Correlation between internal jugular vein collapsibility index and mean arterial pressure in assessing the response of fluid resuscitation in crit- ically ill patients

by Bambang Pujo Semedi

Submission date: 24-Jun-2024 10:26AM (UTC+0800)
Submission ID: 2407530214
File name: -dr_BPS,_Prof_RR,_dr_AU-Correlation_between_internal_jugular.pdf (735.43K)
Word count: 3334
Character count: 17471

Crit Care Shock (2023) 26:125-132

Correlation between internal jugular vein collapsibility index and mean arterial pressure in assessing the response of fluid resuscitation in critically ill patients

Bambang Pujo Semedi[1], Nancy Margarita Rehatta[2], Jusak Nugraha[3], Soetjipto[4], Ronald Melviano[5], Arie Utariani[2]

Abstract

***Background*: Response to resuscitative fluid administration is often difficult to assess clinically, especially in critically ill patients, and therefore it is necessary to use tools to evaluate the response. One of the modalities that can be used is ultrasonography to measure the internal jugular vein collapsibility index (IJVCI) during the respiration cycle.**

***Aim*: To evaluate the correlation between IJVCI and mean arterial pressure (MAP) in assessing response to resuscitative fluid administration in critically ill patients.**

***Patients and methods*: This is an experimental study with pre-post test groups, assessing the response to resuscitative fluid administration in critically ill patients.**

***Results*: A total of 28 subjects aged 18-65 years old were included in the inclusion criteria of this study. The average age of subjects was 50.18 years. Twenty-one subjects responded to the administration of 500 ml Ringer's lactate (RL) crystalloid fluid within 30 minutes based on the IJVCI. Subjects were observed in two periods, the pre-test and post-test periods. There was a significant difference in the IJVCI before and after 500 ml of RL between the two groups ($p<0.05$). As a predictor of IJVCI associated with increased MAP at the cut-off value of 44.40 with a sensitivity of 76.9% and a specificity of 80%. This study showed that IJVCI had a negative correlation with increased MAP ($p<0.05$).**

***Conclusions*: The measurement of the IJVCI can be used to assess the response to resuscitative fluid administration in critically ill patients.**

Key words: IJVCI, MAP, critically ill patients.

[1] Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[2] Department of Anesthesiology and Reanimation, Dr. Soetomo General Academic Hospital, Faculty of Medicine, University Airlangga, Surabaya, Indonesia
[3] Department of Clinical Pathology, Dr. Soetomo General Academic Hospital, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[4] Department of Medical Biochemistry, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[5] Samuel Kristian Lerik Regional Public Hospital, Kupang, Indonesia

Address for correspondence:
Prof. Dr. Nancy Margarita Rehatta, MD
Department of Anesthesiology and Reanimation, Faculty of Medicine, University Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
Tel: +62315020251
Email: rita@fk.unair.ac.id

Introduction

Assessment of intravascular volume status and hypovolemia in critically ill patients in the intensive care unit (ICU) or resuscitation room is often an issue, especially if only relying on physical examination and vital signs. The use of portable echocardiography to measure the inferior vena cava (IVC) collapsibility index during the respiration cycle can predict the assessment of cardiac output (CO) but has limitations in terms of lack of equipment availability, ultrasound expertise, and difficulty in identifying the inferior vena cava. (1,2) Critical illness is defined as a disease process that causes instability of the body's physiology, which can lead to failure of body functions or death in a short period of time. System disorders that cause death most quickly are generally disorders of the neurological, cardiovascular, and respiratory systems. (3)

Accurate assessment of intravascular volume status for treating severe hypovolemia or shock is very challenging but has a very important role in critical illness. It is important to avoid administering fluids that increase morbidity and mortality, and therefore assessing fluid response in critically ill patients precisely and accurately is very important. (2)

