Fatal Traumatic Heart Wounds: Review of 160 Autopsy Cases*

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Abstract

Background: Despite many published retrospective analyses on cardiac injuries in treated patients, there is a striking scarcity of population-based studies that include autopsies.

Objectives: To provide data on fatal traumatic heart wounds in autopsied cases.

Methods: We reviewed 2,487 medico-legal autopsy records from the morgue of the Bursa branch of the Turkish Council of Forensic Medicine for the period 1997–2001.

Results: Of these cases, 160 (6.4%) had cardiac injury; 13.8% were females and 86.2% males, and the mean age was 35.9 years (range 4–65). The most common cause of heart wounds was penetrating trauma (87.5%), namely sharp injuries (48.1%) and firearm injuries (39.4%). The two most common causes of blunt heart wounds were traffic accidents (5.6%) and falls from a height (5%). Rupture was present in 96.9% of the cases, and isolated left ventricle and isolated right ventricle were ruptured in 31.3% and 23.8%, respectively. In penetrating injury the risk of ventricle rupture was higher than of atrium rupture. Alcohol was detected in 16.3% of cases. Only 3.5% of the penetrating cardiac injury cases and 5% of the blunt cardiac injury cases were admitted to hospital.

Conclusions: Given that only a very low percentage of the patients who sustain cardiac injury reach hospital alive, population-based studies, especially autopsy results, should be conducted to define the characteristics of cardiac injuries.

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Traumatic injury accounts for the majority of unnatural deaths throughout the world, with cardiac trauma being the leading cause of death among these victims [1]. Cardiac injuries are present in 7%–12% of all thoracic trauma cases and most of these (80%) are polytrauma patients [2]. Cardiac trauma is characterized by two main mechanisms of injuries – blunt and penetrating trauma. The major causes of non-penetrating cardiac injuries are traffic accidents, kicks by animals, falls, and cardiac resuscitative procedures, while penetrating cardiac injuries are due to a variety of objects, such as knives, bullets, etc. [1,2]. Numerous retrospective analyses on cardiac injuries in treated patients have been reported, which mostly focus on prognostic factors, such as rapid transportation, urgent diagnostic study, and elective surgery [2–5]. However, there is a marked scarcity of population-based studies that include autopsies. The aim of the present study was to provide data on fatal traumatic heart wounds in autopsied cases.

Subjects and Methods

Bursa, with a population of approximately 2.2 million people, is the fourth largest city in Turkey and the largest city in the south Marmara region (4 million people), representing the general demographic features of the region. The morgue in Bursa is the body responsible for forensic autopsies in this region. Autopsies (dead bodies or exhumed bodies) are carried out only at the written request of the prosecutors of the cities in this region. The autopsies are performed by the academic staff of the Department of Forensic Medicine of Uludag University Medical School as part of the graduate and postgraduate curriculum. Approximately 500 medico-legal autopsies are performed by this department annually.

In this study we reviewed the data of 2,487 medico-legal autopsies performed in the Bursa branch during the period 1997–2001. Only cases with confirmed cardiac injuries were included in this survey. Cardiac injury was defined as a) structural disruption of one or more cardiac chambers, and b) cardiac contusion. Data included age, gender, cardiac injuries, mechanism of injury, and associated injuries. The comparison of means was done using the *t*-test, and chi-square test and Fisher's exact test were used for contingency table analysis. A P value <0.05 was considered statistically significant.

Results

For the period 1997–2001 we identified cardiac injuries in 160 (6.4%) of 2,487 autopsied cases. Of the 160 cases, 138 (86.2%) were males and 22 (13.8%) females, and the mean age was 35.9 years (standard deviation 13.2, median 35) with a range of 4–65 years. No statistical difference was found ($F = 3.805$, $P = 0.053$) between the mean age of males [mean (SD) 36.7(12.7)] and females [mean (SD) 36.7 (12.7)]. Four males and three females were younger than 18 years old and 6 males were older than 60.

Heart wounds were caused by penetrating trauma in 140 cases (87.5%) and blunt trauma in 20 (12.5%). The type of injuries and their distribution among sexes are presented in Table 1. No significant difference was observed in the mechanism of injury between males and females ($P > 0.05$).

Cardiac rupture was present in 155 cases (96.9%) and cardiac contusion in only 5 (3.1%). The distribution of injury type and wounded chambers is shown in Table 2. Isolated left ventricle penetrating injury was the most common type of injury (31.2%),

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followed by isolated right ventricle injury (23.8%). No significant difference was observed in single or multiple chamber rupture between penetrating and blunt injury ($P > 0.05$), but in blunt injury the risk of atrium rupture was higher than of ventricle rupture according to the type of penetrating injury ($P < 0.05$, odds ratio 0.27) (0.09<OR<0.80).

