

# The Comparison of Vena Cava Inferior Diameter Measurement and Hemoglobin Level Follow-Up for the Assessment of Traumatic Patient in Emergency Service

Acil Serviste Travma Hastalarının Değerlendirilmesinde Vena Kava İnferior Çapı Ölçümleri ile Hemogloblin Takibinin Karşılaştırılması

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## Abstract

**Objective:** In trauma patients determining and excluding occult bleeding is a difficult and error-prone work in emergency services.

**Material and Methods:** The vena cava inferior diameters were measured by ultrasound at reference time, first hour and third hour, in sixty patients who were admitted to our university hospital and suffered multiple trauma. Their hemoglobin levels and vital signs were observed simultaneously. Follow-up results were compared to each other.

**Results:** No serious bleeding was found in our patient population. The reference time vena cava inferior diameter mean value of our study group was  $16.84 \pm 3.93$  mms. This value was  $16.79 \pm 3.74$  mms for the first hour and  $16.49 \pm 3.23$  mms for the third hour. In the statistical evaluation of data there was no significant difference between the measurements (Pillai analyse  $p=0.29$ ). In contrast, there was a decrease-mean of  $0.68 \pm 0.91$  mg/dl in hemoglobin values particularly between the reference and the third time and it was statistically significant ( $p=0.000$ ). During this time a decrease in hemoglobin level was observed at greater than 1 mg/dl and in 30% of patients. These changes in measuring hemoglobin levels were not correlated with fluid given to the patients. During all time intervals vena cava inferior measurement's specificity was determined as approximately 95% and was 70% for hemoglobin level follow-up.

**Conclusion:** Vena cava inferior serial measurements with ultrasound may be more beneficial to hemogram follow up for excluding occult bleeding in trauma patients. (JAEM 2011; 10: 123-7)

**Key words:** Vena cava inferior, ultrasound, trauma, hemoglobin, emergency department

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## Özet

**Amaç:** Acil serviste travma hastalarında gizli kanamanın tanınması ve dışlanması zor ve hataya açık bir iştir.

**Gereç ve Yöntemler:** Altmış hastanın vena cava inferior çapları gelişinde, birinci saatte ve üçüncü saatte ultrason ile ölçüldü. Bu hastalarda eş zamanlı olarak hemogloblin değerleri ölçüldü ve karşılaştırıldı.

**Bulgular:** Çalışmamızda hasta popülasyonumuzda ciddi kanamalı hasta yoktu. Geliş, inferior vena cava çaplarının ortalama değerleri  $16.84 \pm 3.93$  mm idi. Bu değer birinci ve üçüncü saatler için  $16.79 \pm 3.74$  mm,  $16.49 \pm 3.23$  mm idi. Ölçümlerde anlamlı farklılık yoktu (Pillai analizi  $p=0.29$ ). Geliş ve üçüncü saat hemogloblin ortalama değerlerinde ise  $0.68 \pm 0.91$  mg/dl lik bir düşme olmuştu ve bu istatistiksel olarak belirgin şekilde anlamlı idi ( $p=0.000$ ). Bu aralıkta yaklaşık olarak hastaların %30'unda 1 mg/dl ve üzeri düşme gözlenmişti. Bu değişiklikler verilen sıvı miktarı ile korole değildi. Tüm zamanlar için spesifite vena cava inferior ölçümleri için yaklaşık olarak %95 ve hemogloblin için %70 olarak bulunmuştur.

**Sonuç:** Vena cava inferiorun seri ölçümleri travma hastalarında gizli kanamanın dışlanması için hemogram takibinden daha faydalı olabilir.

(JAEM 2011; 10: 123-7)

**Anahtar kelimeler:** Vena cava inferior, ultrason, travma, hemogloblin, acil servis

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## Introduction

Despite technological and medical advances, trauma continues to take a significant place among the causes of mortality and morbidity among the slice of productive population. Moreover, it causes loss of labor and creates serious financial losses (1, 2).

