THE JOURNAL OF ACADEMIC EMERGENCY MEDICINE

The Effectiveness of Ultrasound in Patients with Non-Traumatic Cardiopulmonary Arrest

Travmatik Olmayan Kardiyopulmoner Arrest Hastalarda Ultrasonografinin Etkinliği

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Abstract

Objective: The purpose of this study was to evaluate the effectiveness of using cardiac ultrasound in emergency departments to direct resuscitation after cardiopulmonary arrest.
Material and Methods: The study was performed prospectively on 73 patients who underwent cardiopulmonary resuscitation in the emergency department at Gaziantep University Faculty of Medicine between January and December 2010. Two senior doctors, who had received emergency cardiac ultrasonography training, performed the cardiac ultrasound, which was done from the apical and subxiphoid windows. SonoSite Titan was used as the sonography device. Ultrasound evaluation and pulse controls were performed spontaneously. SPSS 18.0 was used for statistical analysis.
Results: The cases included 38 males and 35 females. 57.5% of the cardiopulmonary arrest incidents occurred out of the hospital. Only 8.2% of patients had a femoral pulse during the initial evaluation; 91.8% showed no femoral pulse. Although 31.5% of patients had a regular rhythm, 54.8% did not, and ventricular fibrillation was present in 13.7% of patients. Ultrasound inspection detected a heart rate in 13.7% of patients and ventricular fibrillation in 9.6%. In 76.7% of the cases, no heart rate was observed. There were 42 patients with asystole, two with a normal rate and 14 with valvular motion. Ventricular fibrillation was detected in seven cases, and following the evaluation performed simultaneously with ultrasound, pericardial tamponade was found in two and right ventricular enlargement in four cases. Global hypokinesia was detected in one patient and hypovolemia in one patient.
Conclusion: Doctors trained in emergency cardiac ultrasonography can use cardiac ultrasound as a supplementary method for managing cardiopulmonary resuscitation and making appropriate decisions. *(JAEM 2012; 11: 68-72)*
Key words: Cardiopulmonary arrest, cardiopulmonary resuscitation, cardiac ultrasound, pulseless electrical activity

Özet

Amaç: Bu çalışmanın amacı acil servisteki kardiyopulmoner resüsitasyonda, kardiyak ultrasonografinin (USG) resüsitasyonu yönlendirmedeki etkinliğinin değerlendirilmesidir.
Gereç ve Yöntemler: Bu çalışma Ocak 2010 ve Aralık 2012 tarihleri arasında, Gaziantep Üniversitesi Tıp Fakültesi acil servisinde kardiyopulmoner resüsitasyon uygulanan 73 hastada prospektif olarak yapıldı. Kardiyak USG uygulaması acil kardiyak USG kursu görmüş deneyimli iki hekim tarafından apikal ve subksiphoid pencereden gerçekleştirildi. Sonografi cihazı olarak SonoSite Titan kullanıldı. USG değerlendirmesi ve nabız kontrolleri eş zamanlı yapıldı. İstatiksel analiz için SPSS 18.0 kullanıldı.
Bulgular: Olguların 38'i erkek, 35'i kadın idi. Kardiyopulmoner arrestin %57.5'i hastane dışında meydana gelmişti. İlk değerlendirmede hastaların %8.2'sinde femoral nabız var iken, %91.8'inde yoktu. Aynı anda monitörde hastaların %31.5'inde düzenli ritim var iken, %54.8'inde ise ritim yoktu ve %13.7'sinde ventriküler fibrilasyon vardı. USG ile bakıda %13.7'sinde kalp atımı, %9.6'sında ventriküler fibrilasyon tespit edildi, %76.7'sinde kalp atımı görülmedi. USG ile eş zamanlı değerlendirmede; 42 kişide asistoli, 2 kişide normal atım, 14 kişide kapak hareketi, 7 kişide ventriküler fibrilasyon tespit edilirken, 2 kişide perikardiyal tamponat, 4 kişide sağ ventrikül genişlemesi, 1 kişide global hipokinezi, 1 kişide ise hipovolemi tespit edildi.
Sonuç: Kardiyak USG acil hekimleri tarafından kardiyopulmoner resüsitasyonun yönetiminde ve uygun kararlar vermede yardımcı bir yöntem olarak kullanılabilir. *(JAEM 2012; 11: 68-72)*
Anahtar kelimeler: Kardiyopulmoner arrest, Kardiyopulmoner resüsitasyon, kardiyak ultrasonografi, nabızsız elektriksel aktivite