The distribution of injury type according to the place of death is presented in Table 3. No significant difference was observed in the location of death between penetrating and blunt injury ($P > 0.05$). The majority of cardiac injury victims died at the scene (83.1%), and only 5 (3.5%) of the penetrating cardiac injury cases and 1 (5%) blunt cardiac injury case were admitted to hospital. When data on the place of death were analyzed according to the chamber wounded [Table 4], it was found that all except 3 (6.5%) of the 46 cases with atrium rupture died at the scene, while 9 (23.6%) of the 38 cases with isolated right ventricle rupture and 11 (22%) of the 50 with isolated rupture of the left ventricle died during transportation to or in hospital. No significant difference was observed in the place of death with regard to the chamber wounded ($P > 0.05$).

OR = odds ratio

Table 1. Distribution of gender and injury type

Type of injury	Male n (%)	Female n (%)	Total n (%)
Bullet wound	33 (23.9%)	1 (4.6%)	34 (21.3%)
Pellet wound	24 (17.4%)	5 (22.7%)	29 (18.1%)
Stab wound	61 (44.2%)	16 (72.7%)	77 (48.1)
Traffic accident	9 (6.5%)	0	9 (5.6%)
Fall	8 (5.8%)	0	8 (5%)
Tanker explosion	2 (1.5%)	0	2 (1.3%)
Other blunt	1 (0.7%)	0	1 (0.6%)
Total	138 (100%)	22 (100%)	160 (100%)

Table 2. Distribution of injury type and wounded chambers

Chambers	BW	PW	SW	Penetrating injury (%)	TA	Fall	TE	OB	Blunt injury (%)	Total (%)
RA	3	–	4	7 (5%)	1	–	–	–	1 (5%)	8 (5%)
RV	8	1	26	35 (25%)	2	1	–	–	3 (15%)	38 (23.8%)
LA	1	–	1	2 (1.4%)	–	2	–	–	2 (10%)	4 (2.5%)
LV	11	9	28	48 (34.3%)	1	1	–	–	2 (10%)	50 (31.2%)
RA + RV	1	2	1	4 (2.9%)	–	–	–	–	0	4 (2.5%)
RA + LA	1	–	1	2 (1.4%)	–	–	–	–	0	2 (1.3%)
RA + LV	3	–	1	4 (2.9%)	1	–	–	–	1 (5%)	5 (3.1%)
RV + LV	3	4	12	19 (13.6%)	–	1	–	1	2 (10%)	21 (13.1%)
LA + LV	1	1	1	3 (2.1%)	–	1	–	–	1 (5%)	4 (2.5%)
RA + RV + LV	1	1	1	3 (2.1%)	–	–	–	–	0	3 (1.9%)
RV + LA + LV	–	1	–	1 (0.7%)	–	–	–	–	0	1 (0.6%)
All chambers	1	9	1	11 (7.9%)	2	–	2	–	4 (20%)	15 (9.4)
Contusion	–	1	–	1 (0.7%)	2	2	0	–	4 (20%)	5 (3.1%)
Total	34	29	77	140 (100%)	9	8	2	1	20 (100%)	160 (100%)

BW = bullet wound, PW = pellet wound, SW = stab wound, TA = traffic accident, TE = tanker explosion, OB = other blunt, RA = right atrium, LA = left atrium, RV = right ventricle, LV = left ventricle.
The columns in bold denote total numbers and percentages of the groups; columns in regular type denote the numbers in the subgroups.

Table 3. Distribution of injury type and place of death

Type of injury	Place of death: Scene n (%)	Transportation n (%)	Hospital n (%)	Total n (%)
Bullet wound	29 (85.3%)	5 (14.7%)	–	34 (100%)
Pellet wound	27 (93.2%)	1 (3.4%)	1 (3.4%)	29 (100%)
Stab wound	61 (79.2%)	12 (15.6%)	4 (5.2%)	77 (100%)
Penetrating injury	117 (83.6%)	18 (12.8%)	5 (3.6%)	140 (100%)
Traffic accident	6 (66.7%)	3 (33.3%)	–	9 (100%)
Fall	7 (87.5%)	–	1 (12.5%)	8 (100%)
Tanker explosion	2 (100%)	–	–	2 (100%)
Other blunt	1 (100%)	–	–	1 (100%)
Blunt injury	16 (80%)	3 (15%)	1 (5%)	20 (100%)
Total	133 (83.1%)	21 (13.1%)	6 (3.8%)	160 (100%)

