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CPR-related thoracic injuries: comparison of CPR guidelines between 2010 and 2015

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Background/aim: This study aimed to evaluate traumatic thorax complications in post-CPR patients and to investigate whether or not there has been a decrease in these complications since the adoption of current chest compression recommendations.

Materials and methods: Post-CPR patients with return of spontaneous circulation (ROSC) were admitted between January 2014 and January 2016 were analyzed retrospectively. Patients admitted to the ED in 2014 were resuscitated according to 2010 AHA CPR guidelines, while those admitted to the ED in 2015 were resuscitated according to current ERC CPR guidelines.

Results: The study population comprised 48 male and 35 female patients. Of the 2010 AHA guideline patients, 39.21% experienced pulmonary contusion, while 54.83% of 2015 ERC guideline patients had pulmonary contusion. It was found that 11.76% of 2010 AHA guideline patients and 3.22% of 2015 ERC guideline patients had pneumothorax, while 9.8% of 2010 AHA guideline patients and 12.9% of 2015 ERC guideline patients experienced hemothorax. Incidence rates of lung contusion, pneumothorax, and hemothorax were higher in patients with rib fractures.

Conclusion: In this study, traumatic thoracic complications were investigated in patients with ROSC after CPR. The incidence of CRP-related injuries did not decrease on application of the new 2015 ERC CPR guideline recommendations. The most common injury in this study was rib fracture, followed by sternal fracture, lung contusion, hemothorax, and pneumothorax. Statistically, rib fracture had a positive relationship with lung contusion, hemothorax, and pneumothorax.

Key words: Resuscitation, thorax, injury, chest

1. Introduction

Chest compression criteria for cardiopulmonary resuscitation (CPR) are determined by the 2010 American Heart Association (AHA) guidelines. In these guidelines, the application of chest compressions is recommended to a depth of at least 5 cm (1). The current 2015 European Resuscitation Council (ERC) guidelines emphasize that the depth of each chest compression should be at least 5 cm, and 6 cm at most (2–4). Moreover, the 2015 ERC guidelines limit the number of chest compressions per minute to 100–120 (2–4).

This study was conducted to evaluate traumatic thorax complications in post-CPR patients and to investigate whether or not there has been a decrease in these complications since the adoption of the current recommendations.

2. Materials and methods

2.1. Study design

In this study, post-CPR patients with return of spontaneous circulation (ROSC) who were admitted to the Haydarpaşa Numune Training and Research Hospital Emergency Department (ED) between January 2014 and January 2016 were analyzed retrospectively. Trauma patients, patients who had a central line insertion, pediatric patients under 18 years of age, patients with incomplete data, and those who were transferred to other centers were excluded.

Patients admitted to the ED in 2014 were resuscitated according to the 2010 AHA CPR guidelines, while those admitted to the ED in 2015 were resuscitated according to the current ERC CPR guidelines. CPR practice and management were performed by emergency physicians who had advanced cardiac life support certifications. The hospital database was reviewed and patient data were analyzed. Patients were divided into two groups: 2010 AHA guideline patients and 2015 ERC guideline patients. We analyzed iatrogenic thoracic injuries received during CPR by reviewing chest computed tomography (CT) results. The analyzed parameters included age, sex, referral date, rib fracture, sternum fracture, clavicle fracture, scapula fracture, flail chest, costochondral joint separation,

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pulmonary contusion, pneumothorax, hemothorax, cardiac tamponade, and subcutaneous emphysema.

2.2. Statistical analysis

Data were analyzed with SPSS 17.0 (SPSS Inc., Chicago, IL, USA). Parametric data were analyzed with Student's t-test and nonparametric data were analyzed using the chi-squared test. $P < 0.05$ was taken to indicate statistical significance.

3. Results

The mean age of the patients resuscitated according to the 2010 AHA guidelines was 65.67 years, while that of the patients resuscitated according to the 2015 ERC guidelines was 70.19 years. There was no significant difference between the ages of the two groups ($P = 0.07$) (Table 1). The study population comprised 48 male and 35 female patients. There was a comparable sex distribution between patients resuscitated according to the 2010 AHA guidelines and those resuscitated according to the 2015 ERC guidelines (Table 2).

