SONOGRAPHIC MEASUREMENT OF INFERIOR VENA CAVA DIAMETER – A NONINVASIVE TOOL TO DETECT ACUTE BLOOD LOSS

Kanta Das[1], Shamsi Ara Begum[1], Sharmistha Dey[1], M.A. Quddus[2], A S Mohiuddin[1]

[1]Department of Radiology and Imaging, Bangladesh Institute of Research and Rehabilitation for Diabetes, Endocrine and Metabolic Disorders (BIRDEM), Dhaka; [2]Department of Radiology and Imaging, Dhaka Medical College & Hospital, Dhaka

Abstract

Detection and monitoring of blood loss in trauma patients can often be challenging. Change in the inferior vena cava diameter (IVCd) occurs due to alteration in circulating blood volume (CBV) and blood loss. Ultrasonographic measurement of IVCd provides a noninvasive real-time information of the CBV. The present study was designed to determine whether acute blood loss could be detected by sonographic measurement of the IVCd. A total of 50 volunteer blood donors aged 18 to 57 years were studied in the Department of Radiology and Imaging of Dhaka Medical College Hospital (DMCH) from July 2004 to June 2005. The inferior vena cava diameters, both during inspiration and expiration were measured by ultrasound examination immediately before and after donation of a single unit (450ml) of blood. During examination, the transducer was applied to the epigastrium parallel to the median line about 2 cm to the right of it for sagittal sections, and at a right angle to the median line about 3 cm below the xiphoid process for transverse sections. In sagittal sections, the inferior vena cava behind the liver were imaged during inspiration and expiration. The mean diameter of IVC during expiration before and after the blood donation was 17.5mm ($\pm$1.56mm) and 11.93mm ($\pm$1.48mm) respectively. Likewise, the mean diameter of IVC during inspiration before and after the blood donation was 12.96mm ($\pm$1.61mm) and 7.58mm ($\pm$1.29mm) respectively. The decrease in INV diameter following blood loss was significant ($p < 0.01$). Thus, the acute depletion of CBV could be detected by measuring the change of IVCd by sonography. Further study may be undertaken to determine the relationship of unit change of IVCd due to acute blood loss in case of trauma or other conditions.

Ibrahim Med. Coll. J. 2011; 5(2): 51-53

Key words: Sonographic, inferior vena cava

Introduction

Acute loss of blood or hemorrhage frequently occurs in accidents, trauma and other clinical conditions. Physicians lack accurate tools to quantify the amount of blood lost by examining the patient. Physical examination, vital signs, and laboratory evaluation of patients often are unreliable to determine the blood loss because of multiple factors.[1-3] Traditionally, diagnostic peritoneal lavage has been the primary tool for assessing intraabdominal blood loss but it is invasive and somewhat non-specific. Increasingly, ultrasonography, a noninvasive bedside tool, is used to detect the subcapsular, intraparenchymal and intramesenterial hematomas.[4] Sonographic measurement of the inferior vena cava (IVC) has been shown to correlate with the circulating blood volume (CBV). Using the correlation between IVC diameter (IVCd) and CBV, unique information regarding acute and ongoing blood loss and response to resuscitation of the trauma patient can be gained. This is an attractive tool for several reasons. First, it is a

Address for Correspondence:

Dr. Kanta Das, Junior consultant, Department of Radiology and Imaging, BIRDEM, 122 Kazi Nazrul Islam Avenue, Shahbagh, Dhaka 1000, Bangladesh

noninvasive bedside procedure and can be performed serially or when there is a change in the condition of the patient. The measurement of the IVCd is easily performed, and more importantly, this measurement is well suited to the trauma patient because it is performed in the supine position, requires no patient cooperation and less time consuming. The present study was designed to determine whether acute blood loss in a potential trauma patient could be detected by sonographic measurement of the IVCd and if repeated measurements of the IVCd could monitor ongoing blood loss.