Table 4. Distribution of wounded chambers and place of death

Chamber	Place of death: Scene n (%)	Hospital n (%)	Transportation n (%)	Total n (%)
RA	8 (6%)	0	0	8 (5%)
RV	29 (21.8%)	7 (33.3%)	2 (33.3%)	38 (23.8%)
LA	4 (3%)	0	0	4 (2.5%)
LV	39 (29.3%)	9 (42.9%)	2 (33.3%)	50 (31.3%)
RA + RV	4 (3%)	0	0	4 (2.5%)
RA + LA	1 (0.8%)	1 (4.8%)	0	2 (1.3%)
RA + LV	5 (3.8%)	0	0	5 (3.1%)
RV + LV	19 (14.3%)	1 (4.8%)	1 (16.7%)	21 (13.1%)
LA + LV	3 (2.2%)	1 (4.8%)	0	4 (2.5%)
RA + RV + LV	3 (2.2%)	0	0	3 (1.9%)
RV + LA + LV	1 (0.8%)	0	0	1 (0.6%)
All chambers	14 (10.5%)	1 (4.8%)	0	15 (9.4%)
Contusion	3 (2.2%)	1 (4.8%)	1 (16.7%)	5 (3.1%)
Total	133 (99.99%)	21 (100.2%)	6 (100%)	160 (100.1%)

Alcohol was detected in 26 (16.3%) of cases, 25 males and one female. The concentration of blood alcohol ranged from 44 to 256 mg/dl, with an average of 126.8 mg/dl in males (44 mg/dl in the female). All alcohol-positive victims died either at the scene (n=22, 84.6%) or during transportation to hospital (n=4, 15.4%), and no significant difference was observed in the place of death between alcohol-positive and negative cases ($P > 0.05$).

The five most common associated injuries were located in the lungs (n=114, 71.3%), abdominal solid organs

(n=74, 46.3%), abdominal hollow viscus (n=43, 26.9%), intrathoracic blood vessels (n=23, 14.4%; 14 aortic, 6 caval, 1 pulmonary arterial injuries, 2 others), and the extremities (n=15, 9.4%). Other sites of structural injury included brain and/or cerebellum (n=14, 8.8%), spinal cord (n=8, 5%), neck vessels (n=7, 4.4%), intraabdominal vessels (n=3, 1.9%), and trachea (n=2, 1.3%).

Discussion

The results of the present study showed that 6.4% of the autopsied cases had cardiac injuries. Kaiser and Birnbaum [2] reported that injuries of the heart were present in 7–12% of all thoracic trauma cases in their study. Feliciano and co-workers [6], in a review of 312 patients, found 48 cardiac injuries (15.3%). Kulshrestha et al. [7] reported that cardiac injuries accounted for 41% of the deaths resulting primarily from chest trauma. Rhee and team [8] observed that one penetrating trauma cardiac death occurs for every 56 autopsies. Although the results of the present study reveal higher percentages of cardiac injuries in autopsied cases compared to previous studies, this may be due to the scarcity of autopsies of traffic accident victims in Turkey.

Consistent with other studies on cardiac injury [5,9–11], our results demonstrate male dominance (77.7–88%) and average age of 30 years (range 32–38.5 years), suggesting that females are less prone to cardiac injury than males, presumably due to their roles in the professional and social environment.

Reviews of thoracic trauma in children demonstrate an extremely low incidence of cardiac injury. Smyth [12] found no cases of cardiac injury in 94 children with chest trauma, while Meller et al. [13] reported only 2 cases of cardiac injury resulting from blunt trauma in 68 patients. In the present study, we found seven children (4.4%) with cardiac injury.

While some studies [1,9,14] identified penetrating trauma as the major cause of cardiac injury (approximately 90%), which is similar to our results, other authors [5,15] reported a higher rate of cardiac injury due to blunt trauma (26% and 44.1%).

In the United States, the majority of penetrating cardiac injuries are gunshot wounds [1,8,16,17], whereas in Canada, Europe and South Africa most injuries are stab wounds [11,18–20]. In our study, 55% of the penetrating cardiac injuries were stab wounds. Although the chamber most commonly involved in penetrating injury is the right ventricle because of its anterior position, followed by the left ventricle, right atrium and left atrium in descending frequency [1], the penetrating wounds in our study involved the left ventricle (n=89, 63.5%), followed by the right ventricle (n=73, 52.1%). Similar data were reported in two previous studies by Rashid et al. [18] and Oral [21].