Introduction

The use of ultrasonography (USG) for diagnostic and therapeutic purposes in emergency departments has increased rapidly in the last decade. The ACEP (American College of Emergency Physicians) first published a comprehensive guide for USG use in emergency services in 2001 (1). The scope of USG usage in emergency departments was extended when this guide was updated in 2009. In addition to using USG for trauma, pregnancy, abdominal aortic aneurysm and cardiac, biliary and urinary issues, emergency departments have started

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Received / Geliş Tarihi: 20.01.2012 **Accepted / Kabul Tarihi:** 05.03.2012

doi:10.5152/jaem.2012.028

using it for deep vein thrombosis, soft tissue, thoracic and ocular procedures, and some invasive procedures as well (2).

Resuscitating patients in cardiopulmonary arrest (CA) is performed in accordance with the algorithms determined by the American Heart Association (AHA) and the European Resuscitation Council (ERC) (3, 4). Both algorithms emphasize the importance of quickly identifying potentially reversible or treatable causes of CA. In this context, a clear distinction between asystole and true-false pulseless electrical activity must be made. With true pulseless electrical activity (TPEA), no pulse can be detected using the hand and, although a pulse is visible on the monitor, no cardiac contraction is present on USG. In false pulseless electrical activity (FPEA), there is no pulse detected with the hand, but a pulse is visible on the monitor and cardiac contraction is present on USG. Swift detection of the cardiac causes for arrest is critical. In cases where TPEA is detected, the resuscitation approach is more aggressive (5, 6). In patients considered to have CA, the absence of a pulse detected with the hand is a primary indication for initiating chest compression. However, using pulse control to evaluate perfusion during CA may be associated with some risks of its own (7, 8). Being unable to evaluate the pulse with the hand does not always indicate the presence of asystole. Also, a visible rhythm on the monitor, along with the absence of a pulse, does not always indicate the presence of TPEA. It is difficult to evaluate pulse activity, even when there is cardiac contraction, in cases such as pericardial tamponade, pulmonary embolism, pneumothorax and hypovolemia (9). These are common causes of FPEA and can be easily diagnosed with cardiac USG (10-13). Non-effective contractions with causes such as hypo/hyperkalemia, hypovolemia, acidosis, hypothermia or pericardial tamponade can be reversed further and faster than other CA cases (5, 6). The ERC guidelines put out in 2010 emphasize the importance of USG use in determining the potentially reversible causes of cardiac arrest (14). Swift diagnosis by emergency medicine physicians of clinical conditions such as pericardial tamponade, aortic dissection, pulmonary embolism, valvular anomalies, systolic and/or diastolic heart failure and hypovolemia increases the effectiveness of cardio-pulmonary resuscitation (CPR) and survivability. Using cardiac USG during resuscitation is a reliable, quick method that ensures diagnostic accuracy and may also ensure survivability by the doctor's decision on invasive treatment methods. In this study, we observed CA patients in order to evaluate the reliability and effectiveness of a fast sonographic evaluation integrated with advanced cardiac life support (ACLS).