Studies have shown that the response to fluid administration can be defined as a 15% increase in stroke volume (SV), CO, or mean arterial pressure (MAP) after the administration of 500 ml of fluid. MAP is defined as the average arterial pressure in one cardiac cycle, systolic and diastolic. Cardiac output and systemic vascular resistance affect MAP. (1,4) Imaging techniques using ultrasonography have reported that the internal jugular vein collapsibility index (IJVCI) indicative of hypovolemic conditions <39%. (5-12) The Sequential Organ Failure Assessment (SOFA) score is a scoring system to determine the extent of organ failure in an individual. The score is based on six different values, each representing respiratory, cardiovascular, liver, coagulation, renal, and nervous system parameters The greater the score, the higher the mortality rate. (13) Other studies recommended the use of shock index (SI). SI is the ratio of heart rate (HR) to systolic blood pressure (SBP). (14)

This prospective study was conducted to evaluate the correlation between IJVCI and mean arterial pressure (MAP) in assessing response to resuscitative fluid administration in critically ill patients.

Subjects and methods

This was an experimental study with pre-post-test groups in critically ill patients. Assessment of the response to resuscitative fluid administration used mean arterial pressure >15%, which was associated with the IJVCI. The study was conducted in the ICU of Dr. Soetomo General Academic Hospital Surabaya from April 2016 to May 2016. The subjects were patients between the ages of 18-65 years old, breathing spontaneously or fully controlled by mechanical ventilation, approved by the family to participate in the study with a signed consent form, and an IJVCI of >40%. The subjects did not have spinal cord injury, cardiac arrhythmia, irregular breathing patterns, and hemorrhage.

Criteria for critical illness: An illness with impairment of one or more vital functions (respiratory, cardiovascular, neurological) that, if not treated immediately, will be life-threatening in a short period of time.

IJVCI: A comparative measurement of the internal jugular vein diameter during inspiration and expiration using ultrasonography with a linear transducer of 7-10 MHz.

Fluid challenge: A procedure of administering a limited amount of fluid within a predetermined time to assess the response to volume addition. In this study, 500 ml of RL solution was administered within 30 minutes.

Response to fluid administration: The presence of change in hemodynamic status following a fluid challenge that was determined by measuring mean arterial pressure. If the MAP increase was >15%, the patient was considered responsive to fluid administration.

Research flow

a. Patients with critical illness who met the inclusion criteria had their IJVCI measured using ultrasonography with a linear transducer of 7-10 MHz.
b. Performed fluid challenge by administering 500 ml of RL solution within 30 minutes.
c. Measurement of IJVCI using ultrasonography with a linear transducer of 7-10 MHz by a standardized researcher.

Data collection

Data collection included the name, age, sex, vital signs, primary diagnosis, SOFA score, and IJVCI measurement.

Data analysis

The study data were collected from the two periods prior to and following treatment and were then analyzed using SPSS for Windows 20.0 software (IBM, Armonk, NY, USA). Numerical data were tested for normality with Shapiro Wilk, where data with normal distribution were presented in terms of mean and standard deviation (SD), and data with non-normal distribution were given in median and minimum, and maximum range values. The two means, which were normally distributed, were analyzed using the t-test, and the paired t-test analyzed those that were pre-test and post-test groups. Correlation between variables was carried out by bivariate analysis; data that were normally distributed were analyzed using Pearson's correlation, while abnormal data were analyzed using Spearman's correlation. The receiver operating character (ROC) curve was used to find the optimal cut-off value and calculate the sensitivity and specificity for examining IJVCI and MAP. A p-value of less than 0.05 ($p<0.05$) was considered a statistically significant difference.

Results

Subject characteristics

The study was conducted on 28 subjects aged 18-65 years old who suffered from critical illness, observed in two periods: the pre-test and post-test. The average age of patients with critical illness was 50.18 years. The average body weight of this study group was 55.29 kg. The mean SOFA score of this study group was 6.61, and the mean shock index was 2.1. (**Table 1**). Meanwhile, the data for sex obtained from the results of statistical frequency tests identified 17 males and 11 females.

Based on **Table 2**, there were 24 patients with mechanical ventilation control and 4 with spontaneous breathing, in accordance with the inclusion criteria.