From the medical point, multiple trauma patients require rapid and accurate decisions which are challenging, tiring and error-prone, especially for emergency service workers and other trauma teams. Briefly, these are difficult patients. The rapid developments in technology and medical science on this issue have led helpful diagnostic tools to emerge. Especially the more widespread use of ultrasound

and its being an increasingly easily accessible tool day by day is the most important of these developments. By the increase of focused assessment with sonography for trauma (FAST) experience and trends of emergency physicians and trauma teams, early diagnosis and effective intervention have been achieved. With these improvements, ultrasound as well as other available diagnostic tools have some weaknesses and deficiencies in detecting and excluding occult bleeding. A diagnostic method that can satisfy all of these, does not seem to be available at present (3, 4).

It is very important to detect occult bleeding as early as possible in trauma patients. We thought that Inferior vena cava's (VCI) consecutive measurements may be a step on the path to reach the optimal diagnostic procedure and we designed this study. Besides, one of the main aims of our study was to assess hemoglobin (hb) follow up from another point of view, which is a standard procedure in a trauma patient.

We tried to consider a situation that we frequently encounter and thought to cause a false alarm especially during follow-up. This situation is the decrement of Hb level greater than 1 mg/dl and then becoming stable in hours in patients during follow-up who actually do not have bleeding.

## Methods

This study was performed in sixty patients who were admitted to the Suleyman Demirel University Medical Faculty Emergency Department between October 2006 - June 2008 and who suffered multiple trauma such as traffic accidents, falls and blowing. Institutional Review Board approval was obtained before beginning of the study.

Preferentially, measurements were taken by the study's executive assistants rather than the assistant who examined and followed up the patient for standard trauma care in the emergency service. Executive assistants were seniors who were able to perform FAST and were experienced in using ultrasound. Measurements were carried out when the patient was lying on the trauma board in the supine position and the board was parallel to the ground. A CISION 600M trademarked, portable, bedside ultrasound was used for measurements which is routinely used for FAST and other pathologies in our emergency service. Vena cava and aorta were detected with a 3.5 Mhz probe in the transverse aspect. Measurement was taken from the vessel's external border to the opposite wall's internal border, by going across to a distal point which is 20 mms away from the splint point of hepatic veins to the vena cava in this position to standardize and optimize the measurements (Figure 1) (3). Attempts were made to take measurements during expiration during patients' spontaneous breathing. Breath-holding in deep inspiration was used in patients who cooperated well. Measurements were carried out at reference time, in the first and third hours. Hemogram results and vital signs were considered simultaneously. These results were recorded according to study form.

Vena cava inferior's first measurement was carried out after the primary doctor (not the executive one) completed his own procedures with patient. The primary doctor decided the amount and speed of fluid replacement. The second measurement was performed after an hour. The third measurement was done at the third hour. The executive doctor recorded the amount of fluid during this time.

Pregnant women, patients who have a history of congestive heart failure or serious tricuspid valve insufficiency, under the age of 18, who cannot lie in the supine position, who were discharged, hospitalized or went into surgery before taking two measurements at least, who received a blood transfusion before the admission, were excluded from the study.

SPSS 15.0 statistical software was used for statistical analysis of the study. In all statistics,  $p < 0.05$  was used as a significance limit except for tests which make a correlation analysis and Bonferroni correction. All statistical analyses were performed by a medical informatics physician

## Results

Sixty patients were included in our study who met our criteria. Forty-three of the patients were male (71.7%) and seventeen were female (28.3%). The mean age was  $35.8 \pm 16.2$  (between age of 18-85). With 83.3% of all cases, the leading trauma causes were road traffic accidents (50 patients), which could be subdivided into three main categories: vehicle-to vehicle (39 patients), vehicle-to-pedestrian-accidents (5 patients) and motorbike accidents (6 patients) Second in frequency, with 11.7% of all cases, were falls (7 patients). 1.7 % was blowing (1 patient) and 3.4% was other traumas (2 patient).

Reference time VCI diameter mean of the group was  $16.8 \pm 3.9$  mms. This value was  $16.7 \pm 3.7$  mms for the second and  $16.4 \pm 3.2$  mms for the third measurement (Figure 2). Variance analysis from the parametric tests which are used to assess three or more groups in dependent groups was performed for statistical examination of VCI measurements. There was no significant difference between either VCI1-VCI2 nor VCI1- VCI3 ( $p=0.89$ ,  $p=0.12$ ).

