



Evaluation of Thoracic Region Complications Associated with Cardiopulmonary Resuscitation Applied to Cases of Fall From Height

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Abstract

Aim: The most common causes of blunt trauma are traffic accidents and falls from height. Thoracic region complications may be seen in cardiopulmonary resuscitation (CPR). The aim of this study was to examine thoracic complications developing in cases applied with CPR following a fall from height with no direct chest trauma.

Materials and Methods: The thoracic complications of CPR were examined in cases with CPR applied after a fall from height following the exclusion of cases where death occurred and an autopsy was performed.

Results: Evaluation was made of 109 cases who met the study criteria, comprising 82 males and 27 females. Fractures of the sternum and costa were seen at a higher rate than reported in studies in literature. No statistically significant difference was determined between the genders in respect of fracture rates. As age increased, there was found to be a statistically significant increase in fractures.

Conclusion: This is the first study to have examined CPR complications following a fall from height. Just as there are direct effects of trauma on the body in general, there are also known to be some indirect effects. The results of this study showed an increase in thoracic region complications developing after CPR applied to cases who developed cardiac arrest following a fall from height.

Keywords: Resuscitation, autopsy, complication, thorax, costa fracture

INTRODUCTION

Trauma is separated into two groups of blunt trauma and penetrating trauma according to the effect mechanism. Events such as falls from height and traffic accidents are classified in the blunt trauma group, and the penetrating trauma group includes firearms injuries and sharp blade injuries, etc (1). Traffic accidents and falls are the most common causes of blunt trauma (2,3). Falls have been seen to generally be the leading cause of presentations at the Emergency Department as a result of trauma and injury. Falls from height are a significant cause of morbidity and mortality in all age groups. It has been seen that the chest region is protected in trauma associated with falls from height, in contrast to other high kinetic energy traumas (4,5).

Unwanted complications may occur in cardiopulmonary

resuscitation (CPR), such as costa and sternum fractures in particular. Although rare, injuries can also occur in internal organs such as the lungs, liver, heart, or stomach. The frequency of complications can show variability according to the person performing CPR, the surface on which the patient is, the localisation where CPR is performed (in-hospital or out of hospital), and the educational level and the skill of the person performing CPR (6-10). Prevention through the early identification of various complications that can develop associated with CPR is of clinical importance, and the determination in medicolegal autopsies of complications developing as a result of CPR has contcostauted to clinical studies (7,10).

Although there are general studies related to CPR complications, to the best of our knowledge there is no study in literature of patients with cardiac arrest following

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a fall from height. It is thought that in addition to the direct trauma to the chest region after a fall from height, there may also be indirect effects. In bones exposed to high kinetic energy in a fall from height, it is thought that there could be an increase in bone fragility after changes which can occur in the internal structure of the bones. The aim of this study was to examine thoracic complications developing in cases applied with CPR following a fall from height with no direct chest trauma.

MATERIAL AND METHOD

A retrospective examination was made of 4327 autopsy records in an autopsy centre in the east of Turkey between 2012 and 2018. From these, 215 autopsies and records were re-examined of deaths resulting from a fall from a distance of at least their own height. The medical records and autopsy reports were evaluated together.

The medical documents were examined in respect of the examinations made on presentation at the hospital, radiological imaging, follow up and whether or not CPR was applied. In the autopsy reports, the external and internal examination findings were examined.

Patients were excluded from the study if any ecchymous grazed dermabrasions, or crepitation were determined in the examination of the thoracic region or if any costa or sternum fracture was determined with imaging methods. Patients with no trauma determined in the thoracic region in the examination and who were applied with CPR during follow up were included in the study. From examinations of all the medical documents and autopsy reports, it was decided whether the chest trauma had occurred before or after resuscitation. Trauma findings determined in the chest region after a fall from height were accepted as direct trauma, and indirect trauma was defined as trauma originating from secondary rotational or tensile forces which could occur distant from the region that was struck. The decision as to whether the chest trauma occurred before or after resuscitation was made by the physician who conducted the first autopsy together with the researchers by re-examining all the medical documents, autopsy reports and photographs taken during the autopsy. All the autopsies in this study were performed by experienced Forensic Medicine specialists. The majority of the autopsies were performed within 4-8 hours of death, and in general within the first 24 hours.

