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# The effect of the emergency physicians' clinical decision of targeted ultrasonography application in non-traumatic shock patients

# 非創傷性休克患者的針對性超聲應用對急診醫生臨床決策的影響

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***Introduction*:** Clinical evaluation of non-traumatic shock patients with high risk of mortality and morbidity is problematic for emergency physicians. In this study, changes in the investigations, diagnosis and treatment decision of the physicians using the Abdominal and Cardiac Evaluation with Sonography in Shock (ACES) protocol were examined. ***Methods*:** In this clinical prospective study, the patients were ultrasonographically examined within the scope of the ACES protocol at 6 quadrants including cardiac, pleural, peritoneal, inferior vena cava and aorta. Pre- and post-US investigations, diagnoses and treatments were compared. ***Results*:** A total of 141 patients were included in this study. Of these, 92 (65.2%) of the patients were males and 49 (34.8%) were females. The average age of the patients was 62.9±16.8 years (18-97). After the ultrasonographic evaluation, request for new investigations was needed in 25 (17%), and modification of the treatment was needed in 57 (40.4%) of the patients. It was seen that with a targeted ultrasonography (US), the number of the considered pre-diagnoses decreased in 51 (36.2%) of the patients, and the physicians made a new pre-diagnosis in 6 (4.3%) of the patients. When the pre-diagnoses made by the physicians after the US and the final diagnoses clinically made at the end of the follow-up process were compared, there were no changes in the diagnoses in 124 (87.9%) patients. ***Conclusion*:** Ultrasonographic examination is considered useful for rapid evaluation, early diagnosis and treatment planning in non-traumatic shock patients in emergency department. (Hong Kong j.emerg.med. 2015;22:364-370)

**簡介：**非創傷性休克患者有高的死亡和致殘風險，急診醫生的臨床評估有一定的困難。在這項研究中，我們審查了使用腹部和心臟超聲評估休克（ACES）的方案，如何改變醫生的檢驗、診斷和治療的決定。**方法：**在這項前瞻性臨床研究，根據ACES方案，患者的超聲檢查包括6象限：心臟、胸腔兩側、腹腔、下腔靜脈和主動脈。然後比較超聲檢查前後，檢驗、診斷和治療的決定。**結果：**這項研究共納入141例患者。其中92名患者（65.2％）為男性，49名（34.8％）為女性。患者的平均年齡為62.9±16.8年（18-97）。超聲波評估後，25（17％）名患者需要新的檢驗，57（40.4％）名病人需要改變治療。在進行一個有針對性的超聲波檢查後，在51名患者（36.2％）醫生所考慮的臨時診斷數量減少了，在6（4.3％）名病人醫生提出了一個新的診斷。超聲波檢查後的臨時診斷和最終診斷比較，在124（87.9％）名患者未有任何變更。**結論：**在急診科的非創傷性休克患者，超聲檢查對快速評估、早期診斷和計劃治療有幫助。

**Keywords**: Clinical decision, early diagnosis, emergency medicine, point-of-care system

**關鍵詞：**臨床決定、早期診斷、急診醫學、護理點的系統

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## Introduction

The term "shock" was firstly used by French surgeon Le Dran in eighteenth century for soldiers having severe post-traumatic blood loss, and started to appear also in the medical literature in nineteenth century.[1]

Shock can be defined as a condition characterised by insufficient supply of oxygen and nutrients to vital organs compared to metabolic need.[2] Despite its high prevalence and morbidity, the lack of a widely accepted definition and clear diagnosis criteria hinders a comprehensive epidemiologic data follow-up.[3] Arterial hypotension, defined as a systolic blood pressure below 100 mmHg, was found in 19% of patients admitted to the emergency department.[4] According to the estimations, over 1.2 million of patients were admitted to emergency department each year.[5] Mortality rates in shock patients vary depending on the cause. While mortality due to septic shock is 40%-60%, mortality due to cardiogenic shock ranges between 36%-56%.[6]

In shock patients, making the diagnosis before the onset of organ dysfunction is very important in order to reduce morbidity and mortality. Determining the accurate cause of shock in emergency department is possible only in 25% to 50% of the cases.[7,8] Diagnostic accuracy rises to 80% thanks to bedside ultrasonography (US) performed according to the emergency department protocol.[8]