Materials and Methods

The study was conducted at the Department of Radiology and Imaging, Dhaka Medical College Hospital, during June' 04 to July' 05. Fifty healthy blood donors aged 18-57 years were included in the study. The IVCd, both during inspiration and expiration, were measured immediately before and after donation of a single unit (450ml) of blood. Ultrasound examination was performed using gray scale real time ultrasound scanner equipped with 3.5 MHz convex transducer of GE LOGIQ™ α 200 ultrasound machine. During examination, the transducer was applied to the epigastrium parallel to the median line approximately 2 cm to the right of it for sagittal sections, and at a right angle to the median line approximately 3 cm below the xiphoid process for transverse sections. In sagittal sections, the IVC behind the liver were imaged and the maximal and minimum diameter of the IVC during inspiration and expiration were measured. The diameter of IVC was expressed in milimitter as means with standard deviations. Paired t-tests were done to determine the differences before and after donation of blood.

Results

Fifty healthy blood donors (m/ f= 27/23) were studied. The mean diameter of IVC during expiration before blood donation was 17.50 $\pm$1.55mm and after blood donation was 11.93$\pm$1.48mm. The difference of IVCd during expiration before and after blood donation was 5.58$\pm$0.71mm. The mean diameter of IVC in inspiration before and after blood donation was 12.96 $\pm$1.61mm and 7.58$\pm$1.29mm respectively. The decrease of IVCd in inspiration after blood donation was 5.38 $\pm$ 0.77mm. The decrease of IVCd in both inspiration and expiration phase after blood donation was significant ($p < 0.1$).

Table: *The sonographic measurement of the inferior vena cava diameter during inspiration and expiration*

Condition	Diameter of IVC (mm) Mean $\pm$SD		P- value
	Before blood donation	After blood donation	
Expiration	17.5$\pm$1.55	11.93$\pm$1.48	0.00
Inspiration	12.96$\pm$1.61	7.58$\pm$1.29	0.00

P-value reached from paired t- test

Discussion

The objective of the study was to measure the change in the inferior vena cava diameter in relationship to blood loss. Voluntary blood donor was used as a model for trauma patients because a known amount of blood was removed from the circulating blood volume in a controlled fashion. In addition, the blood removed occurred over a brief period of time simulating acute blood loss condition in trauma. Normal diameter of IVC is 25mm.[5] Lyon *et al*. (2004) with 31 volunteer blood donors demonstrated a significant ($p < 0.05$) correlation between blood loss and change in IVCd in both expiratory and inspiratory phase.[6] The change was approximately 5 mm decrease in diameter of IVC both during inspiration and expiration and was consistent regardless of the initial diameter. Our study also revealed that on an average, there was a 5 mm drop in diameter of IVC after 450 ml blood loss in both phase of respiration. Our data indicate that the measurement of the IVC diameter is a reliable indicator of blood loss, even in small amounts. The measurement of the IVCd is a powerful technique to evaluate hypovolemia due to internal and external hemorrhage as well as a guide in resuscitation in trauma patients. Areas of future study include the determination of minimum decrease in IVCd at which an individual would be expected to become hypotensive due to blood loss. Further studies may be undertaken to determine the unit change of IVCd predicting the change in CBV due to sudden blood loss in case of trauma or other clinical conditions.

Therefore, it may be concluded that the measurement of the diameter of IVC may be an important addition to the ultrasonographic evaluation of blood loss in trauma and other potentially volume-depleted patients.

References

1. Wo C, Shoemaker W, Appel P, Bishop M, Kram H, Hardin E. Unreliability of blood pressure and heart rate to evaluate cardiac output in emergency resuscitation and critical illness. *Crit Care Med* 1993; **21**(2): 218-223.
2. Mullins RJ, Townsend CM, Beauchamp RD, Evers BM, Mattox KL, Sabiston Textbook of Surgery 16th edition, W.B. Saunders Company, Philadelphia 2004; 61.
3. Porter J, Ivatury R. In search of the optimal end points of resuscitation in trauma patients: a review. *J Trauma* 1998; **44**(5): 908-914.
4. Gruessner G, Mentges B, Duber C, Ruckert K, Rothmund M. Sonography versus peritoneal lavage in blunt abdominal trauma. *J Trauma* 1989; **29**(1): 242-244.
5. Datta AK, Essential of human Anatomy, Part 1, 4th edition, Current book of international, Calcutta. 1999; 153-154.
6. Lyon M, Blaivas M, Brannam L. Sonographic measurement of the inferior vena cava as a marker of blood loss. *Am J Emerg Med* 2004; **23**: 45-50.