Kulshrestha and associates [7,15] reported that only 10% of their patients who sustained cardiac injury reached the hospital alive. This included 3.5% for penetrating cardiac injuries and 5% for blunt cardiac injuries; in our study 5.2% of patients with stab injuries reached the hospital alive compared to 1.6% with gunshot injuries. It was found that gunshot injuries of the heart portend a worse prognosis than stab wounds [3,4,8,17,19].

Atrial injuries had a greater prehospital mortality compared to ventricular injuries; 4% and 5.2% of patients sustaining injury to isolated left ventricle and isolated right ventricle, respectively, reached the hospital alive, while all atrium rupture cases died at the scene in our study. In contrast, Kulshrestha et al. [15] and Demetriades and van der Veen [20] reported that ventricular injuries have a greater prehospital mortality compared to atrial injuries. Demetriades and van der Veen [20] also noted that the prognosis among hospitalized patients was best with right ventricular injury. Tyburski and colleagues [3] observed that single-chamber injuries had a higher survival rate than multiple-chamber injuries. It is well known that the muscular left ventricle will most likely close over a small injury, followed to a lesser degree by the thin-walled right ventricle, and the atria do not appear to have this capability. This explanation may lend support to our findings. However, one must bear in mind that an accompanying associated injury to vital organs such as lungs and intraabdominal solid organs may also exert a critical effect on the prognosis.

Although we found no significant difference in the place of death between the alcohol-positive and negative cases, all alcohol-positive victims died either at the scene or during transportation to hospital. We contend that alcohol affects mortality, firstly because alcohol may render a person less capable of defending him or herself and escaping quickly from a potentially violent situation, and secondly, the presence of alcohol may limit the victim's ability to call for emergency medical help. Liedtke and DeMuth [22] also concluded that the consumption of alcohol, even in small doses, can dramatically reduce mechanical performance in the presence of otherwise non-fatal cardiac injury secondary to non-penetrating chest trauma.

In view of the fact that only a very low percentage of patients who sustain cardiac injury reach hospital alive, population-based studies, especially autopsy results, should be carried out to define the characteristics of cardiac injuries. In addition to the data presented here on the characteristics of cardiac injuries, our findings also suggest that the fatal cardiac injuries usually cause death at the scene or during transportation and therefore prehospital care and the speed of the transportation is crucial in the management of these cases.

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Research Projects

Resistance of tumor cells to killing by antibody and complement

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Background: Several shields protect tumor cells from immune attack by antibody and complement. Some of these protectors are expressed on the cell surface whereas others are intracellular. Treatment of cancer cells with low, subtoxic doses of complement induces in them enhanced resistance to complement, accompanied by either synthesis or shut-off of certain proteins.

Objectives: Our ongoing research aim is to elucidate, at the molecular level, the mechanisms underlying the protective mechanisms and, based on that, to develop reagents that will counteract these protective mechanisms and thereby sensitize tumor cells to complement-mediated lysis.

Methods: A variety of human tumor cell lines, of carcinoma, leukemia and lymphoma origin, was studied. The cells were treated *in vitro* with antibody and human complement, at low (subtoxic) and high (toxic) doses, and the involvement of several stress response systems in death and survival was investigated. The research utilized biochemical and immunochemical methods for analyses of specific protein expression and location within cells, specific pharmacologic inhibitors of signalling pathways and expression vectors and siRNA in transfection experiments.

Results & Conclusions: Membrane complement regulatory proteins (CD46, CD55 and CD59) have been postulated to be the major line of defense against complement. Our results demonstrate that cancer cells are equipped with additional, no less important, mechanisms that facilitate cell resistance to and recovery from complement damage. Specifically, over recent years we collected data indicating that additional resistance to cancer cells is provided by: a) intracellular protein phosphorylation by PKC, PKA, ERK and p38 MAPK; b) sialic acid residues on the cell surface; c) damage control by hsp90 and PI3-K; d) extracellular C9 phosphorylation by ecto-CK2; and e) removal of the complement membranolytic complex by Mortalin/GRP75. Other proteins involved in protection are Stch and Bcl-2. Further investigation is needed to identify the fine details of the molecular pathways involved in cellular regulation of complement-inflicted damage. Clearly, cancer cells do not rely on a single protective strategy and employ several strategies. Therefore, for cancer immunotherapy to become more efficient, treatment should, in the future, silence the complement protective mechanisms of cancer cells and augment the complement toxic effect on cancer cells.

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