Taking bone development into consideration, the cases were classified in two age groups of younger and older than 24 years (11). Subcutaneous ecchymosis, costa fractures, sternum fracture, pneumothorax, hemothorax, and lung injuries following CPR were accepted as complications.

Ethical permission was obtained with the decision of İnönü University Scientific Research and Publication Ethics Committee Health Sciences Non-Interventional Clinical Research Ethics Committee dated 02/07/2019 and numbered 2019/268.

Statistical Analysis

Data obtained in the study were analyzed statistically using IBM SPSS vn. 25.0 software. The Pearson Chi-square test, Yates' corrected Chi-square test (continuity correction), and Fisher's Exact Chi-square test were used in the statistical analyses. A value of $p < 0.05$ was accepted as statistically significant.

RESULTS

Of the 4327 cases examined, 215 were cases of fall from height, of which 106 were excluded from the study because of fractures in the thoracic region associated with the fall. Evaluation was made of 109 cases that met the study criteria. These cases comprised 82 (75.2%) males and 27 (24.8%) females with a mean age of 45.60 years (range, 1-96 years). When classified in age groups, 24 (22%) cases were aged <24 years and 85 (78%) were aged >24 years.

In the cases that developed complications, injury to the left lung was determined in 22 (20.2%) and to the right lung in 18 (16.5%). Pneumothorax developed on the left in 10 (9.2%) cases and on the right in 4 (3.7%). Hemothorax developed in the left thoracic cavity in 21 (19.3%) and in the right in 24 (22%). There was seen to be ecchymosis in the resuscitation area in 33 (30.3%) cases, and sternum fracture in 39 (35.8%). The rate of sternum fractures was found to be statistically significant in cases aged >24 years ($p < 0.05$). No statistically significant difference was determined between the genders in respect of ecchymosis in soft tissue, costa fracture, or sternum fracture ($p > 0.05$).

In the left hemithorax, the left 3rd and 4th costa were seen to be fractured most, at the rate of 40.4% (n:44), followed by the 5th, 2nd, 6th, 7th and 8th costas, respectively. The 11th and 12th costas were fractured least in the left hemithorax at the rate of 1.8% (n:2). As a result of the statistical analyses, fractures of left costa 1-8 were found to be statistically significant in cases aged >24 years ($p < 0.05$). No statistically significant difference was determined between the genders in respect of left hemithorax costa fractures ($p > 0.05$) (Table 1).

In the right hemithorax, the 4th costa was seen to be fractured most, at the rate of 34.9% (n:38), followed by the 5th, 3rd, 2nd, and 6th costas, respectively. The 10th, 11th and 12th costas were fractured least in the right hemithorax at the rate of 0.9% (n:1). As a result of the statistical analyses, fractures of right costa 2-5 were found to be statistically significant in cases aged >24 years ($p < 0.05$). No statistically significant difference was determined between the genders in respect of right hemithorax costa fractures ($p > 0.05$) (Table 2).

When the localisation of costa fractures was examined, there were seen to be costa fractures in a single region and costa fractures in more than one region. The highest rate was in 43 cases with fractures from the midclavicular line, followed by fractures in the parasternal, anterior axillary, and paravertebral regions. The lowest rate of fractures was seen to be from the posterior axillary and midscapular regions (Table 3).