Twenty (39.215%) 2010 AHA guideline patients experienced pulmonary contusion, while seventeen (54.838%) 2015 ERC guideline patients had pulmonary contusion. The incidence of pulmonary contusion did not differ between the two groups ($P = 0.18$). Six (11.764%) of the 2010 AHA guideline patients and one (3.225%) of the 2015 ERC guideline patients had pneumothorax. The incidence of pneumothorax did not differ between the two groups ($P = 0.245$). Five (9.803%) 2010 AHA guideline patients and four (12.903%) 2015 ERC guideline patients experienced hemothorax. The incidence of hemothorax also did not differ between the two groups ($P = 0.724$).

Thirty-four (65.38%) patients resuscitated according to the 2010 AHA guidelines and twenty (64.516%) patients resuscitated according to the 2015 ERC guidelines developed rib fractures. The incidence of rib fracture did not differ between the groups ($P > 0.05$). All patient injuries are listed in Table 2. The incidence rates of lung contusion ($P = 0.022$), pneumothorax ($P = 0.048$), and hemothorax ($P = 0.023$) were statistically higher in patients with rib fractures (Table 3). No cases of scapula fracture, clavicle fracture, cardiac tamponade, or flail chest were noted in either study group.

Table 1. The t-test results of patients who underwent CPR under the 2010 and 2015 guidelines according to age

	n	Mean age	Standard deviation	P-value
CPR according to 2010 AHA Guidelines	52	65.67	13.56	0.07
CPR according to 2015 ERC Guidelines	31	70.19	8.85	

CPR: Cardiopulmonary resuscitation; AHA: American Heart Association; ERC: European Resuscitation Council.

Table 2. Injuries in patients resuscitated according to the 2010 AHA and 2015 ERC CPR guidelines chest compression recommendations.

	CPR according to 2010 guidelines		CPR according to 2015 guidelines	
	n	%	n	%
Male	34	65.38	14	45.16
Female	18	34.61	17	54.83
Sternal fracture	7	13.46	4	12.90
Lung contusion	20	39.21	17	54.83
Pneumothorax	6	11.76	1	3.22
Hemothorax	5	9.80	4	12.90
Costochondral JS	2	3.92	1	3.22
Subcutaneous emphysema	0	0	1	3.22
Rib fracture	34	65.38	20	64.51

CPR: Cardiopulmonary resuscitation; AHA: American Heart Association; ERC: European Resuscitation Council; JS: joint separation.

Table 3. Associations between rib fractures and other injuries.

	Rib fracture		No rib fracture	
	n	(%)	n	(%)
Male	32	59.26	16	55.17
Female	22	40.74	13	44.82
Sternal fracture	9	16.6	2	6.89
Lung contusion	29	54.71	8	27.58
Pneumothorax	7	13.2		
Hemothorax	9	19.68		
Costochondral JS	3	5.66		
Subcutaneous emphysema	1	1.88		

JS: Joint separation.

4. Discussion

Major updates to the CPR guidelines have been published since 2010. For example, the 2010 AHA guidelines did not limit the depth of compression and recommended a minimum of 100 chest compressions per minute, with no upper limit. In contrast, the 2015 ERC guidelines limited the depth of each compression to 5–6 cm and the number of chest compressions per minute to 100–120. Previously, airway and breathing were ascribed particular importance in the CPR guidelines; however, circulation was brought to the forefront in the 2010 AHA guidelines.

Adequate circulation can be achieved with high-quality chest compressions. More recently, the "push hard, push fast" technique has been highlighted as a high-quality chest compression method that increases the probability of survival in cardiac arrest (3). However, a number of studies have identified chest and abdominal injuries related to CPR. CPR-related injuries can affect mortality and morbidity after ROSC. A recent study revealed that the life-threatening postmortem frequency of post-CPR complications affected less than 0.5% of all CPR-applied patients (5). In cases where spontaneous circulation occurs, intrathoracic injuries due to chest compressions may complicate the clinical course of the patient (6).

