapsibility index were not assessed.

Recommendations

Assessment of volume status by calculating IJV-CI is non-invasive, easier, safer by using bed side ultrasound. It might be used in all healthcare center for assessment of volume status of critically ill patients.

Conflict of Interest: None.
Source of Fund: Nil.

REFERENCES

1. *Rivers, E.P., Coba, V. and Whitmill, M., 2008. Early goal-directed therapy in severe sepsis and septic shock: a contemporary review of the literature. Current Opinion in Anesthesiology, 21(2), pp.128-140.*
2. *Patil, P., Kelly, N., Papadimos, T.J., Bahner, D.P. and Stawicki, S.P., 2014. Correlations between venous collapsibility and common hemodynamic and ventilatory parameters: A multi-variable assessment. OPUS, 12, pp.495-500.*
3. *Victorino, G.P., Battistella, F.D. and Wisner, D.H., 2003. Does tachycardia correlate with hypotension after trauma?. Journal of the American College of Surgeons, 196(5), pp.679-684.*
4. *Jassim, H.M., Naushad, V.A., Khatib, M.Y., Chandra, P., Abuhmaira, M.M., Koya, S.H. and Ellitthy, M.S.A., 2019. IJV collapsibility index vs IVC collapsibility index by point of care ultrasound for estimation of CVP: a comparative study with direct estimation of CVP. Open Access Emergency Medicine: OAEM, 11, p.65.*
5. *Killu, K., Coba, V., Huang, Y., Andrezejewski, T. and Dulchavsky, S., 2010. Internal jugular vein collapsibility index associated with*

hypovolemia in the intensive care unit patients. Critical Ultrasound Journal, 2(1), pp.13-17.

6. *Kelly, N., Esteve, R., Papadimos, T.J., Sharpe, R.P., Keeney, S.A., DeQuevedo, R., Portner, M., Bahner, D.P. and Stawicki, S.P., 2015. Clinician-performed ultrasound in hemodynamic and cardiac assessment: a synopsis of current indications and limitations. European Journal of Trauma and Emergency Surgery, 41(5), pp.469-480.*
7. *Karacabey, S., Sanri, E. and Guneysel, O., 2016. A non-invasive method for assessment of intravascular fluid status: Inferior vena cava diameters and collapsibility index. Pakistan journal of medical sciences, 32(4), p.836.*
8. *Ansari, B.M., Zochios, V., Falter, F. and Klein, A.A., 2016. Physiological controversies and methods used to determine fluid responsiveness: a qualitative systematic review. Anaesthesia, 71(1), pp.94-105.*
9. *Mandeville, J.C. and Colebourn, C.L., 2012. Can transthoracic echocardiography be used to predict fluid responsiveness in the critically ill patient? A systematic review. Critical Care Research and Practice, 2012.*
10. *Constant, J., 2000. Using internal jugular pulsations as a manometer for right atrial pressure measurements. Cardiology, 93(1-2), pp.26-30.*
11. *Chawang, H.J., Kaeley, N., Bhardwaj, B.B., Chauhan, U., Baid, H., Asokan, R. and Galagali, S.S., 2022. Ultrasound-guided estimation of internal jugular vein collapsibility index in patients with shock in emergency department. Turkish Journal of Emergency Medicine, 22(4), pp.206-212.*
12. *Kacar, C.K., Uzundere, O., Bicak, M., Kandemir, D., Kaya, S. and Yektas, A., 2020. Evaluation of the relationship of Delta-CO2 with IVC-CI, IJV-CI, and CVP values in intubated critically ill patients with spontaneous breathing, and who were applied invasive mechanical ventilation in CPAP mode.*