Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 19s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Ultrasonographic assessment to identify early phase of hypovolemic shock in traumatic patients using IVC:AA diameter index

Dr. Sreelakshmi VK[1], Dr. Haneendhar[2], Dr. Melvin Dominic[*3], Ganeshamoorthy G[4], Dr. Sudhier Sharan B[5], Dr. Jithin Gopan S[6], Dr. Karthika Santhosh[7]

[1]Post graduate Third year, MD Emergency medicine Vinayaka Missions Kirupananda Variyar Medical College, Chinnaseeragapadi, Salem- 636308. Email ID: sreelakshmiaravind7@gmail.com

[2]Postgraduate Third year MD Emergency medicine Vinayaka Missions Kirupananda Variyar Medical College, Chinnaseeragapadi, Salem- 636308

[*3]Associate Professor, MD Emergency medicine Vinayaka Missions Kirupananda Variyar Medical College, Chinnaseeragapadi, Salem- 636308

[4]Assistant professor, School of Allied health Sciences Faculty Vinayaka Missions Kirupananda Variyar Medical College, Chinnaseeragapadi, Salem- 636308

[5]Postgraduate Second year, MD Emergency medicine, Vinayaka Missions Kirupananda Variyar Medical College, Chinnaseeragapadi, Salem-636308

[6]Postgraduate Ist year, MD Emergency medicine, Vinayaka Missions Kirupananda Variyar Medical College, Chinnaseeragapadi, Salem-636308

[7]Postgraduate Ist year, MD Emergency medicine, Vinayaka Missions Kirupananda Variyar Medical College, Chinnaseeragapadi, Salem-636308

*** Corresponding Author**
Dr. Melvin Dominic
Email ID: dr.melvindominic@gmail.com

Cite this paper as: Dr. Sreelakshmi VK, Dr. Haneendhar, Dr. Melvin Dominic, Ganeshamoorthy G, Dr. Sudhier Sharan B, Dr. Jithin Gopan S, Dr. Karthika Santhosh, (2025) Ultrasonographic assessment to identify early phase of hypovolemic shock in traumatic patients using IVC:AA diameter index. *Journal of Neonatal Surgery*, 14 (19s), 86-93.

ABSTRACT

Introduction and Objectives: Trauma remains a leading cause of morbidity and mortality, especially in the reproductive age group. Hypovolemic shock, a major consequence of trauma, often lacks classical clinical features in its early stages, making early diagnosis challenging. Traditional parameters such as hypotension, tachycardia, and laboratory markers are often non-specific. The inferior vena cava (IVC) to abdominal aorta (AA) diameter index (IVC:AA index) has emerged as a reliable, non-invasive, bedside ultrasonographic tool for assessing early hypovolemia (Class I shock). This study evaluates the efficacy of the IVC:AA index in detecting early hypovolemia, potentially aiding timely intervention and improving patient outcomes.

Materials and Methods: A prospective analytical study was conducted in the Department of Emergency Medicine, VMKVMCH, Salem, from June 2021 to June 2022, following ethical committee approval. The study included trauma patients undergoing ultrasonographic evaluation of the IVC and AA using a Mindray M5 portable ultrasound with a 3.5–5 MHz curvilinear probe. Measurements were taken at standardized anatomical landmarks in supine patients. The IVC diameter was measured 2 cm from the right atrium inlet, while the AA diameter was measured 10 mm above the celiac trunk. Three readings were recorded to obtain mean values. Correlations were analyzed between IVC:AA ratios, shock index (SI), and patient demographics. Statistical analysis was conducted using SPSS, with a p-value <0.05 considered significant.

Results: A total of trauma patients were analyzed. The mean IVC:AA index was significantly lower in patients with early hypovolemia. A cut-off value of 1.14 was determined as indicative of Class I hypovolemic shock. The index correlated strongly with vital signs, including blood pressure and SI. Patients with lower IVC:AA indices required early fluid resuscitation. The study confirmed the reliability of ultrasonographic assessment in detecting early hypovolemia before traditional clinical signs manifest.

Conclusion: The IVC:AA index is an effective, bedside ultrasonographic tool for early detection of hypovolemic shock in trauma patients. Its integration into emergency protocols can facilitate timely resuscitation and improve patient outcomes.