US was firstly used by emergency department staff in 1980s to exclude 'silent' diagnoses[9] and today its areas of use have substantially expanded due to its non-invasive nature and bedside applicability. US is being commonly used in emergency department as a guide for compelling interventions, to evaluate the anatomy and functions of visceral organs, and to determine pathological conditions such as source of pain. US application in emergency department is different from others. Emergency US can be performed simultaneously with physical examination or resuscitation, and tries to find a response to a focused clinical problem in minutes. This application can be described as an extension to palpation, which is a part of physical examination, and as a visual stethoscope.[10]

Today US is being frequently used in emergency department for diagnosis of organ injury and determination of free fluid in traumatic patients, in biliary and renal pathologies, in determination of abdominal aortic aneurysm or deep vein thrombosis, and in invasive interventions.

In this clinical study, the effect of "targeted US in non-traumatic shock patients" in emergency department on the clinical judgement of the physicians would be explored.

## Methods

This clinical, prospective, single-centre study was conducted on patients who were admitted to the Akdeniz University Hospital Emergency Department with non-traumatic shock. Approval of the local ethics committee and informed consent from the patients were obtained before the study. The academic personnel, nurses and triage staff working in the emergency department were informed about the flow of the study.

In the study, non-traumatic patients with systolic blood pressure of <100 mmHg or shock index (the ratio of pulse to systolic blood pressure) >1 and aged ≥16 years were included. Patients who were traumatic, had cardiopulmonary resuscitation, were pregnant, were aged <16 years, disagreed to participate and from whom the consent could not be obtained were excluded from the study.

In the patients who were included in the study, after the initial examination and stabilisation were performed and the study forms were completed with the information about the patients, admission complains, onset time of the complains, Glasgow Coma Scale (GCS) and vital parameters (arterial blood pressure, pulse, respiratory rate, body temperature and pulse oximetry), the study was started. After the medical history was obtained and the physical examination was performed, as the first part of the study, the pre-diagnosis for the cause of the shock, the diagnostic laboratory tests (whole blood

count, blood biochemistry parameters, blood gases and others), the imaging investigations (electrocardiography, chest X-ray, US, computed tomography and others) and the required treatment applications were marked on the study form 1. The treatment applications were grouped as antibiotics, positive inotropic treatment, intravenous fluid, steroid therapy, blood transfusion and the others.

After the initial study form was completed, US examinations for the patients were performed. The "Abdominal and Cardiac Evaluation with Sonography in Shock" (ACES) protocol was applied to the patients. In this protocol, ultrasonographic cardiac (pericardial fluid, right ventricular diameter, left ventricular function), pleural, peritoneal, inferior vena cava (IVC) and aorta (aorta diameter increase, intra-abdominal free fluid, flaps in the aorta, thrombi in the wall of aorta) evaluations of the patients were performed.

US examination focused on these structures for evaluation was included in the routine Emergency Medicine Education schedule and practically applied on the patients within the scope of the routine applications. Moreover, 2-hour theoretical and 4-hour practical training were provided to the operators on "focused US applications in shock patients".

After the US examination, the study form 2 would be completed. During this stage, the pre-diagnosis for the cause of the shock, the diagnostic laboratory and imaging investigations and the required treatment applications were recorded again on the study form 2. After this period, the relation of the patients to the study was discontinued, and their routine treatments were continued. After the routine evaluation in the emergency department, the final diagnoses were recorded. The outcome (discharge, hospitalisation, referral or died), and the discharge time were recorded on the last part of the study form 2.

The US examinations of the patients were performed using Sonosite MicroMaxx® branded USG device, which was routinely used in the emergency department. The US device had one high frequency HFL 38/13-6 MHz linear probe, one C60/5-2 MHz convex probe and one P17/5-1 MHz sector probe. The probe, having a 38-mm linear surface, provided a screening depth of 60 mm, while the sector probe, having a 17-mm surface, provided a screening depth of 25 cm. The convex probe had a surface area of 60 mm.