Table 1. Number and location of costa fractures in the left hemithorax			
Left hemithorax costa number	Percentage and (number) of cases	According to age groups	Gender
		p	p
1	12.80% (n:14)	0.037	0.745
2	34.9% (n:38)	0.000	0.613
3	40.40% (n:44)	0.000	0.469
4	40.40% (n:44)	0.000	0.469
5	39.40% (n:43)	0.000	0.401
6	32.10% (n:35)	0.000	0.693
7	24.80% (n:27)	0.004	0.676
8	17.40% (n:19)	0.012	0.077
9	7.30% (n:8)	0.196	0.406
10	2.80% (n:3)	1.000	0.573
11	1.80% (n:2)	1.000	1.000
12	1.80% (n:2)	1.000	1.000

* Most cases had more than one costa fracture. Yates's corrected Chi-square test and Fisher's Exact Chi-square test were applied.

Table 2. Number and location of costa fractures in the right hemithorax			
Right hemithorax costa number	Percentage and (number) of cases	According to age groups	Gender
		p	p
1	11.5% (n:21)	0.065	0.487
2	24.80% (n:27)	0.017	0.148
3	28.40% (n:31)	0.006	0.370
4	34.90% (n:38)	0.004	0.968
5	32.10% (n:35)	0.010	0.384
6	22% (n:24)	0.120	0.766
7	11.90% (n:13)	0.290	0.732
8	7.30% (n:8)	0.682	1.000
9	5.50% (n:6)	1.000	0.160
10	0.90% (n:1)	1.000	1.000
11	0.90% (n:1)	1.000	1.000
12	0.90% (n:1)	1.000	1.000

* Most cases had more than one costa fracture. Yates's corrected Chi-square test and Fisher's Exact Chi-square test were applied.

Table 3. Localisation of costa fractures	
Localisation of costa fractures	No of cases - percentage
Midclavicular	43-39.45%
Parevertebral	8-7.33%
Anterior axillary	9-8.25%
Midscapular	2-1.83%
Posterior sternal	3-2.75%
Mid axillary	4-3.66%
Parasternal	10-9.17%
Posterior axillary	2-1.83%

* in some cases there was more than one costa fracture localisation at the same time

DISCUSSION

Cardiopulmonary resuscitation (CPR) is a life-saving procedure in cases with traumatic or non-traumatic cardiac arrest. However, just as in all medical interventions, there are some complications in CPR. It is important that complications which could develop are reduced to a minimum as far as possible and that treatment can be started by diagnosis after the development. To the best of our knowledge, this is the first study to have examined complications developing in cases applied with CPR after a fall from height with no direct trauma to the chest region.

Fractures have been reported to be more often in the left hemithorax and in the upper costas (except the 1st costa). More fractures have been reported in the 3rd, 4th, and 5th costas in particular (9,10,16). In the current study, fractures

were seen more often in the upper costas (except the 1st) and located in the left hemithorax. That the most frequent fractures were of the left and right 4th costas was consistent with findings in literature. It was an expected result that the fractures costas were those in the area where CPR was applied.

There are various studies in literature related to the localisation of costa fractures developing associated with CPR. In studies conducted in Turkey, fracture localisation has been reported to be mostly in the mid-clavicular line (7, 8,17), whereas studies from other countries have stated that the fracture localisation occurs in the axillary line and sterno-chondral junction (10,15). The fracture localisations in the current study were seen to be mostly in the mid-clavicular line, consistent with the previous Turkish studies. The difference in fracture localisation can be attributed to differences in ethnicity or the application of CPR.

It has been shown in literature that females have a smaller and thinner sternum than males and the sternum is more frequently fractured (14). In literature, elderly individuals have been reported to be at higher risk of costa fractures (15). It has also been reported that while the incidence of costa fractures increases with age, this does not apply to sternal fractures (9). The results of the current study showed that sternal and costal fractures statistically significantly increased as age increased. However, in contrast to the literature, no significant difference was determined between the genders in respect of sternal and costal fractures. The effects such as rotational or tensile forces to which individuals are exposed in a fall from height were seen to change the effect on fractures with gender but not with increasing age.

