ORIGINAL RESEARCH PAPER

General Surgery

AN OBSERVATIONAL STUDY ON SONOGRAPHIC ASSESSMENT OF INFERIOR VENACAVA DIAMETER AS A PREDICTOR OF SHOCK IN TRAUMA PATIENTS

KEY WORDS: Shock,IVC diameter,Collapsibility,EFAST,Resuscitation

Prof.P. Thangamani M.S., FMAS., FAES., FICS.,Professor, Institute of General Surgery, Madras Medical College, Chennai, Tamil Nadu, India.

Dr.K.Anandan M.S. Assistant Professor, Institute of General Surgery, Madras Medical College, Chennai, Tamil Nadu, India.

Dr.S.P. Sushmitha* M.S. Post Graduate, MS General Surgery, Institute of General Surgery, Madras Medical College, Chennai, Tamil Nadu, India. *Corresponding Author

ABSTRACT

The objective of this study was to evaluate the utility of sonographic measurement of IVC diameter as a predictor of shock in trauma patients. **METHODS:** This was a prospective observational study conducted in a tertiary care centre. After getting approval from ethical committee and written informed consent, 132 patients aged 18-70 years, brought to the emergency room after being subjected to trauma who satisfied the inclusion criteria were selected for the study. The vitals of the patients were recorded and detailed history and systemic examination was taken into account and sonographic measurement of IVC diameter done. **DISCUSSION:** This study shows that the measurement of IVC diameter is a reliable indicator of shock in trauma patients and may even predict it in patients who still have normal blood pressure due to sympathetic overactivity. In our study, one subject with a small IVC diameter in the shock group showed normal values for both blood pressure and pulse rate at arrival, but these values deteriorated within 12 hour of arrival. Secondly, serial measurements of IVC diameter can be used to monitor ongoing blood loss and monitor fluid therapy and can even be used as an alternative to direct central venous pressure measurement, which is not suitable as a routine procedure. Central venous pressure has its own limitation of invasiveness, time consumption and risk of bleeding. Measurement of IVC diameter, therefore, can be a very useful way to evaluate the patient's hemodynamic status. This was easily performed and was well suited in trauma patients because it could be performed in supine position and required no patient cooperation. The results of our study suggested, that IVC diameter was smaller in those patients with hypotension as compared to those with normotension. Patients with >50% collapsibility of IVC required aggressive resuscitation as compared to those with 50% collapsible in many patients who presented without hypotension suggesting blood loss despite normal blood pressure. IVC collapsibility reduced post resuscitation in both group of patients. The use of bedside ultrasound may be a very useful tool for rapidly stratifying the patients requiring immediate resuscitation, may even predict significant hypovolemia in patients who still have normal blood pressure due to sympathetic over activity, monitor ongoing blood loss and also it can be used to assess fluid responsiveness. IVC diameter evaluation can be done soon after EFAST scan. It can be done without any special preparation or any invasive procedures and with an added advantage of preventing over or under resuscitation. **CONCLUSION:** Based on this observational study, we conclude that sonographic measurement of diameter of inferior vena cava, a simple bedside procedure might be very helpful in predicting shock earlier in patients with trauma even with stable vitals, which can make a huge difference in deciding aggression of resuscitation in selected patients, to prevent the progression of stages of shock.

INTRODUCTION:

Point-of-care ultrasound has been increasingly used in evaluating shocked patients including the measurement of inferior vena cava diameter (IVC). Nevertheless, there have been conflicting results regarding its value [4-6]. There are four components that affect the outcome of ultrasound studies. These are the effectiveness and technical limitations of the ultrasound machine, the experience of the operator, the body built of the patient, and the pathology studied.