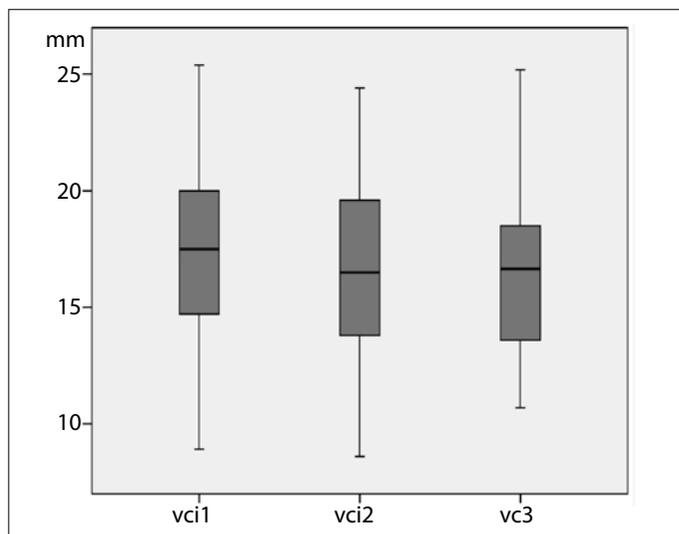
In our study we found the Hb mean values as  $14.4 \pm 1.8$  mg/dl for the reference time,  $13.8 \pm 1.8$  mg/dl for the 1<sup>st</sup> hour, and  $13.9 \pm 1.7$  for the 3<sup>rd</sup> hour (Figure 3). According to these values, a change of  $0.64 \pm 1.07$  mg/dl was determined between reference time and the first hour. A  $0.68 \pm 0.91$  mg/dl decrement was seen at 3<sup>rd</sup> hour when compared to the arrival time level. When the frequencies of the dif-



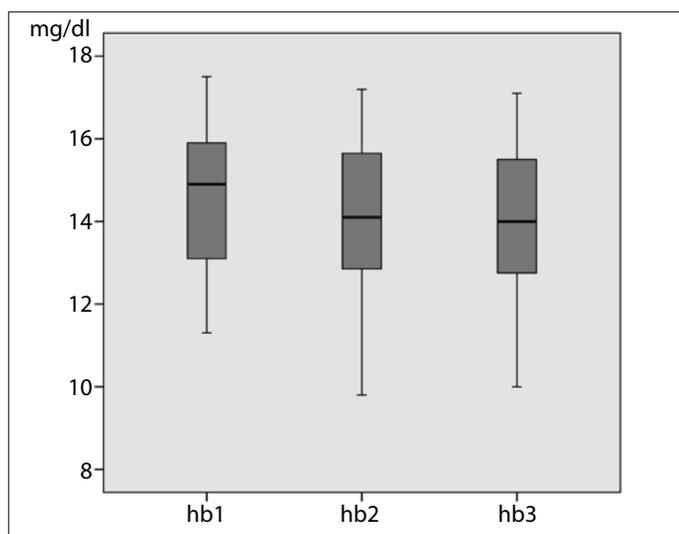
Figure 1. Example of vena cava inferior measurement

ferences are observed, 29% of the patients' Hb levels decreased by 1mg/dl and more, at reference time and the 1<sup>st</sup> hour. This ratio was 31% for reference and 3<sup>rd</sup> hour. When the frequencies of the patients are observed whose Hb decreased to 1.5 mg/dl and more, the ratios were 18% and 22%. Variance analysis in dependent groups was performed for the statistical analysis of these Hb level changes. There was no significant difference in Hb levels between the reference time and the first hour ( $p=0.45$ ). The 1<sup>st</sup> hour and 3<sup>rd</sup> hour measurements were statistically not significantly different ( $p=0.12$ ). However, there was a significant difference between the reference Hb level and the third hour ( $p=0.000$ ).

Among our patients there were none who were normotensive and passed to the hypotensive side, besides a few patients between the first and second measurements as well as the first and the third measurements. There was no statistical difference between these measurements.