In the current study, the complications that developed most were seen to be ecchymosis forming in the soft tissue and fractures in the sternum and costas. The rates of complications seen (sternum and costa fractures) were higher than those in most studies in literature (7,9,12,13). Bone fractures are seen with the direct effect of general body trauma. In addition, because the skeletal system is exposed to high kinetic energy in these traumas, this is thought to decrease resistance and increase fragility.

CONCLUSION

Previous studies in literature of CPR complications have been conducted on non-traumatic cases or without differentiation of traumatic and non-traumatic cases. In this context, the current study is of value as the first study to have examined CPR complications after a fall from height.

Just as there are direct effects of general body trauma, there are also known to be some indirect (rotational or tensile forces) effects. The results of this study demonstrated an increase in thoracic region complications after CPR applied to cases that developed cardiac arrest following a fall from height. Therefore, more care must be taken when applying CPR to patients who develop cardiac arrest following a

fall from height. This increase in bone fragility needs to be investigated with new prospective studies.

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REFERENCES

- Hoyt DB, Potenza BM, Cryer HG, et al. Surgery: scientific principles and practise. 2nd edn. Philadelphia: Lippincott-Raven; 1997;267–421.
- Ceylan S, Açıkel CH, Dündaröz R, et al. Determining the prevalence and trauma features of the patients which applied to the emergency service of a training hospital because of trauma. J Med Sci. 2002;22:156-61.
- Gül HS, Armağan HH, Karaman K, et al. Evaluation of Fall Cases Presenting To The Emergency Department. Med J SDU. 2019;26:430-4.
- Oktay C. Approach to the multi-trauma patient and recent developments. Anatolian Journal of Emergency Medicine October 2000;73-95.
- Avşar A, Okdemir E, Keten A, Karanfil R, Tree falling related death. Dicle Medical Journal. 2015; 42:331-4.
- Kim MJ, Park YS, Kim SW, et al. Chest injury following cardiopulmonary resuscitation: a prospective computed tomography evaluation. Resuscitation. 2013;84:361–4.
- Boz B, Erdur B, Acar K, et al. Frequency of skeletal chest injuries associated with cardiopulmonary resuscitation: forensic autopsy. (Article in Turkish) Ulus Travma Acil Cerrahi Derg. 2008;14:216–20.
- Özer E, Şam B, Tokdemir MB, et al. Complications of cardiopulmonary resuscitation. Cumhuriyet Medical Journal. 2010;32:315–22.
- Black CJ, Busuttill A, Robertson C. Chest wall injuries following cardiopulmonary resuscitation. Resuscitation. 2004;63:339–43.
- Krischer JP, Fine EG, Davis JH, et al. Complications of cardiac resuscitation. Chest. 1987;92:287–91.
- Cech DJ, Martin ST. Body Systems Contocostauting to Functional Movement, 3rd edn. St Louise Missouri. Elsevie. 2012;105–28.
- Deliliga A, Chatzinikolaou F, Koutsoukis D, et al. Cardiopulmonary resuscitation (CPR) complications encountered in forensic autopsy cases. BMC Emerg Med. 2019;19:23.
- Hashimoto H, Moriya F, Furumiya J. Forensic aspects of complications resulting from cardiopulmonary resuscitation. Legal Med. 2007;9:94–9.
- Rabl W, Baubin M, Haid C, et al. Review of active compression-

- decompression cardiopulmonary resuscitation (ACD-CPR). Analysis of iatrogenic complications and their biomechanical explanation. *Forensic Sci Int.* 1997;89:175–83.
15. Baubin M, Rabl W, Pfeiffer KP, et al. Chest injuries after compression-decompression cardiopulmonary resuscitation (ACD-CPR) in cadavers. *Resuscitation.* 1999;43:9-15.
 16. Miller AC, Rosati SF, Suffredini AF, et al. A systematic review and pooled analysis of CPR-associated cardiovascular and thoracic Injuries. *Resuscitation.* 2014;85:724–31.
 17. Şam B, Saka E, Süner Ç. Resuscitation complications in forensic autopsies. *The Bulletin of Legal Medicine.* 2003;8:5-8.