The difference in hemodynamic status prior to and after 500 ml RL administration

To assess the response of fluid administration in critically ill patients, MAP and heart rate before and after 500 ml RL crystalloid solution administration within 30 minutes were compared.

There was a significant difference in MAP and heart rate values before and after the administration of 500 ml RL crystalloid solution within 30 minutes ($p<0.05$) (**Table 3**).

The difference in IJVCI prior to and after 500 ml RL administration

Based on **Table 4**, the McNemar statistical test showed that there was a significant difference in the IJVCI before and after 500 ml of RL crystalloid fluid administration. Despite 7 subjects that were found to have no change in the IJVCI, 21 subjects had a decreased IJVCI.

The ROC curve analysis was used to calculate the cut-off value, sensitivity, and specificity of IJVCI as predictors of response in increasing of MAP. Youden's index, with the highest sum of sensitivity and specificity, was used to determine the optimal cut-off value for differentiation. Based on the ROC curve, IJVCI showed an area under the curve 0.764 (95%CI [0.572-0.956]; p=0.018) (**Figure 1**). Correlation analysis has been carried out with Spearman correlation to analyze the association of IJVCI and the increase of MAP. It was found significant that the IJVCI was negatively correlated with an increase in MAP (r^2=0.510; p=0.000) (**Figure 2**).

Discussion

The general concept of fluid challenge administration is to quickly observe a response to a very limited amount of fluid administration, and there are 4 important elements that must be considered before conducting the technique: (3)

1. Type of fluid. Either crystalloid or colloid can be used, as we already know about the advantages and benefits of each. In this case, neither was superior to the other, but the important thing to know was when to give and the reason for choosing that particular fluid. In this study, we used 500 ml RL crystalloid fluid within 30 minutes with the expectation that the fluid we administered within that time period could still remain intravascular before entering the interstitial tissues, although in theory, colloid fluids last longer in the intravascular but with side effects that may be greater than the administration of crystalloid fluids.
2. The rate of fluid administration. A previous study by Muller L, Toumi M, et al. in 2011 conducted a fluid challenge technique using 100 ml crystalloid in the first 1 minute, followed by 400 ml within 14 minutes, and found that it was safe to do so with a significant response and no significant side effects. (15)
3. Response assessment. The most important parameters to consider are clinical conditions that describe hemodynamic improvement such as blood pressure, MAP, and heart rate. The results of this study showed a significant difference ($p<0.05$) in the comparative clinical parameters prior to and after 500 ml RL crystalloid fluid administration.
4. Complications. Pulmonary edema due to congestive heart failure is the most serious complication of fluid administration. Assessment of the response to fluids using the IJVCI is influenced by cardiopulmonary interactions, where the most influential factors are the intrathoracic pressure during respiration and venous return to the right atrium. Hyperinflation can cause the heart to be pushed into the cardiac fossa in addition to increased intrathoracic pressure, and increased pressure in the right atrium can also disrupt venous blood flow to the right atrium leading to a distension of the internal jugular vein. Response to fluid administration will be difficult to assess in patients with these problems, and 7 of the 28 study participants did not experience changes in the IJVCI prior to and after the administration of 500 ml RL crystalloid fluid within 30 minutes.

Assessment of volume status using the IJVCI was previously performed by Keith Killu, Victor Coba, et al. in 2010, which reported that an IJVCI of >39% was indicative of hypovolemia, and conversely, that

of <39% was indicative of normovolemia, with p=0.001 (p<0.05). (5) In our study, we found that an IJVCI of 44.40 was the optimal cut-off value for differentiation normovolemia or hypovolemia. This suggested that the collapsibility index can be used to assess volume status.

The efficacy of evaluating the fluid administration response by using the IJVCI in the 28 subjects resulted in 21 subjects showing a response, with a change in collapsibility index following administration of 500 ml RL crystalloid fluid within 30 minutes, with a p-value=0.00 (p<0.05). This showed that there was a significant difference, which meant that the IJVCI was effective for assessing fluid response.