Keywords: *Hypovolemic Shock, Trauma, Ultrasonography, Inferior Vena Cava, Abdominal Aorta, IVC:AA Index, Emergency Medicine, Early Diagnosis, Fluid Resuscitation, FAST Scan.*

1. INTRODUCTION

Trauma is the leading cause of mortality and morbidity in the reproductive age group. The mortality and morbidity are mainly attributed to hypovolemic shock [1]. Hypovolemia results in a reduction of systemic venous return causing reduction in the stroke volume, responsible for the decrease in cardiac output. Classical clinical features of hypovolemia are absent in early hemorrhagic shock. Presence of documented hypotension, tachycardia or sign of tissue hypoperfusion are insufficient to confirm the diagnosis of hypovolemia as they are non-specific[2] Laboratory parameters such as metabolic acidosis, high urea level and hemoconcentration are neither non-sensitive nor specific[3] In hypovolemia, early fluid resuscitation and definitive corrective measure of the source of bleeding along with early non-invasive and bedside investigation will be helpful in effective management. Inferior Vena Cava (IVC)/Aorta(Ao) diameter (IVC/Ao index is a convenient, quick and effective way of evaluating body fluid status at an early phase (Class 1 hypovolemic shock)[4]. Study is to observe the Efficacy of IVC/Aorta (Ao) diameter index. reaching accurate diagnosis of early diagnosis of hypovolemic phase and facilitate the initiation of definitive management and treatment in hope to reduce the mortality and morbidity, either in post-traumatic condition or in any body fluid deprived condition. Now a day ultrasound units are present in most Emergency room to routinely perform the focused assessment sonography in trauma victims (FAST) and emergency USG in critically ill patients.

2. MATERIALS AND METHODOLOGY

This study is Prospective analytical study conducted in the Department of Emergency Medicine VMKVMCH, Salem over a time period from June 2021 to June 2022, after obtaining Ethical committee approval the study is under taken.

VMKV hospital has a 30 bedded Emergency Department and trained emergency physicians. We receive a variety of Emergency trauma cases in which fluid resuscitation plays an important role.

The ultrasound examination was performed by the researcher who was familiar with ultrasound. The researcher, who was the second year trainee in emergency medicine specialty programmer, had obtained necessary testimonial validation by a consultant radiologist.

The principal of abdominal ultrasound and hands on training, in particular in IVCD and AAD measurement, were carried out on a total of 20 volunteers. The consultant demonstrated the appropriate technique on the first few patients, followed by the researcher himself performing in front of the consultant. In subsequent patients, the researcher will do the initial measurement, followed by the consultant, in order to verify and validate the researchers. There was a positive and significant correlation between the researcher and the radiologist score. The subsequent measurement was done by researcher alone on the real participants. The vital signs were taken. The height and weight were also recorded. They were subsequently placed on an adjustable couch. The ultrasound measurement was carried out once the donor was in comfortable supine position. The measurement evaluation was done with an ultrasound machine Premium Hand-Carried Colour Doppler Diagnostic Mindray® Model M5 fabricated in China. Curvilinear probe 3.5 to 5 MHz was used with B mode scan. The probe was placed underneath the xiphoid process in a longitudinal position. The IVCD was measured 2 cm from the junction of right atrium inlet, where its anterior and posterior walls were parallel. The IVCD was measured during regular breathing cycle, and the maximum value was recorded. The AAD was measured 10 mm above the celiac trunk. Three readings were taken to get the mean value for both diameters.

The procedure is explained in patients own language and oral consent was obtained from all the eligible candidates. While the patient lie supine, the using standard at random time by emergency physician. During the same period simulations assessment of IVC/ABDOMINAL AORTA inferior vena cava and abdominal aorta diameter was done by me and emergency physician, who owns a certified training experience in ultrasound imaging and is unaware of a diagnosis of the patients. The results obtained to each other and the required data is documented.

Curvilinear probe 3.5 to 5 MHz was used with B mode scan Sonosite ultrasound machine easily available for bedside sonography at the emergency room the subxiphoid region of the patient lying supine pointer towards the right hip until, Demographic data consisted of gender, age, race, weight, height, shock index (SI) and body mass index (BMI) were recorded. The observed primary outcome was the difference of IVCD:AAD ratios pre and post blood donation which was analyzed by using paired *t* test. The secondary data included the blood pressure and pulse rate pre and post blood donation. Correlation studies were carried out between the BMI and SI and the IVCD, AAD and IVCD:AAD index. Hepatic veins into the ivc /abdominal aorta visualized. The probe is then placed longitudinal plane at the junction and longitudinal section of the ivc/abdominal aorta visualized conformed Seen during right atrium when see probe. The maximum internal anteroposterior diameter of ivc and abdominal aorta junction longitudinal section on the M mode.