The statistical analysis was performed using SPSS for Windows 21.0 software. The demographic and clinical properties of patients were expressed using mean± standard deviation (SD), median, range and percentage (%) values. While dichotomous parameters as changes assays, treatment and diagnosis after ultrasonography were investigated with McNemar-Bowker test, ordinal parameters such as change of initial diagnosis were investigated using Friedman tests. Results were evaluated within the 95% confidence interval (CI) and at a significance level of 0.05.

## Results

Throughout the study period, 144 patients who met the inclusion criteria were included in the study. However three patients were excluded because they refused to participate in the study (Figure 1). Of the 141 patients, 92 (65.2%) were males and 49 (34.8%) were females. The average age of the patients was 62.9±16.8 years (18-97). The average of the GCS

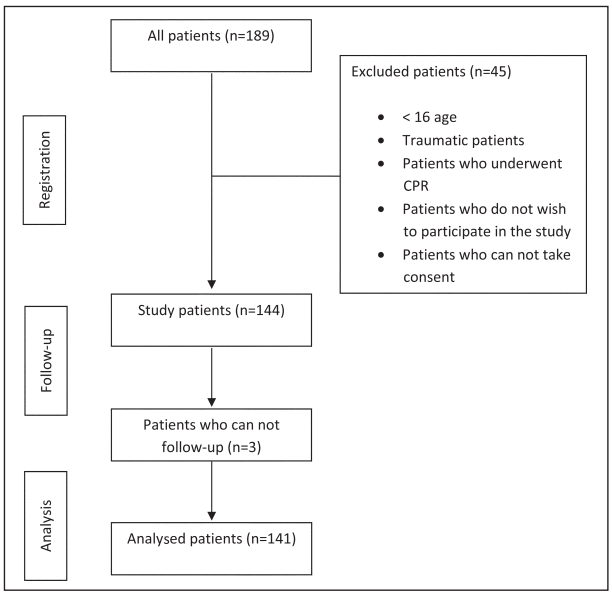



**Figure 1.** Patient flow chart.

values was 14.1±2.4. The average time in the emergency department was 291.2±203.5 minutes (30-1185). The number of the obese patients (body mass index >30) was 28 (19.9%). The demographics and vital signs of the patients are shown in Table 1.

The targeted US findings are shown in Table 2. Of the 5(3.5%) with abdominal aortic aneurysm (Aortic diameter >3 cm), only 1 (0.7%) had thrombi in the wall of aorta. None of these patients had intra-abdominal free fluid or aortic flaps. IVC collapse, which, when observed ultrasonographically, suggested to the clinicians that the shock was caused by hypovolemic or a distributive cause was detected in 38 (27%) patients. Of these patients, only 10 (26.3%) could be discharged, 14 (36.8%) were hospitalised in the ward, 12 (31.5%) were hospitalised in the intensive care unit, and 2 (5.2%) died. Among the patients evaluated, the most common pathology found using US examination was left ventricular dysfunction, which was seen in 81 (57.5%).

In the 141 patients who were admitted to the emergency department with a clinical picture of shock, after the targeted US examination, some of the considered pre-diagnoses were removed or new pre-diagnoses were added in totally 57 (40.5%) patients. As a result of this, new investigations such as blood sample test, computed tomography or X-ray were needed in 25 (17.7%) patients, and the treatment was changed such as intravenous hydration, positive inotropic treatment, antibiotic treatment in 57 (40.4%) patients (p<0.001). When the final diagnoses were made after all evaluations were compared with the pre-diagnoses, diagnostic change was seen only in 17 (12.1%) patients (Table 3).

The processes of the patients after treatment in the emergency department are shown in Table 4. The result showed that only 43 (30.5%) of the patients in this group could be discharged. Of the remaining patients, 39 (27.7%) were hospitalised in the intensive care units and 4 (2.8%) dies (2 due to sepsis, 1 due to dysrhythmia and 1 due to massive gastrointestinal bleeding). The fact that totally 98 (69.5%) patients were hospitalised or died, of whom 43 (30.5%) with very severe conditions, reintroduced the importance of this study group in terms of health.