TECHNICAL CONSIDERATIONS

Operators should standardize their technique in scanning the IVC. IVC can be measured through different approaches including the subxiphoid or subcostal approach [7,8]. It is preferred to measure the IVC directly through a trans-hepatic approach using a portable machine and a small print convex array probe with a frequency of 3-5 MHZ while the patient is in supine position. The probe is located in the mid-clavicular line between the ribs of the right lower chest wall at 90 degrees perpendicular to the skin. The marker points proximally towards the head. The probe may be slightly directed towards the right to be parallel to the IVC. The probe is then shifted slowly transversely to get the best longitudinal perpendicular view. This is better than the subxiphoid approach [7] as the IVC is located slightly to right and the diameter of the IVC may be overestimated by getting an oblique section.

In general, it is advised to use the B mode to evaluate the gross collapsibility of the IVC and the M mode to accurately measure the changes in IVC diameter. The IVC can be measured in both longitudinal and transverse sections.

Figure 1

The IVC diameter is measured in time-motion mode using a moderate speed (25 mm/s), ideally with acquisition of respiratory traces. Three measurements should be averaged. The IVC diameter can be measured either close to its entrance to the right atrium or 1 to 2 cm caudal to the hepatic vein– IVC junction (approximately 3–4 cm from the junction of the IVC and the right atrium). Compared with the caudal location, measurement of IVC collapsibility close to the IVC–right atrium junction may be influenced more by contraction of the diaphragm. Measurements over one respiratory cycle should be obtained first in end-expiration and then in early inspiration.

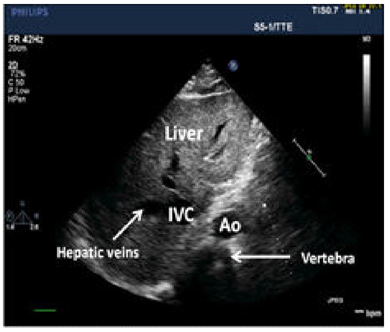

Figure 2

Figure:2 Identification of the inferior vena cava (IVC) in transverse view. The probe is positioned at the subxiphoid level, perpendicular to the skin.

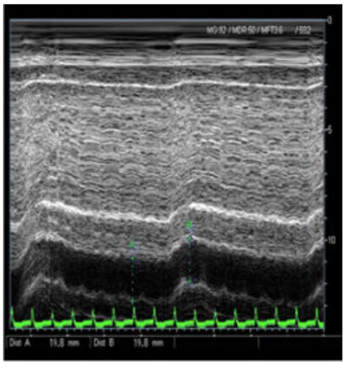

Figure 3

Figure3: Measurement of inferior vena cava respiratory variations in time-mode. Measurements are performed at end-expiration (A = 19.8 mm) and during inspiration (B = 19.8 mm).

It has more recently been integrated into several critical care/emergency ultrasound protocols as a non-invasive estimate of central venous pressure (CVP).

The American Society of Echocardiography recommends that the following specific values be used when guiding interventions:

Right Atrial Pressure (RAP)

	IVC Size	% Collapse	RA Pressure
Low	< 2.1 cm	> 50 %	3 mmHg
Intermediate	< 2.1 cm	< 50 %	8 mmHg
	> 2.1 cm	> 50 %	8 mmHg
High	> 2.1 cm	< 50 %	15 mmHg

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IVC v CVP

Correlation Between IVC Diameter Plus CI and CVP

IVC Max Diameter (cm)	CI	CVP (mmHg)
< 1.5	100% (total collapse)	0-5
1.5-2.5	> 50%	6-10
1.5-2.5	< 50%	11-15
> 2.5	< 50%	16-20
> 2.5	0% (no collapse)	>20

STUDY DESIGN:

The study was conducted on 132 patients brought to emergency room in Department of General surgery in Madras medical college, Chennai over a period of six months. Patients were explained about the procedure in detail and informed written consent was obtained.

METHODOLOGY:

After getting approval from ethical committee and written informed consent, 132 patients aged 18-70 years, brought to the emergency room after being subjected to trauma who satisfied the inclusion criteria were selected for the study. The vitals of the patients were recorded and detailed history and systemic examination was taken into account and sonographic measurement of IVC diameter done and patients were grouped into two: Group A patients with hypotension and Group B patients with normotension. Sonographic measurement of Inferior vena cava diameter at inspiration and expiration were recorded in both the groups and observed.