Next the transverse aortic section in the supxiphoid region is noted lying left lateral to IVC, appearing more circular and pulsatile. The maximum internal anteroposterior diameter of the abdominal aorta in the longitudinal section at the same plane is measured on the M mode of the ultrasound machine.

The inferior vena cava /abdominal aorta index is now derived by taking the ratio of the two respective diameters measured.

Picture: Bedside portable digital ultrasound scan machine, the Sonosite M Turbo

Picture: Curvilinear probe of the ultrasound machine used visualize the IVC and ABDOMINAL AORTA

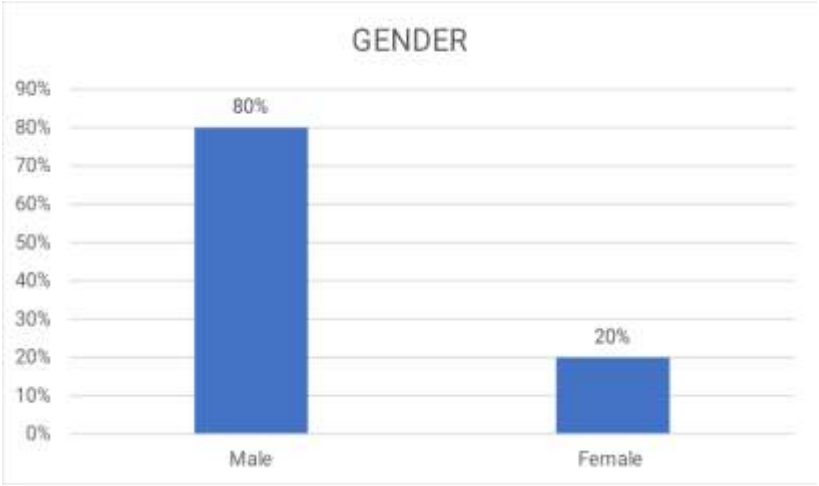
Some even view ultrasound as a tool comparable to stethoscope in daily clinical practice. The routine use of ultrasound in trauma through focused assessment with sonography in trauma (FAST), which is incorporated as an adjunct to primary survey and resuscitation in ATLS manual, has made the presence of the machine in ED as a must [24, 25]. We suggest that the FAST should also include the assessment of IVCD and AAD as part of the assessment of hypovolemia post trauma.

Statistical Analysis-

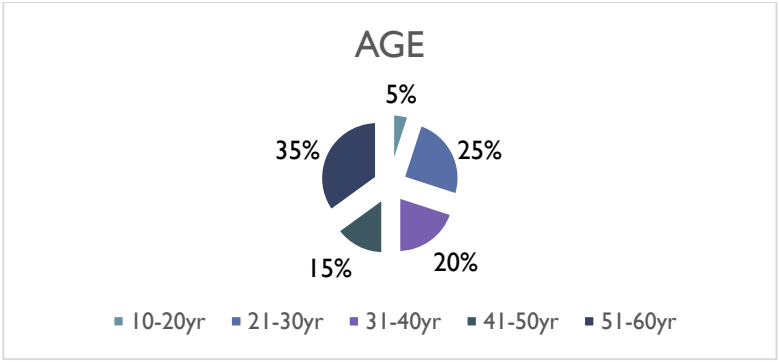
All data were compiled in to Microsoft excel 2021 spread and analysis was accomplished using statistical method for calculations.