Materials and Methods

The study was planned prospectively with the local ethical committee's approval. It included 73 of the 189 adult CA patients who underwent resuscitation in Gaziantep University Faculty of Medicine between January 2010 and December 2010. SonoSite Titan (Sonosite Inc. 2007, USA) was used as the USG device in the study, and examination was performed with a tightly curved array probe (2-4 MHz) in 2D mode. The USG device was kept ready and available in the resuscitation room throughout the duration of the study. Two senior doctors, who had received emergency cardiac USG training, performed all USG examinations. For the evaluations with USG, patients were monitored at the first, second and third inspections by the USG team, through the apical and subxiphoid windows, while resuscitation was being performed and the femoral pulse was checked. All inspections were completed in 10-second spans. Standard forms were used to record patient age, gender, whether arrest had occurred out-of-hospital or during follow-up in the hospital, respiration on arrival, how upper airway control was provided, the state of vascular access and the duration of CPR. The femoral pulse of all patients was evaluated during the heart rate beat moment on the monitor and with USG in the fifth minute of CPR and when there was a response to CPR or before CPR was terminated. Findings were recorded on the forms.

All data were evaluated with SPSS Ver. 18.0 (SPSS Inc., Chicago, Illinois, USA) statistical software.

Results

A total of 80,674 patients applied to our hospital emergency department for diagnostic and treatment purposes between January 2010 and December 2010. During this period, CPR was performed on 186 patients in the emergency department. Of 105 who had been brought to the emergency services as out-of-hospital CAs, 42 (40%) were included in the study because the USG team was ready and available. Among the 81 patients who developed CA during emergency department follow-up, 31 (38.2%) were included in the study because the USG team was ready and available. Of the 73 patients included in the study, 57.5% (n=42) had developed CA out-of-hospital and 42.5% (n=31) had developed CA during follow-up. The patient average age was calculated as 63.8±15.5 (19-85) years. There were 38 (52.1%) males (average age: 65.9±12.1 years) and 35 (47.9%) females (average age: 61.5±18.3 years). Table 1 shows the airway, vascular access, femoral pulse and respiration conditions of the patients at the initiation of CPR. In the first evaluation, the rhythms of six patients with femoral pulses were normal on the monitor. While the cardiac contractions of two patients were evaluated as normal during USG evaluation, three had right ventricular dilatation and one had global hypokinesia. These patients were intubated in a controlled manner. CPR was initiated when ventricular fibrillation (VF) or asystole developed in patients while treatment protocols were being determined. TPEA was identified at the first inspection in 13 patients and FPEA in four. The second

Table 1. Airway, vascular access, respiration and pulse conditions of patients at the initiation of CPR

	CA During Survelliance in Service	Off-Hospital CA
Airway		
Ambu	1 (3.2%)	14 (33.3%)
ETE	3 (9.7%)	11 (26.2%)
No airway control	27 (87.1%)	17 (40.5%)
Vascular access		
None	7 (22.6%)	19 (45.2%)
1 Vascular access	22 (71%)	23 (54.8%)
2 Vascular access	2 (6.4%)	0
Femoral Pulse		
Present	6 (19.4%)	0
Absent	25 (80.6%)	42 (100%)
Respiration		
Present	29 (93.5%)	5 (11.9%)
Absent	2 (6.5%)	37 (88.1%)

ETE: Endotracheal intubation

inspection identified TPEA in eight and FPEA in eight patients. At the third inspection, only three persons were identified with FPEA.

In the USG evaluation of three patients whose rhythms had been evaluated as VF on the monitor, the first evaluation found asystole in two patients and valvular motion was observed in one patient. During the second evaluation, the femoral pulse was absent in two patients, although a normal heart beat was detected on the monitor and by USG. One person who was evaluated with only a pulse showed valvular motion on USG. While one person whose rhythm was evaluated as VF on the monitor was identified with asystole on USG, one whose femoral pulse was absent and evaluated with asystole on the monitor was diagnosed with VF using the cardiac USG. At the time when CPR was terminated, two people, whose femoral pulses were absent, were identified with normal rhythms on the monitor and a normal heart beat on the USG. Table 2 shows the femoral pulse, monitor rhythm, USG heart beat and USG finding results of the patients, at the initiation of CPR, at the fifth minute and at the termination of CPR. Pericardiocentesis was performed in the emergency department on patients identified with pericardial tamponade (two in the first evaluation and two in the second evaluation; all were within the scope of FPEA). Of the two who were discharged from the service because they were admitted, one died in the emergency department and the other in intensive care. Two patients identified with asystole and VF in the first evaluation showed pericardial tamponade by USG in the second evaluation and one patient identified with hypovolemia in the first evaluation was found to have aortic dissection on the cardiac USG in the third evaluation. Average CPR duration was found to be 43.08±6.62 minutes (25-55 minutes). Of the 73 patients included in the study, 47 (64.4%) died in the emergency department, 14 (19.2%) died in the intensive care unit, one (1.4%) was discharged from the emergency department, nine (12.3%) were discharged from the department they had been transferred to after intensive care and two (2.7%) were sent to the emergency department at another center.