RESULTS:

Table: 1

AGE DISTRIBUTION				
	NORMOTENSIVE		HYPOTENSIVE	
	FREQUENCY	PERCENT	FREQUENCY	PERCENT
20-30YRS	53	53.5	16	48.5
30-40YRS	26	26.2	14	42.4
40-50YRS	18	18.1	3	9.1
50-60YRS	2	2.2	0	0
TOTAL	99	100	33	100

Table 2:

	NORMOTENSIVE GROUP				HYPOTENSIVE GROUP			
SEX	FREQUENCY	PERCENT	VALI	CUMULATIV	FREQUENCY	PERCENT	VALID PERCENT	CUMULATIVE PERCENT
MALE	64	64.6	64.6	64.6	21	63.6	63.6	63.6
FEMALE	35	35.4	35.4	100.0	12	36.4	36.4	100.0
TOTAL	99	100.0	100.0		33	100.0	100.0	

Table 3:

GROUP	NORMOTENSIVE				HYPOTENSIVE			
PARAMETER	MEAN	SD	95% CONFIDENCE INTERVAL		MEAN	SD	95% CONFIDENCE INTERVAL	
			LOWER	UPPER			LOWER	UPPER
AGE	30.97	7.731	29.61	32.4	30.42	6.129	28.3	32.45
SBP (mmHg)	118.35	7.485	116.78	119.9	79.03	3.235	78	80.12
DBP (mmHg)	79.85	6.21	78.56	81.03	50.67	5.588	48.79	52.76
PR (Beats/min)	90.65	12.358	88.22	93.21	127.27	3.702	126.06	128.42
MAP (mmHg)	92.44	6.128	91.12	93.67	59.88	4.505	58.42	61.57
SI (HR/SBP)	0.7699	0.14948	0.7406	0.8022	1.6121	0.10475	1.5767	1.6457
MSI (HR/MAP)	0.9893	0.18837	0.9526	1.0276	2.1355	0.21088	2.0591	2.2015
IVCE (mm)	11.6786	2.96862	11.1003	12.2936	7.8715	0.43248	7.7362	8.0312
IVCI (mm)	6.7037	3.16763	6.0582	7.3582	3.46	0.4182	3.3322	3.6103
CI [(IVCE-IVCI)/IVCE]%	45.68	14.218	42.9	48.73	55.94	3.259	54.79	56.94

- The age distribution in Normotensive Group is between 20-30 years is 53.5%, 30-40 years is 26.2%, 40-50 years is 18.1%, 50-60 years is 2.2%.
- The age distribution in Hypotensive Group is between 20-30 years is 48.5%, 30-40 years is 42.4%, 40-50 years is 9.1%, 50-60 years is 0%.
- The gender distribution in Normotensive and Hypotensive group in Male is 65% & 64% and Female is 35% & 36% respectively.
- The frequency of distribution of systolic blood pressure in Normotensive and Hypotensive group with mean values of 118.35 and 79.03 respectively.
- The frequency of distribution of diastolic blood pressure in Normotensive and Hypotensive group with mean values of 79.85 and 50.67 respectively.
- The frequency of distribution of mean arterial pressure in

Normotensive and Hypotensive group with mean values of 92.44 and 59.88 respectively.

- The frequency of distribution of pulse rate in Normotensive and Hypotensive group with mean values of 90.65 and 127.27 respectively.
- The IVCE was positively correlated with systolic blood pressure with R value of 0.758 and R square value of 0.575.
- There is a significant correlation between Collapsibility Index & Shock Index with R value of 0.575 and R square value of 0.331.
- In our study, there are also patients with normal BP showing decreased IVC diameter and collapsibility index of more than 50%, indicating that those patients were in early stages of shock.