3. RESULTS

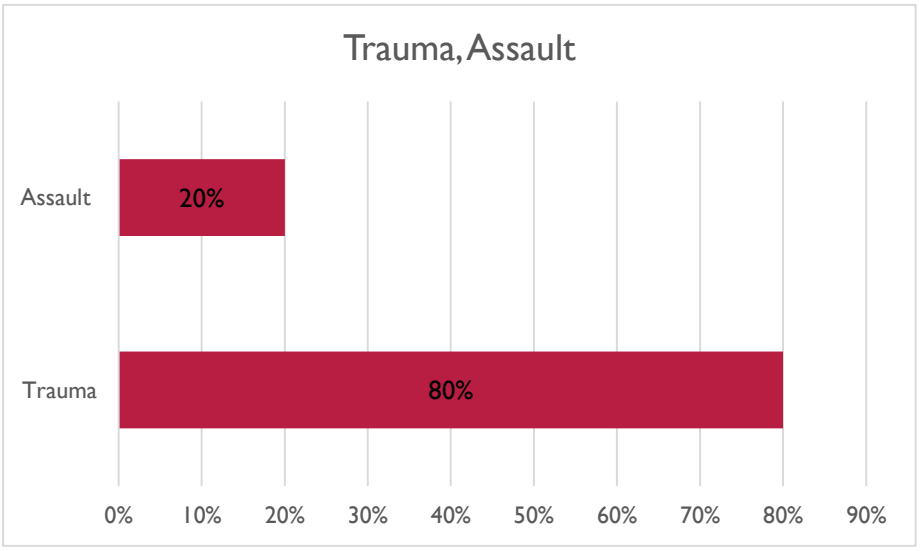
Graph 1: The schematic representation below shows the number of patients enrolled in this study



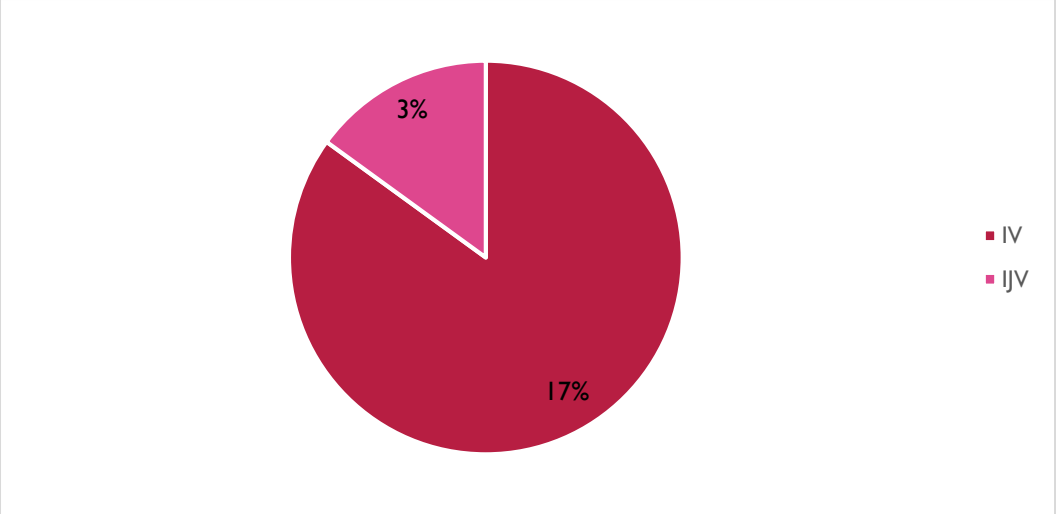
Graph 2: Pie graph depicting percentage distribution age wise (years)



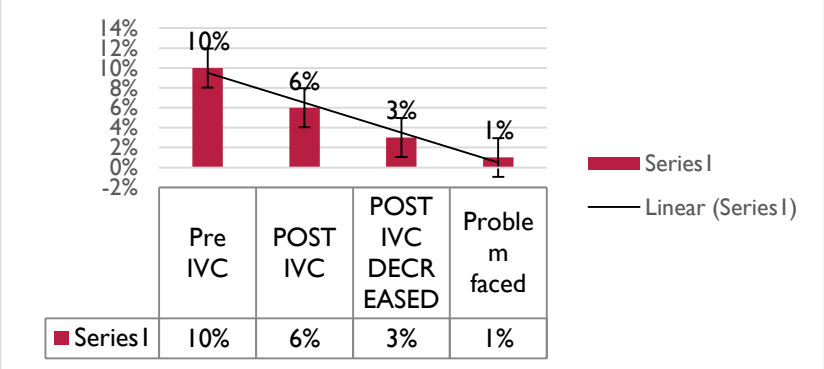
Graph 3: The graph depicting percentage distribution Trauma and Assault Number of patients