**Table 1.** Demographic characteristics of the patients and vital signs

| Patient characteristics | Mean±SD |
|---|---|
| Demographic features | |
| Age (year) | 62.9±16.8 |
| Gender (M/F)* | 65.2/34.8 |
| Glasgow Coma Scale | 14.1±2.4 |
| Time of stay in the emergency department (minute) | 291.2±203.5 |
| Vital parameters | |
| Systolic blood pressure (mmHg) | 92.3±18.9 |
| Pulse (/minute) | 113.3±36 |
| Respiratory rate (/minute) | 27.3±8.9 |
| Temperature (°C) | 36.8±0.9 |
| Pulse oximetry (%) | 91.9±8.7 |

*Values are given in percent
SD=standard deviation

**Table 2.** The ultrasonographic findings in patients with shock

| Anatomical region | Yes | No |
|---|---|---|
| | Number (%) | Number (%) |
| Intraperitoneal free fluid | 15 (10.6%) | 126 (89.4%) |
| Intrapleural fluid | 20 (14.2%) | 121 (85.8%) |
| Abdominal aortic aneurysm | | |
| Aortic diameter (>3 cm) | 5 (3.5%) | 136 (96.5%) |
| Intra-abdominal free fluid* | 0 (0%) | 141 (100%) |
| Appearance of flap in aortic* | 0 (0%) | 141 (100%) |
| Thrombus in the wall of the aorta* | 1 (0.7%) | 140 (99.3%) |
| Collapse of the inferior vena cava | 38 (27%) | 103 (73%) |
| Pericardial fluid | 20 (14.2%) | 121 (85.8%) |
| Right ventricular diameter | | |
| Normal | 120 (85.1%) | |
| Dilated | 21 (14.9%) | |
| Left ventricular function | | |
| Hyperdynamic | 58 (41.1%) | |
| Normal | 60 (42.6%) | |
| Mildly decreased | 17 (12.1%) | |
| Severe decreased | 6 (4.3%) | |

*Ultrasonographic findings accompanying abdominal aortic aneurysm.

**Table 3.** Evaluation of changes assays, treatment and diagnosis after ultrasonography

| Evaluations | n (%) | p |
|---|---|---|
| New assays | | |
| Yes | 25 (17.7%) | 0.252 |
| No | 116 (82.3%) | |
| Change of treatment | | |
| Yes | 57 (40.4%) | <0.001 |
| No | 84 (59.6%) | |
| Change of initial diagnosis | | |
| No change | 84 (59.6%) | 0.167 |
| Decrease | 51 (36.2%) | |
| Increase | 6 (4.3%) | |
| Comparison with the initial diagnosis of definitive diagnosis | | |
| No change in diagnosis | 124 (87.9%) | 0.274 |
| Change in diagnosis | 17 (12.1%) | |

**Table 4.** Processes of patients after emergency treatment

| Processes | n (%) |
|---|---|
| Discharged | 43 (30.5%) |
| Admission to intensive care unit | 29 (20.6%) |
| Hospitalisation | 55 (39.0%) |
| Referred to other centres | 10 (7.1%) |
| Died | 4 (2.8%) |
| **Total** | **141 (100%)** |

The final diagnoses made after the emergency department evaluations for the study patients are shown in Table 5. As seen in this table, the majority of the diagnoses consisted of primary infective conditions followed by cardiopulmonary diseases. The result showed that the proportion of the conditions treatable with early diagnosis and appropriate approaches was high, and this increases the tendency towards the dynamic studies on this subject.

## Discussion

Nowadays, the number of patients admitted to emergency department is increasing. Due to the increased life expectancy, patients who are both elderly and have many co-morbid conditions are more frequently admitted to emergency department. This further increases the need for rapid diagnosis and treatment. Therefore, physicians have to utilise diagnostic methods that are easy-to-use, rapidly accessible and have the least potential side effects. As in other specialties, US applications have increasingly being used also in emergency medicine, and are now an indispensable part of patient care. In emergency department, US has provided early diagnosis or