DISCUSSION:

The IVC is a highly compliant vessel, whose size and dynamic vary with the changes in total body water and respirations. Measurement of IVC diameter is easily performed and is well suited in trauma patients because it can be performed in supine position and requires no patient cooperation. In addition, this can be performed rapidly and can be added to the FAST sonography of the trauma patient with minimum additional time. The use of M-mode is a very useful innovation to quickly measure IVCe and IVCi diameters and the collapsibility index.

In our study, the most common age group affected was 20-35 years. The mean age of patients in hypotension group (29 years) and patients in normotension group (32 years) were comparable to Nguyen et al[6] (38 and 39 years respectively) and Matsumoto et al(41 years). It was observed that, male patients (65%) had more trauma which was comparable to other studies done by Yang Li et al[8](83%), Airapetian et al[9](51%). In all studied groups of patients, road traffic accident, fall from height and assault were the common mechanisms of injury. In our study, the mean heart rate of all patients was 104 beats/min which was higher than study done by Radomski et al, 88.6 beats/min. In our study, mean systolic blood pressure of all patients was 102 mmHg, which was higher as compared to study done by Radomski et al [10](97.1 mmHg). Our study revealed that both IVCe and IVCi are significantly smaller in patients with shock, a finding that has also been reported in a recent study. The maximum IVCe diameter in the shock group was 8 mm. In a study by Ando et al[12]., in hemodialysis patients, the IVCe diameter below which hypotension would occur was found to be 8±3 mm. Furthermore, Yanagava et al[11]. found that IVCe diameter of below 9 mm is associated with the presence of shock in trauma patients. In certain pathological conditions that are not uncommon in trauma patients, such as pain, anxiety, and acid-based disturbances, forceful inspiration can alter the diameter of the IVCi and make it unsuitable as a standard of CBV. According to the study done by Henry et al [14], a Caval Index (collapsibility index) of greater than or equal fifty percent (CI % ≥ 50%) was predictive of greater fluid responsiveness to initial bolus of 500ml to 2000ml than a Caval Index of less than fifty percent (CI ≥ 50%) . The normal shock index, defined as heart rate divided by systolic blood pressure, ranges from 0.5 and 0.72 in adults. An increase in shock index occurs with progressive loss in circulation blood volume (CBV) and a shock index >1 was an indicator of blood loss and high mortality. It was observed in our study that, as the shock index (SI) increased, patient's prognosis worsened but was not statistically significant (P=0.14). Kevin et al, [21] in their study found correlation between shock index of >0.9 and mortality. They even found better correlation by age specific shock index. Jeffrey and Federl reported that a collapsed IVC indicated hypovolemia secondary to major blood loss in six of seven trauma patients. They also reported that none of the trauma patients with normal IVC developed clinical hypovolemia in the immediate period after CT scan. Mirvis et al. noted a flattened IVC in 10 of 13 patients who were in shock after blunt abdominal trauma.

CONCLUSION:

Based on this observational study, we conclude that sonographic measurement of diameter of inferior vena cava, a simple bedside procedure might be very helpful in predicting shock earlier in patients with trauma even with stable vitals, which can make a huge difference in deciding aggression of resuscitation in selected patients, to prevent the progression of stages of shock. However, there are certain limitation to this study like operator dependence, increased intra-abdominal pressure, right sided heart failure

ABBREVATIONS:

IVC	-	INFERIOR VENA CAVA
SBP	–	SYSTOLIC BLOOD PRESSURE
DBP	–	DIASTOLIC BLOOD PRESSURE
MAP	-	MEAN ARTERIAL PRESSURE
IVCE	–	IVC DIAMETER IN EXPIRATION
IVCI	–	IVC DIAMETER IN INSPIRATION
CI	–	COLLAPSIBILITY INDEX
CVP	–	CENTRAL VENOUS PRESSURE
RAP	–	RIGHT ATRIAL PRESSURE

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