Limitations

The sample selection of this study was not completely homogeneous, so in order to achieve good homogeneity, it is necessary to have similar disease types to assess the response to fluids. This study has not yet compared the effectiveness of assessing the response to fluid using the IJVCI with other modalities such as central venous pressure, inferior vena cava collapsibility, and cardiac index, and therefore further research needs to be conducted to assess the factors that affect the IJVCI. Discrepancies in response between the subjects may be due to other factors such as high intrathoracic pressure, cardiac contractility problems, or other causes. The presence of these factors can make the fluid response difficult to assess.

Conclusion

The IJVCI was effectively used to assess the response to resuscitative fluid administration in critically ill patients aged 18-65 years old. There was a significant difference in the IJVCI prior to and after administration of 500 ml RL crystalloid fluid within 30 minutes. No significant side effects were observed in the administration of 500 ml RL fluid within 30 minutes.

Approval from the research ethics committee

This research has obtained approval from the Research Ethics Committee of Dr. Soetomo General Hospital Surabaya, with number 447/Panke.KKE/VI/2016.

Acknowledgment

We thank all teachers, residents, nursing staff, and laboratory staff in Soetomo Hospital, Medical Science, Faculty of Medicine, Universitas Airlangga, that involved in patient management and data collection, without whose hard work and dedication the study would not have been possible.

Table 1. Subject characteristics

Characteristics	n	Mean	SD
Age (year)	28	50.18	17.304
Weight (kg)	28	55.29	10.484
SOFA	28	6.6071	2.16606
Shock index	28	1.215	0.26
Initial MAP (mmHg)	28	62.6321	7.47856
Initial HR (per minute)	28	111.1071	17.51050
RR (per minute)	28	18.7500	3.53422
Final MAP (mmHg)	28	73.0929	7.41375
Final HR (per minute)	28	105.4643	15.62638

Legend: SOFA=Sequential Organ Failure Assessment; MAP=mean arterial pressure; HR=heart rate; RR=respiration rate; SD=standar deviation.

Table 2. Frequency of respiratory assistance

Respiratory assistance	Number of the subjects (n)	Percentage (%)
Ventilatory controlled	24	85.7
Spontaneous breathing	4	14.3
Total	28	100.0

Table 3. Comparison between pre-test and post-test groups

Variables	Pre-test group	Post-test group	p-value
MAP (mmHg)	62.63±7.48	73.09±7.4	0.000[1*]
Heart rate (beat per minute)	111.11±17.51	105.46±15.62	0.000[1*]
Systolic pressure (mmHg)	89.71±8.04	100.86±9.59	0.000[1*]
Shock index	1.25±0.26	1.05±0.19	0.000[1*]

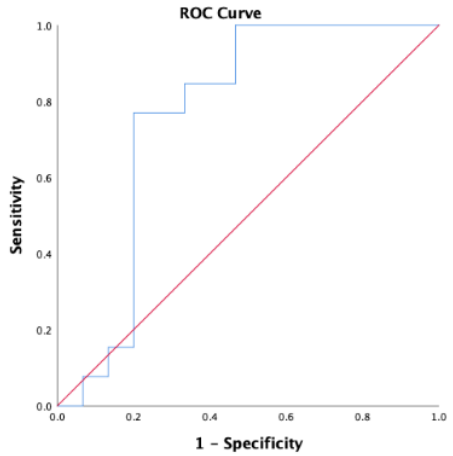
Legend: MAP=mean arterial pressure; SD=standard deviation. All values are mean±SD unless otherwise stated. [1]Paired t-test; [*]statistically significant ($p<0.05$).