**Table 5.** Causes of illnesses

| Causes of illnesses | n (%) | Causes of illnesses | n (%) |
|---|---|---|---|
| Sepsis | 40 (28.4%) | Excessive intake of drugs | 2 (1.4%) |
| Dehydration | 22 (15.6%) | Massive pleural effusion | 2 (1.4%) |
| Acute renal failure | 11 (7.8%) | Chronic obstructive pulmonary disease attack | 2 (1.4%) |
| Abdominal infection | 9 (6.4%) | Valvular dysfunction | 1 (0.7%) |
| Drug side effects | 9 (6.4%) | Anaphylaxis | 1 (0.7%) |
| Dysrhythmias | 8 (5.7%) | Cerebral oedema | 1 (0.7%) |
| Left ventricular failure | 7 (5.0%) | Acute leukocytosis | 1 (0.7%) |
| Pulmonary thromboembolism | 7 (5.0%) | Pericarditis | 1 (0.7%) |
| Gastrointestinal bleeding | 4 (2.8%) | Vasovagal syncope | 1 (0.7%) |
| Anaemia | 3 (2.1%) | Hyperosmolar coma | 1 (0.7%) |
| Cardiac tamponade | 2 (1.4%) | Bowel obstruction | 1 (0.7%) |
| Acute myocardial infarction | 2 (1.4%) | Cor pulmonale | 1 (0.7%) |
| Mesenteric ischaemia | 2 (1.4%) | **Total** | **141 (100%)** |

exclusion of many important conditions as well as enabling safer interventions, saved the life of numerous patients or enhanced the quality of care.[11]

Patient with non-traumatic shock condition for which the cause cannot be explained is one of the critical admissions most frequently seen in the emergency department. In this patient group, early diagnosis and targeted treatment are essential factors for good survival. In their study in 2004, Jones et al[12] found that hypotension in shock patients was the strongest marker of negative outcome among the clinical variables. Again in the same study, it was demonstrated that persistent hypotension was an independent determinant of mortality, intensive care need and organ failure. Hypotension has been considered to be more successful to demonstrate blood loss than heart rate. Despite tachycardia is generally considered as an early finding of hypovolemia, heart rate may change due to other internal and external stimuli. Shock index is a physiological variable that correlates well with left ventricular diastolic end pressure.[13] Therefore, our study population consisted of patients who had shock index >1, and who were clinically considered as suffering from shock.

The traditional physical examination techniques may be misleading in terms of complex shock physiology. Shock patients have high mortality and this correlates with the severity and duration of hypotension. Therefore, the diagnosis and initial care should be correct. While US performed by radiologists focuses on anatomy and pathology, the area of importance is shifted to the physiological evaluation in the US performed by clinicians.

Shock is a condition that should be diagnosed as soon as possible in emergency department patients due to its risk of morbidity and mortality. A bedside US application is very important to determine the possible causes of shock for emergency physicians. During the recent years, US has been clinically used in various areas and is very useful for physicians during the stage of judgement about patients.[14-16] Non-traumatic shock patients are one of these difficult groups. In this patient group, the applicability and efficacy of US should be demonstrated with studies in order for it to be widely used and to be included in the emergency medicine schedule as a routine application.

Targeted US application in non-traumatic shock patients was examined in two studies conducted in 2004[7] and 2009.[17] The targeted US application in the study by Jones et al[12] did not include upper left quadrant evaluation.

In order to accelerate the diagnostic process and to start the targeted treatment in the most appropriate and most rapid manner, Atkinson et al[17] conducted a study in 2008. The authors created an ACES protocol. In this protocol, the patients were ultrasonographically evaluated at 6 quadrants including cardiac, pleural, peritoneal, inferior vena cava and aorta. The ACES protocol was considered useful especially during the initial management stage until detailed information can be obtained about the patients, and was described as an applicable method complementing the clinical evaluation for undifferentiated hypotensive patients in emergency department. In our study, we investigated whether the targeted US examinations defined in the ACES protocol can make a change in the physicians' clinical diagnosis and treatment selections.

During the course of our study, some of the subjects recruited required request of new investigations and/or treatment modification after a targeted US examination. When we compared the pre-diagnoses we made before and after the US examination using the final diagnosis as the reference, we found a reduction in the number of pre-diagnoses or determination of new pre-diagnoses. US examination is considered useful for rapid evaluation, early diagnosis and treatment in non-traumatic shock patients in emergency department.

## Conclusions

Targeted US application in non-traumatic shock patients in emergency department has an impact on reduction of requested investigations, change of treatment selection and discovery of new diagnoses.

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