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ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ

Does Flattened IVC on CT Can Show Hypovolemia in Trauma Patients?

Travma Hastalarında BT'de İVK'nın Yassılaşmış Olarak Görülmesi Hipovolemiyi Gösterebilir mi?

Can Erkan Arslan[1], Murat Yeşilaras[2], Özge Duman Atilla[2]

ÖZ

Amaç:

Bu çalışmada, künt gövde travmalı (KGT) hastalarda bilgisayarlı tomografi (BT) ile saptanan abdominal inferior vena kava (IVK) çapındaki düzleşmenin; yaşamsal bulgular, kan transfüzyon gereksinimi ve mortalite arasındaki ilişkiyi araştırdık.

Gereç ve Yöntem:

Bu retrospektif çalışmaya KGT ile acil servise (AS) başvuran ve abdominal BT çekilen 18 yaşından büyük hastalar dahil edildi. IVK çapı, renal venler seviyesinin üstünden ve altından ölçüldü. BT görüntüleri üç acil tıp uzmanı tarafından değerlendirildi. IVK anterior çapı transvers çapının yarısından daha az olanlar düz IVK olarak tanımlandı.

Bulgular:

Çalışmaya 74 hasta dahil edildi. Hareket artefaktları ve İVK'nın çevre dokulardan ayırt edilememesi nedeniyle 3 hastada İVK ölçümü yapılamadı. Bir hastada hem üst hem de alt İVK ölçümleri, 2 hastada ise üst İVK ölçümleri yapılamadı. Ölçümleri renal ven seviyesinin üzerinde yapılan 71 hastanın 21'inde IVK düzleşmesi vardı. Düzleşmiş ve düzleşmemiş IVK'lı hastalar arasında başlangıç hemoglobin değerleri (p = 0.044) ve uygulanan kan transfüzyonları (p = 0.027) açısından istatistiksel olarak anlamlı bir fark vardı. Ölçümlerin renal ven seviyesinin altında yapıldığı 73 hastanın 16'sında IVK düzleşmesi vardı. Başlangıç hemoglobin değerleri açısından düzleşmiş ve düzleşmemiş IVK'lı hastalar arasında anlamlı bir fark vardı (p = 0.042). Yoğun bakımda yatış ve mortalite oranları açısından suprarenal ve infrarenal ölçüm grupları arasında anlamlı bir fark yoktu.

Sonuç:

BT'de IVK'nın böbrek venleri seviyesinin üstünde belirlenen çapı, KGT'li hastalarda hipovoleminin ciddiyetini ve gerekli olan kan transfüzyonu miktarını öngörebilir. BT görüntüleri incelenirken, İVK çapının da incelenmesi travma hastalarının rolüm durumu hakkında bilgi verebilir.

Anahtar Kelimeler: inferior vena kava, kan transfüzyonu, künt travma, bilgisayarlı tomografi

ABSTRACT

Aim:

In this study, we investigated the relationship between IVC flattening detected in the CT and vital signs, blood transfusion requirement and patient outcome in patients with blunt torso trauma.

Material and Methods:

Patients older than 18 years of age who presented to the emergency department (ED) with blunt torso trauma and underwent abdominal CT were included in this retrospective study. IVC diameter was measured above and below the level of the renal veins. The CT images were evaluated by three emergency medicine attending physicians. An anteroposterior diameter less than half of the transverse diameter was defined as IVC flattening.

Results:

Seventy-four patients were enrolled in the study. Because of motion artifacts and inability to distinguish the IVC from the surrounding tissues, IVC measurements could not be carried out properly in 3 patients. One patient lacked both upper and lower IVC measurement results and 2 patients lacked upper IVC measurement results. Of the 71 patients in whom the measurements were made above the level of the renal veins, 21 had IVC flattening. There was a statistically significant difference between patients with flattened and non-flattened IVC by means of initial hemoglobin values (p = 0.044) and applied blood transfusions (p = 0.027). Of the 73 patients in whom the measurements were made below the level of the renal veins, 16 had IVC flattening. There was a significant difference between patients with flattened and non-flattened IVC by means of initial hemoglobin values (p = 0.042). There was no significant difference between the suprarenal and infrarenal measurement groups with respect to intensive care hospitalization and mortality rates.

Conclusion:

In patients with blunt torso trauma, the measurement of the IVC above the renal veins may predict the severity of hypovolemia and the amount of blood transfusion required. While the CT images are examined, the examination of the inferior vena cava may give information on the volume status of the trauma patients.

Keywords: inferior vena cava, blood transfusion, blunt trauma, computed tomography

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[1] Health Sciences University, Bursa Higher Specialization Training and Research Hospital, Emergency Medicine Department, Bursa, Turkey

[2] Health Sciences University, Tepecik Training and Research Hospital, Department of Emergency Medicine, Izmir, Turkey.