Discussion

Three different rhythms may occur in CA cases: defibrillatable rhythms, asystole and pulseless electrical activity (PEA). ACLS guidelines suggest three different algorithms for approaching the patient, based on rhythm. This guide considers monitor rhythm analysis, pulse palpation, medicine and response to invasive procedures as primary predictive factors in approaching the patient in the presence of PEA (15). However, some of the patients evaluated with PEA after monitor and pulse assessment may be FPEA, which manifests with peripheral perfusion failure or actual ventricular contraction (16). Most causes of FPEA, such as pericardial effusion, hypovolemia, pulmonary embolism and pneumothorax, are reversible causes that can be identified with cardiac USG within a very short period of time, giving a vital patient the chance for survival (10-13). Case reports and clinical studies performed within the last decade show that cardiac USG is largely beneficial to CPR in emergency services and other areas (10-13, 17). Cardiac USG can lead to CPR with better results, reversing spontaneous circulation and reducing treatment time by enabling rapid determination of the causes of FPEA (14, 18, 19).

Severe hypovolemia can cause CA, and this condition can be identified with USG. The determination of a decrease in intravascular volume is possible through evaluating end-diastolic volume, filling

Table 2. Femoral pulse, monitor and ultrasonography (USG) results at the initiation and termination of CPR and at the fifth minute

	Initiation of CPR	Fifth Minute	Termination of CPR
Femoral Pulse			
Present	6 (8.2%)	9 (12.3%)	23 (31.5%)
Absent	67 (91.8%)	64 (87.7%)	50 (68.5%)
Monitor Rhythm			
Present	23 (31.5%)	27 (37%)	28 (38.4%)
Absent	40 (54.8%)	32 (43.8%)	45 (61.6%)
VF	10 (13.7%)	14 (19.2%)	
USG Heart Beat			
Present	10 (13.7%)	18 (24.7%)	28 (38.4%)
Absent	63 (86.3%)	55 (75.3%)	45 (61.6%)
Asystole	56 (76.7%)	41 (56.1%)	45 (61.6%)
VF	7 (9.6%)	14 (19.2%)	
USG Findings			
Global Contraction	2 (2.7%)	10 (13.7%)	21 (28.8%)
Asystole	42 (57.5%)	32 (43.8%)	45 (61.6%)
VF	7 (9.6%)	14 (19.2%)	
Valvular Motion	14 (19.2%)	9 (12.3%)	
Pericardial Tamponade	2 (2.7%)	4 (5.5%)	2 (2.7%)
Right Ventricular Dilatation	4 (5.5%)	2 (2.7%)	
Global Hypokinesia	1 (1.4%)	2 (2.7%)	5 (6.9%)
Hypovolemia	1 (1.4%)		

reduction in the right ventricle along with shrinking and observing hyperkinetic left ventricular wall movement (20, 21). While continuing CPR, rapid fluid and blood replacement is fundamental to treatment. In our study, a patient whose rhythm was evaluated with FPEA at the first inspection with USG was identified with hypovolemia and, after being treated with aggressive fluid therapy, the patient was revived back to normal sinus rhythm and taken into intensive care.