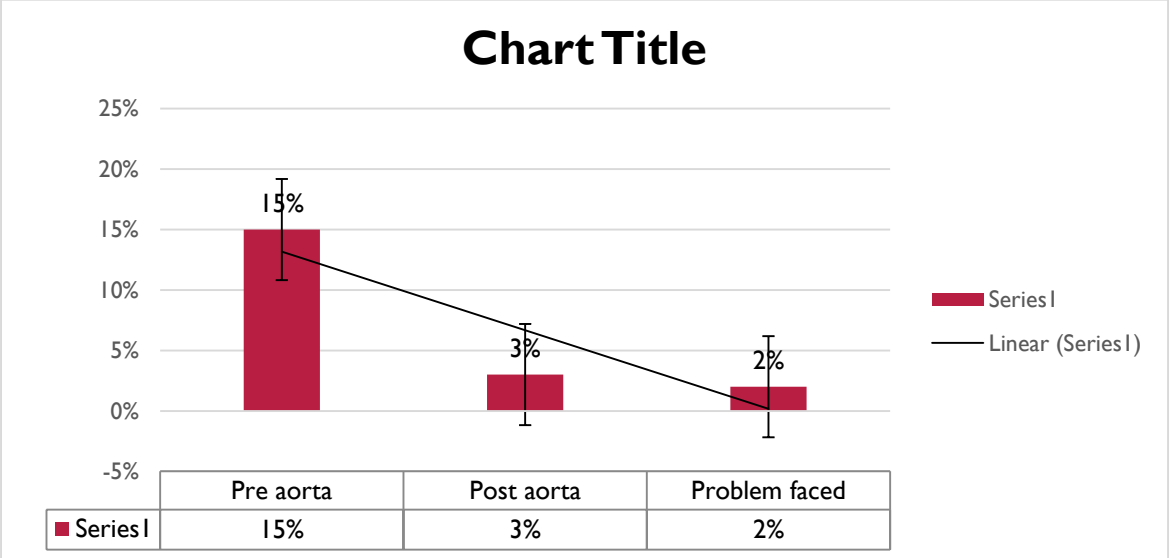
Graph 4: Pie diagram depicting percentage distribution of various sites of Intra Vein and Central venous access Or IJV



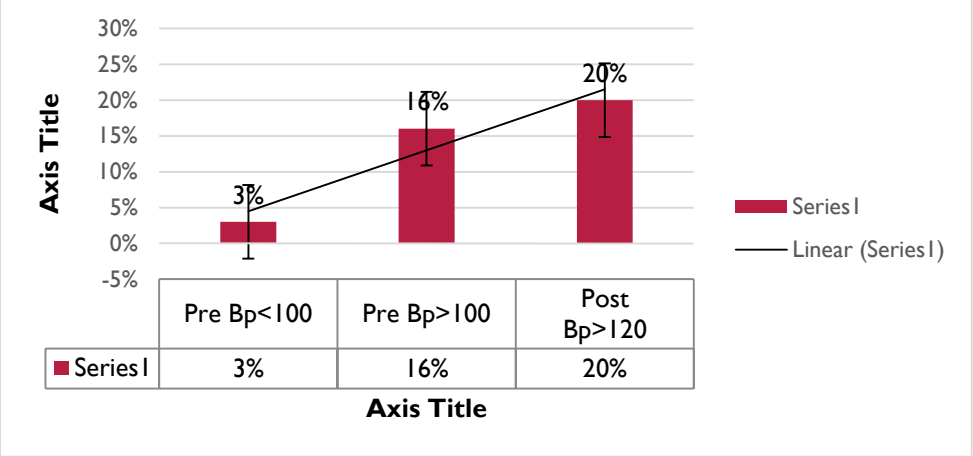
Graph 5: The diagram depicting percentage distribution of various in Inferior vena cava (IVC)