Corresponding Author: Can Erkan Arslan, MD **Address:** Health Sciences University Bursa Higher Specialization Training and Research Hospital, Emergency Medicine Department, Bursa, Turkey **Phone:** +90 555 864 13 93 **e-mail**: canerkanarslan509@hotmail.com

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Introduction

The determination of hypovolemia in trauma patients may be helpful in detecting the need for fluid infusion or blood transfusion. The inferior vena cava (IVC) can easily be visualized by ultrasonography in most patients. The sonographic examination of the respiratory changes in the anteroposterior (AP) diameter of the IVC is known to be a useful method for identifying hypovolemia (2-4). However, it requires a bedside ultrasound device and a physician trained in ultrasonography. Computed tomography (CT) is an important imaging modality in the management of trauma patients. In most cases, the decision between surgery or non-operative care is based on the CT results. Evaluating the IVC on CT scan is not part of the standard protocol for trauma patients. Recent studies emphasize that IVC flattening determined by the ratio of its anteroposterior diameter to its transverse diameter in the abdominal CT may help predict the degree of hypovolemia in patients with blunt trauma (2,5-8). In this study, we investigated the relationship between IVC flattening detected in the CT and vital signs, blood transfusion requirement and patient outcome in patients with blunt torso trauma.

Material and Methods

This retrospective study was conducted between 01.01.2010-01.10.2013 at a tertiary care academic medical center that receives approximately 200,000 annual adult ED visits. The study was approved at 10.12.2013 (248) by the institutional review board prior to the commencement of the investigation.

Patient selection

Our hospital information system was searched for patients who admitted to the emergency department (ED) with blunt trauma and underwent abdominal CT imaging. All available electronic or paper medical records of these patients were examined and patients older than 18 years were included in the study.

Patients whose records were inaccessible and/or who had concomitant penetrating injuries were excluded from the study. Those who were referred from another hospital or who were given more than 500 mL of fluid in the ambulance or in the ED prior to CT imaging were also excluded from the study. The referral emergency service and ambulance medical records of the patients are also archived in our hospital.

The patients' demographic data, New Injury Severity Score (NISS), trauma mechanism, vital signs, blood and fluid resuscitation, and outcomes were recorded.

CT scan protocol and measurement of the IVC
All the CT images were obtained by "Siemens Emotion Duo 2 section/sec" device with 6mm section thickness. The CT scans were viewed on standard abdominal window settings. All measurements were made on Picture Archiving and Communication System (PACS). The IVC diameter was measured in two different locations, above and below the renal veins (Figure 1). In order to ensure that the measurement depicted the mean diameter of the vein, consecutive sections were evaluated before choosing a localization for measurement. The measurements of case number 71 are illustrated in Figure 2. IVC flattening was defined as an IVC with an anteroposterior diameter less than half of the transverse diameter.

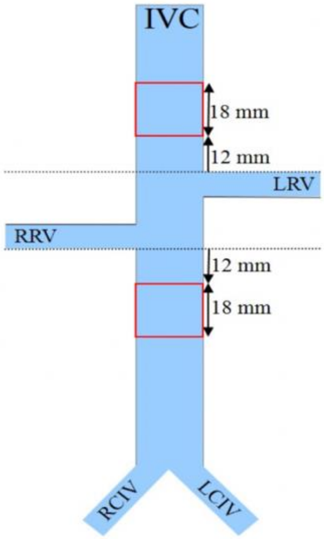

Figure 1. Schematic View of the localizations for inferior vena cava measurement above and below the level of the renal veins
IVC: Inferior vena cava, RRV: Right renal vein, LRV: Left renal vein, RCIV: Right common iliac vein, LCIV: Left common iliac vein

The IVC measurements were made by three emergency medicine attending physicians with more than 10 years of experience who were blinded to each other's measurements. The inter-rater reliability of the measurements was established prior to starting data collection.

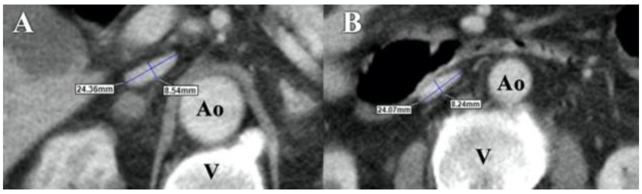

Figure 2. Inferior Vena Cava measurement below (A) and above (B) the level of the renal veins in case number 71
Ao: Aorta, V: Vertebra

Variables and analysis

The primary endpoint of our research was to compare the initial vital signs, hemoglobin levels (the first measured value and the lowest value detected in the hospital), and blood transfusion requirements of patients with flattened vs non-flattened IVC with respect to the CT measurements. The secondary end point was to compare the two groups in terms of mortality, intensive care unit admission and NISS.

The statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 22.0. Qualitative data were expressed as frequencies and percentages. Quantitative data were expressed median, interquartile range (IQR), minimum (min) and maximum (max) values. The Fisher's Exact Test was used to calculate the differences between groups with respect to blood transfusion (more or less than 4 units), intensive care hospitalization and mortality. The Mann-Whitney U Test was used to compare age, blood pressure, heart rate, NISS, initial hemoglobin and lowest hemoglobin values. The consistency of the CT-determined IVC measurements was determined using intraclass correlation coefficient (ICC). The reliability of measurements was calculated through a group of 60 patients chosen by simple randomization, where each observer measured the IVC diameter of 40 patients. Intraclass correlation test was used for the interrater reliability of the measurements. All examinations were performed at a 95% confidence interval. A p value less than 0.05 was considered statistically significant.

Results

Seventy-four patients meeting the inclusion criteria were included in the study (Figure 3). The number of male patients was 60 (82.2%). The median age was 47 years (IQR: 27, min 18, max: 89). Trauma mechanisms were as follows: fall from height (n=53, 71.6%), assault (n=9, 12.2%), traffic accident (n=2, 2.7%) and other mechanisms (fall from stairs, work accident) (n=10, 13.5%). The number of CT scans performed with intravenous contrast was 45 (60.8%). The median time elapsed from admission to CT scanning was 78 minutes (IQR: 27; min: 9, max: 378). Because of motion artifacts and inability to distinguish the IVC from the surrounding tissues, IVC measurements could not be carried out properly in 3 patients. One patient lacked both upper and lower IVC measurement results and 2 patients lacked upper IVC measurement results. The intraclass correlation coefficient (ICC) of the three physicians for the IVC diameter measurements with CT was found to be 0.93.

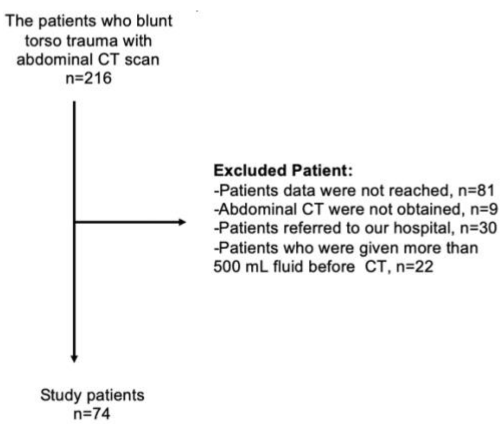

Figure 3. Patient flow diagram

The measurements made above the renal veins (n=71) revealed a median value of 27.9 mm (IQR: 5.5; min:15.7, max 36.1) for transverse diameter and a median value of 16.8 mm (IQR: 7.4; min:7.7, max: 28.1) for AP diameter. According to these measurements, IVC flattening was observed in 21 (30%) patients. The measurements made below the renal veins (n= 73), revealed a median value of 24.7 mm (IQR: 3.7; min:13.7, max: 32.6) for transverse diameter, and a median value of 15.1 mm (IQR: 5.9; min:5.7, max: 24.9) for AP diameter. According to these measurements, IVC flattening was observed in 16 patients (22%).

Age, vital signs, NISS, hemoglobin levels, blood transfusion frequencies and outcomes of the patients with flattened and non-flattened IVC with respect to the measurements made above and below the renal veins are shown in Table 1.

Discussion

In our study, it was found that blunt torso trauma patients with IVC flattening measured above the renal veins in abdominal CT had significantly lower initial hemoglobin and initial systolic blood pressure values and their lowest hemoglobin level detected during hospitalization was also significantly lower compared to other groups. In addition, these patients received a greater amount of blood transfusion. Among patients with IVC flattening measured below the renal veins, only the initial hemoglobin values were statistically significantly lower.

In similar studies evaluating the IVC diameter on abdominal CT, different measurement localizations were used. In the study of Yang et al, the IVC was measured at four different localizations from the origin to the iliac bifurcation. Miraflor et al made two measurements: above and below the renal veins (6). In the study by Nguyen et al, only suprarenal measurements were used (9). Previous studies also emphasize that measurements made above and below the renal veins cannot predict hypovolemia with the same sensitivity. Therefore, we chose two localizations, above and below the renal veins. In order to ensure reliable measurements, there should be a consistency between the observers. We found an excellent consistency among observers' measurements (ICC = 0.93). The reliability of the measurements has not been studied in previous similar studies.