Table 4. Efficacy of the IJVCI in evaluating fluid responsiveness

Initial IJVCI	Final IJVCI		n	p-value
	Low (<40%)	High (>40%)		
Low (<40%)	0	0		
High (>40%)	21	7	28	0.00[*]

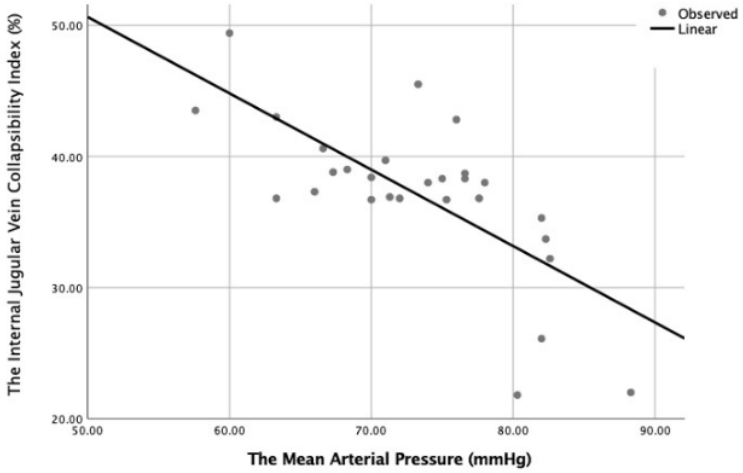
Legend: IJVCI=internal jugular vein collapsibility index.
This test used McNemar statistical test. [*]Significant difference with $p<0.05$.

Figure 1. ROC curve of IJVCI towards the increasing of MAP



Legend: ROC=receiver operating characteristic; IJVCI=internal jugular vein collapsibility index; MAP=mean arterial pressure. The cut-off value with the increasing of MAP was 44.40 with a sensitivity of 76.9% and specificity of 80%.

Figure 2. The correlation between IJVCI and MAP (p 0.000)



Legend: IJVCI=internal jugular vein collapsibility index; MAP=mean arterial pressure.

References

1. Vincent J-L, Weil MH. Fluid challenge revisited. Crit Care Med 2006;34:1333-7.
2. Weil MH, Henning RJ. New concepts in the diagnosis and fluid treatment of circulatory shock. Thirteenth annual Becton, Dickinson and Company Oscar Schwidetsky Memorial Lecture. Anesth Analg 1979;58:124-32.
3. Frost P, Wise MP. Recognition and early management of the critically ill ward patient. Br J Hosp Med (Lond) 2007;68:M180-3.
4. Marik PE, Lemson J. Fluid responsiveness: an evolution of our understanding. Br J Anaesth 2014;112:617-20.
5. Killu K, Coba V, Huang Y, Andrezejewski T, Dulchavsky S. Internal jugular vein collapsibility index associated with hypovolemia in the intensive care unit patients. Crit Ultrasound J 2010; 2:13-7.
6. Donahue SP, Wood JP, Patel BM, Quinn JV. Correlation of sonographic measurements of the internal jugular vein with central venous pressure. Am J Emerg Med 2009;27:851-5.
7. Stawicki SP, Kent A, Patil P, Jones C, Stoltzfus JC, Vira A, et al. Dynamic behavior of venous collapsibility and central venous pressure during standardized crystalloid bolus: A prospective, observational, pilot study. Int J Crit Illn Inj Sci 2015;5:80-4.
8. Elsadek WM, Elaela AHA, Nassar HM, Kamel MM, Mohamed AA, Ali HM. Sonographic Evaluation of internal jugular vein diameter and Cross-sectional Area Measurements in Correlation with Left Ventricular End Diastolic Area as a Tool for Perioperative Assessment of Volume Status in Pediatric Patients Undergoing Cardiac Surgery. Anesth Essays Res 2017;11:453-7.
9. Avcil M, Kapci M, Dagli B, Omurlu IK, Ozluer E, Karaman K, et al. Comparision of ultrasound-based methods of jugular vein and inferior vena cava for estimating central venous pressure. Int J Clin Exp Med 2015;8:10586-94.
10. Lipton B. Estimation of central venous pressure by ultrasound of the internal jugular vein. Am J Emerg Med 2000;18:432-4.
11. Kent A, Patil P, Davila V, Bailey JK, Jones C, Evans DC, et al. Sonographic evaluation of intravascular volume status: can internal jugular or femoral vein collapsibility be used in the absence of IVC visualization? Ann Thorac Med 2015;10:44-9.
12. Fluid challenge algorithm for critical care patients [image on the Internet]. 2006 May [cited 2023 Mar 7]. Avalaible from https://anaesthesiaconference.kiev.ua/downloads/fluid%20challenge%20algorithm_2006.pdf
13. Vosylius S, Sipylaite J, Ivaskevicius J. Sequential Organ Failure Assesment Score as the determinant of outcome for patients with severe sepsis. Croat Med J 2004;45:715-20.
14. Koch E, Lovett S, Nghiem T, Riggs RA, Rech MA. Shock index in the emergency department: utility and limitations. Open Access Emerg Med 2019:11:179-99.
15. Muller L, Toumi M, Bousquet P-J, Riu-Poulenc B, Louart G, Candela D, et al. An increase in aortic blood flow after an infusion of 100 ml colloid over 1 minute can predict fluid responsiveness: the mini-fluid challenge study. Anesthesiology 2011;115:541-7.