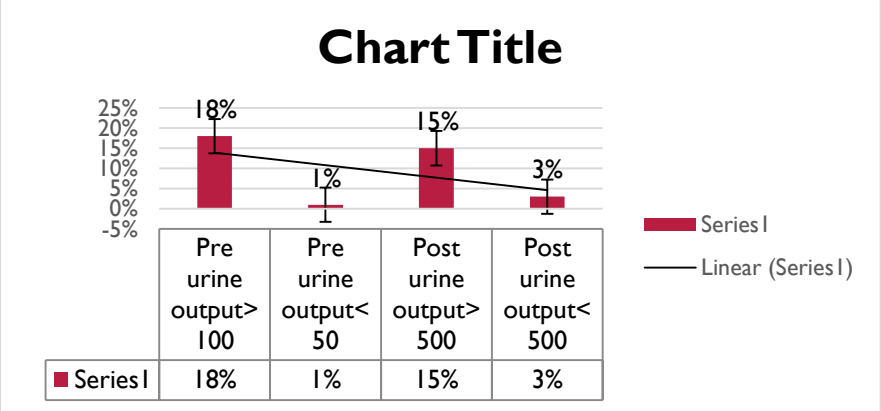
Graph 6: The diagram depicting percentage distribution of various in Abdominal Aorta (AA)



Graph 7: The diagram depicting percentage distribution of various in Blood pressure (BP)



Graph 8: The diagram depicting percentage distribution of various in Urine output



4. DISCUSSION

The ability of emergency physician to differentiate hypovolemic shock with the other type of shock will facilitate the initial management and resuscitation without the need to endeavor into much complicated and invasive procedures. Over reliance on classical signs and symptoms of hypovolemia as those summarized by Advance Trauma Life Support (ATLS) will lead to myriads of possibilities and differential diagnosis of the underlying causes [5]. Likewise, the biochemical markers, even some are useful, are of limited use in ED, essentially due to time factor [6]. The ATLS guideline for hypovolemic shock classification which has the stepwise vital sign categorization has been used widely in order to facilitate clinician evaluating hydration or volume status [7]. However, this classification is not fully supported by robust evidence based [8, 9].

The use of ultrasound in trauma is advocated primarily in discovering the presence of free fluid in the dependent area of intra peritoneal cavity, pericardial sac, thoracic cavity and the possibility of tissue damage in the liver and spleen [10]. The specificity and sensitivity of ultrasound in detecting intra peritoneal free fluid is 86 and 99 %, respectively [11, 12]. However, the amount of fluid itself is not predictable through ultrasound [13]. Ultrasonographically measured IVC diameter was recognized as a non-invasive way to assess fluid status in critical care and acute setting. It was pioneered by nephrologists and then expanded further by cardiologist and emergency physician. Recently, the IVC diameter (IVCD) measurement is used to assess intravascular fluid status in patients who are stable hemodynamically but potentially may dwell into profound shock [14]. The change of the IVCD is very well explained by the nature of the structural wall of the vessel itself. It is a highly compliant vessel with good sensitivity to changes in intravascular volume [15]. Studies had shown repeatedly that the IVCD changes before there are any apparent detectable changes in vital signs [16, 17]. This has rendered the use of IVCD measured ultrasonography becoming more popular among the fraternity of critical care and acute medicine, including in emergency department.

To our knowledge, no study was done before with regard to the IVCD:AAD index measurement in the early of hypovolemia (class I shock). Our study has further confirmed and enhances Kosiak's study and its applicability in clinical setting. In our study, the focus is on the ratio or index of inferior vena cava to aorta diameter (IVCD:AAD). We believe that in order to obtain a valid result of the parameter, the emphasis should be on the standardization of measurement method of IVCD:AAD, rather than relying much on respiratory cycle. Further, it is also a question of feasibility in ED setting to measure IVCD in certain phase of respiration. Physiologically, the AAD does change with cardiac cycle and with fluid loss [18]. The changes