**Figure 2.** Boxplot graph of Vena cava inferior measurements  
 VCI1: Vena cava inferior reference time measurements  
 VCI2: Vena cava inferior first hour measurements  
 VCI3: Vena cava inferior third hour measurements



**Figure 3.** Boxplot graph of hemoglobin measurements  
 Hb1: Hemoglobin level of reference time measurements  
 Hb2: Hemoglobin level of first hour measurements  
 Hb3: Hemoglobin level of third hour measurements

Similarly, patients' pulse measurements were investigated. In our study, 68% of the patients who were tachycardiac in their first visit became normocardiac in their last visits. 7% of the patients who were normocardiac in their first visit were on the point of tachycardiac in their last visit. When we look at the significance of these changes, the difference was not meaningful statistically. The changes between the first and third measurements were not significant ( $p>0.05$ ).

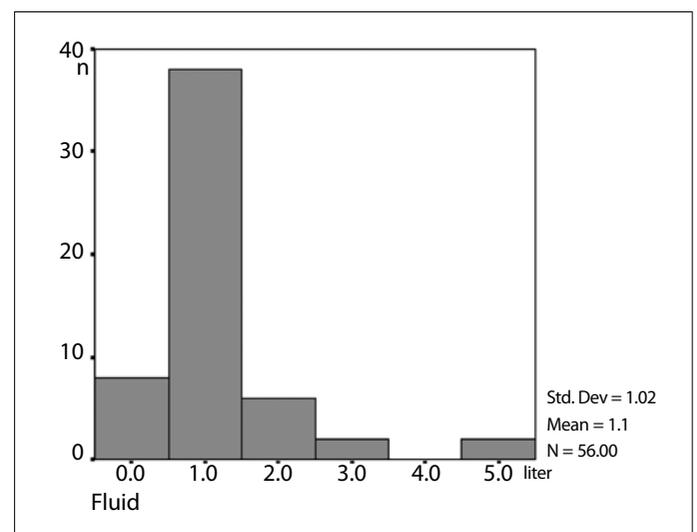
We decided to consider if there was a correlation between these changes in Hb levels and the amount of fluid given to the patients. The distribution of liquid amount according to our patients is given in Figure 4. We analysed if there was a correlation between Hb differences and fluid given to the patients. No correlation was found ( $p=0.88$  and  $p=0.16$ ), and we tried to find if there was a correlation between the fluid amount and VCI measurements values also. There was not a significant correlation between VCI differences and amount of fluid. Similarly, no correlation between VCI measurements and Hb differences was found ( $p=0.43$  and  $p=0.44$ ).

None of our patients had serious bleeding so we could not calculate a sensitivity either for VCI measurement or Hb level follow-up. However, specificity was found to be 95% for VCI measurement, and 70% for Hb follow-up for the reference time and first hour. When we calculate this value for the reference time and the third hour we found specificity of 96% for VCI and 68% for Hb follow-up.

**Discussion**

We took the VCI measurements and simultaneously looked for Hb levels of our patients at reference time and at first and third hour. Zehtabchi et al. considered major trauma patients' serial hematocrit measurements' diagnostic performance in their study in 2005 (5). In their study they showed that in the 4<sup>th</sup> hour Hb change can detect bleeding. According to this information, we preferred to make the third measurement at three hours after admission.

The amount of fluid given to our patients between admission time and the first hour was recorded, but after the first hour we did not record the fluid amount. Stampler et al. showed a 4 mg/dl decrease of hematocrit level in 45 minutes in healthy volunteers who are resuscitated aggressively, but after 45 minutes no decrement had



**Figure 4.** 'Histogram graphic' display of the liquid distribution given to the patients

been seen Similarly, Glick et al. caused a blood loss of about 30% of total blood in dogs, and after that hematocrit decreased at a rate of 17% (5). This decrement is deeper in fluid given to the group, but the decrement stopped in 30-60 minutes and no change was seen during 6 hours follow-up in all cases. It was thought that the fluid amount given in this time period would not change the results and affect the basic aims of our study.