FPEA can be identified in patients developing CA related to cardiac tamponade. If pericardiocentesis can be performed quickly, it is possible to revive patients. Cardiac USG is certainly the basic guideline for the identification of pericardial tamponade in patients and in directing pericardiocentesis (10). Collapse in the left atrium and ventricle along with the heart wallowing in pericardial fluid with a pendulum motion leads to the diagnosis of cardiac tamponade (22). Many studies have shown that performing cardiac USG in emergency, when patients are developing CA, contributes to the identification of cardiac tamponade and improves the treatment period (23-26). The results from previous studies and from our study agree with each other. Pericardiocentesis was performed in the emergency department on four patients identified with cardiac tamponade by cardiac USG at the first and second evaluations during CPR. One of these patients died in the emergency department, three were put into intensive care, and two were discharged with full recovery.

Massive pulmonary embolism is another cause of CA that may lead to FPEA and for which positive results can be obtained through quick diagnosis and treatment. The ACLS guidelines recommend diagnosing these patients quickly by performing thrombolytic therapy immediately or resorting to embolectomy (27). The presence of dilatation of the right heart pulmonary artery in cardiac USG evaluation is a significant finding pointing to pulmonary embolism (27). Studies are available showing that the use of cardiac USG has great benefits for diagnosing acute pulmonary embolism (12, 27, 28). In our study, diagnoses of for patients for whom we considered massive pulmonary embolism after identifying right ventricular dilatation as a result of inspection with cardiac USG were confirmed with further examination. While one of these patients died in the emergency department, thrombolytic treatment was initiated for the other three and they were put into intensive care. Two of them were discharged with full recovery.

The use of pulse control to evaluate the presence of a heart beat may contain inherent risks. Studies have shown that there is a considerable degree of failure to detect the pulse in cases where there is actually a pulse present and, in contrast, there are situations where a pulse was detected when it was actually absent, due to inaccurate evaluations (7, 8, 29). For this reason, cardiac USG should be considered a very valuable evaluation tool. We encountered similar situations in our study. A femoral pulse could not be detected in two people at the second evaluation and at the termination of CPR, while showing a normal sinus rhythm on the monitor and a regular heart rate on USG. One person who was evaluated with a pulse showed only valvular motion on USG.

Protocols used for the treatment of patients developing CA contain clues for terminating resuscitation. If the patient shows no response to treatment, the usual time limit and the team's state of fatigue are used to end resuscitation. Despite these indications, the presence of electrical activity on the cardiac monitor poses a problem for making the decision to end resuscitation (9, 30). Similar prematurely terminating resuscitation, unnecessary extensions are also harmful. Regardless of the patient's monitor rhythm, cardiac USG ensures accurate information about heart contractility in patients with no pulse. The determination of the absence of heart contractility with cardiac USG indicates that there is no response to CPR. In some studies, all patients identified with complete heart failure with cardiac USG could not be saved, although CPR was extended (9, 30, 31). In our study, all of the patients for whom no contractility in the heart was identified with cardiac USG, performed while considering the termination of CPR, were lost.

Modern ultrasound technology enables performing cardiac USG during CA. If cardiac USG is performed appropriately during CA, and interpreted accurately, it can facilitate distinguishing PEA-type arrest, learning the cause of the arrest, choosing a suitable treatment and making the right decision regarding CPR termination. In addition, through increased studies in this area, integrating cardiac USG use with the ACLS protocol may become a possibility in the future.

Limitations

In our study, the necessity to perform USG inspection quickly, and within a limited period of time, led to incomplete USG inspection of some cases; these were excluded from the study. In addition, VF rhythm should be defibrillated upon detection. Performing a USG inspection within a short period of time, until defibrillation was applied under the appropriate conditions and without delaying defibrillation, was a restrictive element in our study.

Conclusion

Using cardiac USG during CPR provides a substantial contribution to the resuscitation team, in areas such as identifying PEA type, determining and identifying possible arrest causes, choosing appropriate treatment methods and terminating resuscitation procedures. Therefore, the use of cardiac USG could help emergency medical professionals make the proper management decisions. Cardiac USG use, integrated with the ACLS protocol, could provide great benefits.

Conflict of Interest

No conflict of interest was declared by the authors.

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