are the result of interaction between intravascular fluid volume and the compliance of the wall. To our knowledge, there are very limited or absence of studies done on assessing the aorta diameter, in particular relating to the IVCD:AAD index level in hypovolemic state [19]. Agreeably, the range of size obtained in this study might be slightly lower than those found from other studies [20]. This might be attributed to smaller physical size of Asian population. Similar observation of aortic diameter variance was reported among black population in the USA [21]. With mathematical calculation, we propose IVCD:AAD index cut-off point for hypovolemic shock class I as 1.14. Any index measurement below the value given should be considered as fluid deprived and in the early phase of hypovolemic shock (class I shock). Our study has proven the use of the index to diagnose hypovolemic shock at the very early stage. We hope the use of sonography among critically ill patients can be an adjunct apparatus in assisting the physician to diagnose and manage patients in a more efficient way. The dramatic growth of ultrasound use in ED has led to the development of various ultrasonography techniques, protocols and algorithms in order to expedite diagnosis with high accuracy and reliability [22, 23]. Some even view ultrasound as a tool comparable to stethoscope in daily clinical practice. The routine use of ultrasound in trauma through focused assessment with sonography in trauma (FAST), which is incorporated as an adjunct to primary survey and resuscitation in ATLS manual, has made the presence of the machine in ED as a must [24, 25]. We suggest that the FAST should also include the assessment of IVCD and AAD as part of the assessment of hypovolemia post trauma. We also suggest the development of software in the ultrasonography machine that automatically calculates the IVCD:AAD index. The use of the sonography in the assessment of fluid loss is ideally carried out as early as possible such as during the pre hospital care and at the triage counter in the ED. This technique can be easily taught among the paramedics and the nurses with minimal difficulty [26].

Few limitations arise from our study. This study was conducted in relatively healthy donors, who have no other confounding factors and co-existing clinical issues, which is not the case in real situation. The above result was not tested in intubated or ventilated patient. We expect the result might vary in view of changes in intra-thoracic pressure and other physiological changes. In assessing intra-abdominal structure with ultrasound, the main limitation is the bowel gas and variability in anatomical position. Despite of the limitations, this study can be a preliminary step in providing new insight of the utility of IVCD:AAD index in mild hypovolemic state and with the ease of use and as a non-invasive method, we strongly recommend that this method of assessing the early fluid loss in any condition can be further explored in a bigger scale research especially in the real ED setting.

5. CONCLUSION

The ultrasonography use in trauma patients has become increasingly important as a bedside assessment tool which is non-invasive and quick. The use of IVC:AA diameter index in detecting the early phase of hypovolemia is a promising technique to detect mild hypovolemia and should be studied in bigger research capacity in the near future.

REFERENCES

[1] Hardaway RM. Traumatic shock alias posttrauma critical illness. Am Surg. 2000;66(3):284–90.CAS PubMed Google Scholar

[2] Chen L, McKenna TM, Reisner AT, Gribok A, Reifman J. Decision tool for the early diagnosis of trauma patient hypovolemia. J Biomed Inform. 2008;41(3):469–78. doi:10.1016/j.jbi.2007.12.002. Epub 2008 Jan 18.Article PubMed Google Scholar

[3] McGhan LJ, Jaroszewski DE. The role of toll-like receptor-4 in the development of multi-organ failure following traumatic haemorrhagic shock and resuscitation. Injury. 2012;43(2):129–36. doi:10.1016/j.injury.2011.05.032.Article PubMed Google Scholar

[4] Kosiak W, Swieton D, Piskunowicz M. Sonographic inferior vena cava/aorta diameter index, a new approach to the body fluid status assessment in children and young adults in emergency ultrasound—preliminary study. Am J Emerg Med. 2008;26(3):320–5.Article PubMed Google Scholar

[5] Johari HG, Eskandari S. New trauma protocols versus advanced trauma life support recommendations. J Trauma. 2011;71(4):1097. doi:10.1097/TA.0b013e3182302847.Article PubMed Google Scholar

[6] Odom SR, Howell MD, Silva GS, Nielsen VM, Gupta A, Shapiro NI, et al. Lactate clearance as a predictor of mortality in trauma patients. J Trauma Acute Care Surg. 2013;74(4):999–1004.Article CAS PubMed Google Scholar

[7] Esposito TJ, Sanddal ND, Hansen JD, Reynolds S. Analysis of preventable trauma deaths and inappropriate trauma care in a rural state. J Trauma. 1995;39(5):955–62.Article CAS PubMed Google Scholar

[8] Graham CA, Parke TR. Critical care in the emergency department: shock and circulatory support. Emerg Med J. 2005;22(1):17–21.PubMed Central Article CAS PubMed Google Scholar

[9] Brasel KJ, Guse C, Gentilello LM, Nirula R. Heart rate: is it truly a vital sign? J Trauma. 2007;62(4):812–7.Article PubMed Google Scholar

[10] Beck-Razi N, Fischer D, Michaelson M, Engel A, Gaitini D. The utility of focused assessment with sonography for trauma as a triage tool in multiple-casualty incidents during the second Lebanon war. J Ultrasound Med. 2007;26(9):1149–56.PubMed Google Scholar

