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Clinical paper

Intra-thoracic injuries associated with cardiopulmonary resuscitation – Frequent and serious☆

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ABSTRACT

Aim of the study: The aim of the study was to evaluate prevalence, seriousness and risk factors of intra-thoracic injuries (ITI) injuries associated with CPR in non-survivors after out-of-hospital cardiac arrest.
Methods: This was a prospective forensic autopsy cohort study conducted in a single institution. Pathologists recorded autopsy data using standardized protocol which contained data from external and internal examination of the body focused on ITI.
Results: In total, 80 persons were included in this study. CPR-associated injuries were found in 93.7% of cases; majority of injuries were skeletal chest fractures (rib fractures in 73.7%, sternal fractures in 66.3%). ITI were identified in 41.2% of cases. Contusion of at least one lung lobe was found in 31.2%, lung laceration in 2.5%, and hemothorax in 5.0% of cases. Transmural heart contusion was identified in 17.5% of cases; hemopericard on the grounds of right atrium rupture of aortic rupture was revealed in 8.7% of cases.

Risk factor analysis did not show any statistically significant correlation between ITI and any of general data (age, gender, BMI, cause of death, season of the year or location where the body was found) or CPR specifications (type and duration of CPR, manner of chest compressions). A strong correlation between ITI and skeletal chest fractures was proven.
Conclusion: ITI present frequent and serious complications of unsuccessful CPR. ITI could contribute to the death only provided the fact that ROSC had been achieved. Correct performance of chest compressions according to guidelines is the best way to avoid ITI.

Introduction

Cardiopulmonary resuscitation (CPR) presents a complex of emergency procedures aimed at restoring the flow of oxygenated blood to the brain and heart in individuals in cardiac arrest.[1–3] Out of all CPR techniques, chest compressions present the most aggressive technique with intensive repetitive violence against victim's chest. There were many changes in CPR international guidelines within the last decades, but effective chest compression remains the cornerstone of successful CPR.[2–4]

Early and effective CPR might be a potentially life-saving measure. On the other hand, CPR frequently generates a wide spectrum of iatrogenic injuries to the resuscitated person. Reported CPR-associated injuries vary from simple skin abrasions and bruises through skeletal chest fractures to severe life threatening injuries such as cardiac tamponade, cardiac rupture or liver lacerations.[1,5,6]

The total incidence of CPR-related injuries ranges from 21% to 97%.[3,6] Skeletal chest fractures present the vast majority of identified injuries – rib fractures are reported in 60–85%, sternal fractures in 15–58% of patients. Major intra-thoracic injuries (ITI) occur in up to 3–5% of persons.[5–12] Although skeletal chest injuries are very common, their clinical relevance in future patient management is usually very low. In contrast, reported incidence of ITI is not very

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high, but they might be life-threatening and might thwart resuscitation efforts.

In the available literature, there are either studies investigating all CPR related injuries[7,10–12] or studies focused on the examination of skeletal chest injuries.[8,13–16] To our best knowledge, there has been no relevant study investigating ITI as a primary outcome measure which may have caused an underpowered analysis of published CPR related intra-thoracic injuries.

With respect to aforementioned issues, we have conducted a prospective autopsy study aimed at exploring ITI injuries after CPR. The aim of the present study was to evaluate prevalence, seriousness and risk factors of ITI injuries associated with CPR in non-survivors after out-of-hospital cardiac arrest.

Methods

Design and setting

This was a prospective forensic autopsy cohort study conducted in a single institution. The study was approved by the Ethics Committee of the University Hospital Ostrava. For this type of study, formal consent was not required. The study analyzed intra-thoracic injuries in non-survivors of cardiac arrest who received CPR. Within the study period (1st September 2012–30th August 2015), all non-survivors who underwent CPR after out-of-hospital cardiac arrest and were brought to the Department of Forensic medicine of University Hospital Ostrava were assessed for the study inclusion. Only persons who died on the scene were included in the study.