Weil and Maurat first considered the VCI by ultrasound. They showed the increment of its diameter in right heart failure and inspirium (6). Cheriex et al. placed a central venous catheter and found a correlation between VCI diameter and right atrial pressure (7). Tetsuko et al. reported that VCI diameter is decreased after ultrafiltration (8). Gunst et al. showed that Vena cava changes are correlated with the central venous pressure changes (9). Kusuba et al. determined a weak correlation between the withdrawn fluid and postdialysis systolic pressure and a strong correlation between VCI diameter and withdrawn fluid in dialysis patients (10). Lyon and his friends reported a significant decrement of VCI diameter in voluntary blood bank donors after being taken one unit of blood (3). Ando et al found the mean of VCI diameter to be about 16.7 mms in a healthy group of voluntaries and showed that it is not affected by age, gender or body surface area (11).

All of these studies show that VCI measurement is a sign of total body volume. In our study we tried to find whether it can be used in multiple trauma patients. No serious bleeding was detected in our study group. Mean VCI measurement was  $16.8 \pm 3.9$  mms. This value was similar to Lyon's study (17.4 mms) and Ando's study (16.7 mms). There was no significant difference among these three results when analysed statistically. There was no significant difference between serial VCI diameters of our population either.

One of other aims of our study was to consider the problems that we frequently encounter in trauma patients during routine Hb follow-up. The decrements of Hb levels were causing a false alarm and it was extending the follow-up time. This decrement was a mystery if it was related with the fluid given to the patient. Similarly, performance to detect bleeding of Hb follow-up was suspicious. Paradis et al checked the hematocrit levels of their patients with bleeding, at the 15<sup>th</sup> and 30<sup>th</sup> minutes and they found the sensitivity respectively to be 20% and 27% (12). Kass et al. studied 500 healthy voluntary phlebotomy adults and measured hematocrit levels at the 30<sup>th</sup> minutes and they found sensitivity of >90% (13). Zehtabchi et al. tried to compare the admission time and the 4<sup>th</sup> hour hematocrit levels and studied if it was related to a major injury. They found the specificity rather high (94-95%), but the sensitivity was low (16-40%) (5). In our study we could not calculate the sensitivity but the specificity was 68% and 70%. Although specificities of our study were different, the testing value of Hb was 1 mg/dl (3 unit of hematocrit), but other studies' test values were 5 and 10 hematocrit units. In our study a  $0.64 \pm 1.07$  mg/dl change was seen between reference time and first hour Hb levels but this change was not statistically significant. However, we found a statistically significant decrement ( $0.68 \pm 0.91$  mg/dl) between reference time and third hour Hb. In our emergency service we often try to find a bleeding focus if we observe 1 mg/dl or more reduction in the Hb level.

Among our patients there is no one who was normotensive and passed to the hypotensive side besides a few patients between the first and second measurements as well as the first and the third measurements. Also there was no significant difference between VCI's serial measurements in our trauma population.

As is known, hypovolemic shock appears earlier than tachycardia blood pressure changes. In addition to this, frequently seen factors in traumatic patients with pain and anxiety may cause tachycardia. In our study, 68% of the patients who were tachycardiac in their first visit became normocardiac in their last visits. 7% of the patients who were normocardiac in their first visit were on the point of tachycardia in their last visit. When we look at the significance of these changes, the difference was not meaningful statistically.

This decrement in Hb level is almost explained with the given fluid related to dilution. We analysed if there was a correlation between Hb differences and fluid given to the patients. But, similar to Zehtabchi's study, no correlation was found. Although hemodilution is a plausible and expected result, lack of correlation can be explained with the rapid redistribution of fluid given to the patient. Greenfield et al. showed that 64% of fluid given to non-bleeding healthy adults diffused to the extravascular area in 20 minutes (14).

When we consider the frequencies of the differences during the reference time-first hour period, 29% patients had 1 or more decrement in Hb levels. This ratio was 31% for reference time-third hour period. That means a false and unnecessary alarm in 1 of 3 patients in our current practice when we regard 1 mg/dl decrement as borderline. 1.5 and 2 mg/dl decrement seems to be more suitable for follow-up. In all of the time periods of our study we found the specificity as 70% for Hb follow-up.

## Conclusion

In our study, no significant difference was found between VCI's serial measurements. Also no serious bleeding was detected in our group. In all of the time periods of our study we found the specificity of 95% for VCI measurement. Vena cava inferior serial measurements with ultrasound may be more beneficial to hemogram follow up for excluding occult bleeding in trauma patients.

## Conflict of Interest

No conflict of interest was declared by the authors.

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