[11] Tsui CL, Fung HT, Chung KL, Kam CW. Focused abdominal sonography for trauma in the emergency department for blunt abdominal trauma. Int J Emerg Med. 2008;1(3):183–7.PubMed Central Article

[12] Rose JS. Ultrasound in abdominal trauma. Emerg Med Clin North Am. 2004;22(3):581–99. vii.Article PubMed Google Scholar

[13] Rose JS, Richards JR, Battistella F, Bai AE, McGahan JP, Kuppermann N. The fast is positive, now what? Derivation of a clinical decision rule to determine the need for therapeutic laparotomy in adults with blunt torso trauma and a positive trauma ultrasound. J Emerg Med. 2005;29(1):15–21.Article PubMed Google Scholar

[14] Lyon M, Blaivas M, Brannam L. Sonographic measurement of the inferior vena cava as a marker of blood loss. Am J Emerg Med. 2005;23(1):45–50.Article PubMed Google Scholar

[15] Byeon K, Choi JO, Yang JH, Sung J, Park SW, Oh JK, Hong KP. The response of the vena cava to abdominal breathing. J Altern Complement Med. 2012;18(2):153–7.

[16] Grant E, Rendano F, Sevinc E, Gammelgaard J, Holm HH, Gronvall S. Normal inferior vena cava: caliber changes observed by dynamic ultrasound. AJR Am J Roentgenol. 1980;135(2):335–8.Article CAS PubMed Google Scholar

[17] Kusaba T, Yamaguchi K, Oda H, Harada T. Echography of inferior vena cava for estimating fluid removed from patients undergoing hemodialysis. Nippon Jinzo Gakkai Shi. 1994;36(8):914–20.CAS PubMed Google Scholar

[18] Sefidbakht S, Assadsangabi R, Abbasi HR, Nabavizadeh A. Sonographic measurement of the inferior vena cava as a predictor of shock in trauma patients. Emerg Radiol. 2007;14(3):181–5.Article CAS PubMed Google Scholar

[19] Ando Y, Yanagiba S, Asano Y. The inferior vena cava diameter as a marker of dry weight in chronic hemodialyzed patients. Artif Organs. 1995;19(12):1237–42.Article CAS PubMed Google Scholar

[20] Muhs BE, Vincken KL, van Prehn J, Stone MK, Bartels LW, Prokop M, et al. Dynamic cine-CT angiography for the evaluation of the thoracic aorta; insight in dynamic changes with implications for thoracic endograft treatment. Eur J Vasc Endovasc Surg. 2006;32(5):532–6.Article CAS PubMed Google Scholar

[21] Jonker FH, Mojibian H, Schlosser FJ, Botta DM, Indes JE, Moll FL, et al. The impact of hypovolaemic shock on the aortic diameter in a porcine model. Eur J Vasc Endovasc Surg. 2010;40(5):564–71.Article CAS PubMed Google Scholar

[22] Pedersen OM, Aslaksen A, Vik-Mo H. Ultrasound measurement of the luminal diameter of the abdominal aorta and iliac arteries in patients without vascular disease. J Vasc Surg. 1993;17(3):596–601.Article CAS PubMed Google Scholar

[23] Lederle FA, Johnson GR, Wilson SE, Gordon IL, Chute EP, Littooy FN, et al. Relationship of age, gender, race, and body size to infrarenal aortic diameter. The Aneurysm Detection and Management (ADAM) Veterans Affairs Cooperative Study Investigators. J Vasc Surg. 1997;26(4):595–601.Article CAS PubMed Google Scholar

[24] Kendall JL, Hoffenberg SR, Smith RS. History of emergency and critical care ultrasound: the evolution of a new imaging paradigm. Crit Care Med. 2007;35(5 Suppl):S126–30.Article PubMed Google Scholar

[25] Jain AR, Stead L, Decker W. Ultrasound in emergency medicine: a colorful future in black and white. Int J Emerg Med. 2008;1(4):251–2.PubMed Central Article PubMed Google Scholar

[26] Press GM, Miller SK, Hassan IA, Blankenship R, del Junco D, Camp E, et al. Evaluation of a training curriculum for prehospital trauma ultrasound. J Emerg Med. 2013;45(6):856–86.