This page is intentionally left blank

Correlation between internal jugular vein collapsibility index and mean arterial pressure in assessing the response of fluid resuscitation in crit- ically ill patients

ORIGINALITY REPORT

15%	9%	10%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Central Florida Student Paper	1%
2	www.spandidos-publications.com Internet Source	1%
3	medscimonit.com Internet Source	1%
4	Wu, Yunfan, Shusheng Zhou, Zhihua Zhou, and Bao Liu. "A 10-second fluid challenge guided by transthoracic echocardiography can predict fluid responsiveness", Critical Care, 2014. Publication	1%
5	www.researchsquare.com Internet Source	1%
6	Jean-Louis Vincent. "Fluid challenge revisited", Critical Care Medicine, 05/2006 Publication	1%

7	Manjit Mahendran, Arvind Kumar, Smriti Hari, Mohd Usman et al. "Subclavian Vein Collapsibility as a Predictor of Fluid Responsiveness in Spontaneously Breathing Hypotensive Patients", New Emirates Medical Journal, 2023 Publication	1 %
8	api.repository.cam.ac.uk Internet Source	1 %
9	"ESICM 2010 WEDNESDAY SESSIONS 13 October 2010", Intensive Care Medicine, 2010 Publication	1 %
10	m.moam.info Internet Source	1 %
11	scholar.sun.ac.za Internet Source	1 %
12	journals.plos.org Internet Source	1 %
13	Alireza Zeraatchi, Fatemeh Safavi, Taraneh Naghibi. "Evaluation of the Effect of Three Different Tidal Volumes on Internal Jugular Vein Collapsibility Index in Hypovolemic Mechanically-Ventilated Patients Before and After Fluid Therapy", Journal of Advances in Medical and Biomedical Research, 2023 Publication	1 %

14	"Abstracts Criticare - IJCCM2024", Indian Journal of Critical Care Medicine, 2024 Publication	<1 %
15	"Annual Update in Intensive Care and Emergency Medicine 2017", Springer Science and Business Media LLC, 2017 Publication	<1 %
16	pure.bond.edu.au Internet Source	<1 %
17	www.hindawi.com Internet Source	<1 %
18	www.scribd.com Internet Source	<1 %
19	dergipark.org.tr Internet Source	<1 %
20	iris.univpm.it Internet Source	<1 %
21	Prastiya Indra Gunawan, Darto Saharso, Dian Purnama Sari. "Correlation of serum S100B levels with brain magnetic resonance imaging abnormalities in children with status epilepticus", Korean Journal of Pediatrics, 2019 Publication	<1 %
22	ejournal2.undip.ac.id Internet Source	<1 %

23	iris.unica.it Internet Source	<1%
24	journals.sbmu.ac.ir Internet Source	<1%
25	www.dovepress.com Internet Source	<1%

Exclude quotes	On	Exclude matches	< 10 words
Exclude bibliography	On		

Correlation between internal jugular vein collapsibility index and mean arterial pressure in assessing the response of fluid resuscitation in crit- ically ill patients

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8