Another issue was the selection of the threshold value to determine IVC flattening by its AP to transverse ratio. In previous studies, values varying between 1.9-4 were used. In the study of Johnson et al, a value of 2.5 was chosen, whereas Milia et al. chose a value of 4 (2,10). In this study, it was also emphasized that the efficacy of IVC ratio in predicting shock decreases with increasing age. After reviewing the previous studies, we chose the value 2, for this was the most commonly preferred value and would be easy to use in daily practice. In three studies similar to our's with respect to measurement locations, suprarenal measurements were found to be more compatible than infrarenal measurements (2,6,10). Similarly, in our study, the measurements made above the renal veins were more consistent with the clinical parameters we examined.

	Measurements made above the renal veins			Measurements made below the renal veins		
	Flattened IVC n=20	Non flattened IVC n=51	p value	Flattened IVC n=16	Non flattened IVC n=57	p value
Age, median (IQR), year	55 (30)	47 (25)	0.038*	56 (34)	7 (26)	0.038*
SBP, median (IQR), mm/Hg	18 (27)	128 (22)	0.021*	120 (40)	128 (23)	0.096*
DBP, median (IQR), mm/Hg	73 (22)	75 (17)	0.186*	70 (25)	77 (17)	0.310*
Pulse rate, median (IQR), min	87 (28)	84 (21)	0.603*	90 (18)	83 (22)	0.197*
NISS, median (IQR)	53 (49)	41(20)	0.352*	41 (41)	41(32)	0.901*
Blood transfusion need of more than 4 units, n (%)	7 (33)	4 (8)	0.009**	4 (25)	7 (12)	0.242**
İnitial hemoglobin value, median (IQR), g/dL	13.4 (3.2)	14.5 (1.7)	0.044*	12.4 (4.2)	14.5 (1.5)	0.042*
Lowest hemoglobin value, median (IQR), g/dL	9.9 (6.8)	13.1 (3.4)	0.01*	10.8 (5.3)	12.9 (4)	0.078*
İntensive care unit admission, n (%)	6 (30)	6(10)	0.084**	4 (25)	8 (14)	0.444**
Exitus, n (%)	5 (25)	7 (14)	0.299**	4 (25)	8 (14)	0.444**

IVC: inferior vena cava, IQR: interquartile range, SBP: Systolic blood pressure, DBP: diastolic blood pressure, NISS: New injury severity score,
* Mann-Whitney U test, **Fisher exact test

Table 1. Flattened and non-flattened IVC measured above and below the renal veins and their relation with age, vital signs, blood transfusion needs and hospitalization end points of the patients

When the data on vital signs are examined, it is seen that the patients in the flattened IVC group have lower blood pressure and higher heart rate values (Table 1). These findings are in accordance with the literature, suggesting that blood loss causes IVC flattening. This situation is valid for measurements made both above and below the renal veins. However, it seems that measurements made above the renal veins represent blood loss more reliably. Blunt torso trauma patients whose abdominal CT scans reveal IVC flattening are more likely to need blood transfusions.

Unlike other similar studies, we could not determine a relationship between IVC flattening and the severity of the injury, as we did with hypovolemia. This is quite surprising, considering that hypovolemia is associated with the severity of the injury. We believe that our preference of NISS over ISS may have affected the results. The most severely injured 3 body regions were taken into account to calculate NISS, which may have affected the data to compare the overall severity of the injury.

Although IVC flattening was found to be associated with initial blood pressure, hemoglobin levels and blood transfusion requirement, there was no difference between flattened and non-flattened groups with respect to intensive care unit admissions and death, which was consistent with the literature. We believe that this might be related to concomitant head traumas.

Limitations

Our research had a small sample size. Many patients with severe trauma could not be included in the study because they received fluid resuscitation or underwent operation prior to CT imaging. Since only hemodynamically stable patients for whom CT imaging was possible were included in the study, our data should not be generalized to patients who are not stable enough to be taken to the radiology unit.

The recommended section thickness for abdominal studies is 5mm or less. However, the section thickness used in our study was 6mm. In addition, all the measurements were made by emergency medicine physicians. In literature, the measurements were mostly made by radiologists. However, the emergency medicine physicians participating in the study had sufficient experience in CT evaluation and the intraclass correlation of the measurements was very high.

Conclusion

In patients with blunt torso trauma, the measurement of the IVC above the renal veins may predict the severity of hypovolemia and the amount of blood transfusion required. While the CT images are examined, the examination of the inferior vena cava may give information on the volume status of the trauma patients.

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Authors' Contribution: Conceived and designed the experiments (CEA, MY), data collection (CEA, MY), analyzed and interpreted the data (MY, CEA, ODA), contributed reagents, materials, analysis tools or data (CEA, MY, ODA) wrote the paper (CEA, MY). All authors reviewed and edited the manuscript and approved the final version.

Ethical Statement: The study was approved at 10.12.2013 (248) by the institutional review board prior to the commencement of the investigation.
All authors declared that they follow the rules of Research and Publication Ethics.

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