There was no difference between the two groups in the current study in terms of age or sex. The avoidance of differences in both age and sex is important when aiming for an equal and homogeneous distribution, to reduce the impact of age and sex on CPR-associated complications (6).

Sternum fractures occur during CPR at a significant rate (7). The incidence of sternum fracture in this study was not significantly different between the two groups. The 2015 ERC guidelines recommend a chest compression depth of 5–6 cm, but this may not be applicable to each compression during CPR. As a result, chest compressions performed according to the above recommendation led to an incidence of sternum fracture similar to that of the 2010 AHA guideline group.

Rib fractures are one of the most common complications during CPR (8). Rib fractures may lead to serious complications, such as pneumothorax, hemothorax, lung contusion, major vascular injuries, and flail chest (8–10). In the current study, the incidence of rib fracture did not significantly differ between the two groups. Furthermore, there was a significant relationship between rib fractures and pneumothorax, hemothorax, and pulmonary contusion (Table 3).

The incidence of pulmonary contusion also did not differ between the two groups. The 2015 updates to the CPR compression recommendations resulted in no significant change in the lung contusion rate. Moreover, the recommendations regarding the correct depth and rate of chest compressions in the 2015 ERC guidelines did not reduce the incidence of lung contusion. Pulmonary contusions after CPR are common injuries (6). Lung contusion may lead to hypoxia during the early stages and may also cause pneumonia and atelectasis as late complications (10,11).

Recent studies have shown that pneumothorax can occur after CPR (4). Pneumothorax is a life-threatening pathology that may result in mortality and morbidity, in intubated patients in particular. It may also cause hypoxia by reducing the function of the lungs. Therefore, diagnosis and treatment of pneumothorax is essential (6). The current study revealed that the incidence of pneumothorax was not statistically different between the two CPR groups. In the 2015 ERC guidelines, a compression depth of 5–6

cm was recommended. However, this depth is not always applicable in clinical practice for each chest compression. As a result, the chest compression recommendations to "push hard, push fast", with a depth of 5–6 cm and up to 100–120 compressions per minute, resulted in the same incidence of pneumothorax as that of the group that did not undergo resuscitation according to these recommendations.

Hemothorax may occur during chest compressions, including as a result of rib fractures sustained during chest compressions. Previous studies revealed that hemothorax occurred in CPR-administered patients with ROSC (10). Therefore, early diagnosis and adequate treatment is important. The incidence of hemothorax was the same between the two groups examined in the current study. Changes proposed by the 2015 ERC guidelines regarding the depth and rate of chest compressions did not reduce the incidence of hemothorax.

The current study found no case of flail chest, scapula fracture, clavicle fracture, or cardiac tamponade. Further studies are needed to evaluate the relationship between these injuries and CPR.

This study shows that the updates to the CPR guidelines have not significantly altered the clinical outcomes. After ROSC, it is important to evaluate the patient for traumatic injury via radiographic interventions (11). It is further suggested that the detection and treatment of traumas can reduce mortality and morbidity in CPR patients (12).

In conclusion, in this study, traumatic thoracic complications were investigated in patients with ROSC after CPR. The incidence of CRP-related injuries did not decrease on application of the new CPR guideline recommendations. The most common injury in this study was rib fracture, followed by sternal fracture, lung contusion, hemothorax, and pneumothorax. Statistically, rib fracture had a positive relationship with lung contusion, hemothorax, and pneumothorax. Treatment of this trauma may reduce patient mortality and morbidity. No difference in the incidence of CPR-associated trauma was found when resuscitation was performed according to the recommendations of the 2010 AHA versus 2015 ERC guidelines. This study shows that the changes in these guidelines made no significant difference to the clinical outcomes. After ROSC, it is important to evaluate the patient for traumatic injury using radiographic interventions. It is also suggested that the detection and treatment of these traumas can reduce patient mortality and morbidity.

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