Exclusion criteria were ages below 18 years, persons who were resuscitated under transport to the hospital, and death caused by trauma (victims of traffic accidents, crime victims, suicide victims etc.). Another exclusion criterion was unavailable or incomplete medical data (mobile emergency care unit records about CPR, documents about post-mortem examination).

The standard response to out-of-hospital cardiac arrest in Czech Republic is provided by an emergency dispatch center sending out mobile emergency care unit with advanced life support equipment staffed with professional rescuers (physician and paramedic). All professional teams performing advanced life support are allowed to withdraw from CPR measures and to declare death at the scene. Within the study period, CPR of all included persons was performed in accordance with The 2010 American Heart Association Guidelines for CPR and Emergency Cardiovascular Care.[17]

Under Czech legislation, a medico-legal autopsy is compulsory in cases of unnatural or unexplained deaths. All medico-legal investigations in Moravian-Silesian region (population of approximately 1.2 million people) are performed at the same center – Department of Forensic Medicine, University Hospital Ostrava.

Data collection

General data (age, gender, cause of death, location where body was found) and data about CPR provided (basic life support/advanced life support, duration of CPR, specification of persons performing chest compressions, defibrillation, drugs administration) were extracted from medical records (mobile emergency care unit records). These data were inserted into the standardized study protocol just before the beginning of any autopsy.

All autopsies in this study were routine autopsies performed in accordance with the Recommendation (99) 3 on the Harmonisation of Medico-Legal Autopsy Rules, adopted by the European Council in 1999.[18] Two experienced pathologists/forensic experts were involved in the autopsies of every person included in the study. Pathologists recorded autopsy data using standardized study protocol which contained data from external examination of the body (presence and localization of cutaneous lesions, subcutaneous emphysema etc.) and data from internal examination focused on ITI. Involved pathologists paid close attention to the investigation of any ITI during autopsies of all persons included in the study.

For the purposes of subsequent analysis, ITI were defined as diagnosed serious traumatic changes of lungs, heart or aorta (contusions or bruising of pleura or mediastinum were considered clinically insignificant).

Data analysis

The acquired data underwent detailed analysis using the means of descriptive statistics. Differences between continent and incontinent subgroups of residents were tested using a chi-square test and Fisher exact test for categorical variables, two-sample *t*-test for means of data with normal distribution and Wilcoxon test for data without normal distribution. A level of significance of $\alpha = 0.05$. Statistical analyses were performed using Stata v.13 software.

Table 1
General data regarding study population with/without ITI (intra-thoracic injuries).

Parameter	Total ($n = 80$)	With ITI ($n = 33$)	Without ITI ($n = 47$)	*P*-value
Age (years, mean ± SD)	58.2 ± 15.20	58.5 ± 15.92	58.0 ± 14.84	0.655
Gender, *n* (%)				
Female	19 (23.7)	8 (24.2)	11 (23.4)	0.931
Male	61 (76.3)	25 (75.8)	36 (76.6)	
BMI (kg/m^2, mean ± SD)	27.7 ± 5.04	27.8 ± 5.02	27.6 ± 5.15	0.844
Cause of death, *n* (%)				
Cardiac	45 (56.2)	17 (51.5)	28 (59.6)	0.786
Respiratory	15 (18.7)	7 (21.2)	8 (17.0)	
Drowning	4 (5.0)	1 (3.0)	3 (6.4)	
Hepatic & gastrointestinal	7 (8.8)	3 (9.1)	4 (8.5)	
Cerebral	4 (5.0)	3 (9.1)	1 (2.1)	
Intoxication	5 (6.3)	2 (6.1)	3 (6.4)	
Location where body was found				
Indoors	57 (71.2)	20 (60.6)	37 (78.7)	0.078
Outdoors	23 (28.8)	13 (39.4)	10 (21.3)	
Season of the year, *n* (%)				
Spring	24 (30.0)	12 (36.4)	12 (25.5)	0.091
Summer	28 (35.0)	12 (36.4)	16 (34.0)	
Autumn	13 (16.2)	7 (21.2)	6 (12.8)	
Winter	15 (18.8)	2 (6.0)	13 (27.7)	

[a] Statistically significant.