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Fatal cardiac trauma in the city of Manaus, Amazonas state, Brazil.

Trauma cardíaco fatal na cidade de Manaus/AM, Brasil.

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A B S T R A C T

Objective: to determine the frequency of fatal cardiac trauma in the city of Manaus, Brazil, between November 2015 and October 2016, and to clarify the mechanisms of trauma and death, previous hospital treatment, as well as the injuries associated with cardiac trauma. **Methods:** retrospective, observational, and cross-sectional study, which reviewed the necropsy reports of individuals whose cause of death was cardiac injury. **Results:** the cardiac trauma rate was of 5.98% (138 cases) out of 2,306 necropsies performed in the study period by Instituto Médico Legal (IML) de Manaus (IML is a Brazilian institute responsible for necropsies and cadaveric reports). Males accounted for 92% of the cases. The median age was 27 years (14-83). Gunshot wounds (GSW) was the trauma mechanism in 62.3% and stab wound (SW) in 29.7%. Exsanguination was responsible for most of the deaths and cardiac tamponade was present in second place. On-site death occurred in 86.2% of the cases. The ventricles were the most common site of cardiac injury. Hemothorax was identified in 90.6% of the individuals. Only 23 patients (16.7%) were taken to the hospital (Emergency Room), but six (26.2%) were submitted only to chest drainage, not to thoracotomy. The lung was unilaterally affected in 57% of the cases and bilaterally in 43%. **Conclusion:** fatal cardiac trauma represented an index of 5.98% in the city of Manaus. Most patients die at the scene of the trauma, usually due to exsanguination caused by gunshot wound. About a quarter of patients who reached the hospital and died were not diagnosed with cardiac trauma in time.

Keywords: Heart Injuries. Cardiac Tamponade. Exsanguination. Mortality.

INTRODUCTION

Cardiac trauma is among the most lethal lesions in history. Before the first successful cardiac suture performed by Rehn, in 1882, cardiac lesions were synonyms of inevitable death. With practical and scientific experience, it was demonstrated that this type of lesion could be surgically treated as soon as it was diagnosed[1].

Numerous patients come to the Emergency Room (ER) victims of penetrating or blunt traumas, hemodynamically stable or in severe hypovolemic shock. Many die during transport or at the trauma scene[2]. Currently, it is up to the general surgeon or trauma surgeon in the ER to diagnose and treat early cardiac trauma, in an attempt to further reduce mortality rates, mainly by reducing waiting time for thoracotomy, obtaining bleeding control and/or cardiac tamponade[3].

The indication of early surgery in cardiac trauma diagnosed cases is paramount for a favorable clinical outcome. In its turn, the surgeon needs a high index of suspicion in those cases with hemodynamic stability, otherwise, a fraction of these patients may rapidly die because of the delay in the diagnosis of cardiac injury[4-6].

Despite of important contributions to the understanding of trauma mechanisms, the profile of patients who die at the trauma scene, mortality, the impact of prehospital withdrawal, and hospital intervention, few studies have analyzed this issue in the post-mortem environment[7-10]. Thus, clarifying the profile of patients with cardiac injury to the necropsy study, as well as elucidating the cases that received some type of treatment or hospital care, or the direct cause of death, such as cardiac tamponade or exsanguination, could justify preventive actions measures in an attempt

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to reduce mortality. This paper aims to contribute to elucidating these issues.

METHODS

A retrospective study, which reviewed the necropsy reports of individuals whose cause of death was cardiac injury, alone or in association with other lesions, during a 12-month period (from November 1st, 2015 to October 31st, 2016) in the city of Manaus. The necropsies were performed by Instituto Médico Legal (IML). The study was approved by the Research Ethics Committee of Universidade Federal do Amazonas (registered under number 1,808,394. CAAE: 58316716.6.0000.5020).

In order to standardize collected data, the following terms were used:

Cardiac trauma: when there was a description of lesions in the pericardium or cardiac chambers and/or in the great vessels (aortic root, pulmonary artery trunk, superior vena cava, and pulmonary).

Cardiac Tamponade: when the cardiac lesion was associated with the presence of blood only in the pericardial sac, in the absence of another lesion to justify the death.

Exsanguination: when the cardiac lesion was associated with the presence of blood in the pleural cavity, in the absence of evident cardiac tamponade.

Data were entered in a collection form which included: identification (registration number and number of the death certificate), gender, age, date of death, trauma mechanism (blunt or penetrating), description of lesions and of internal organs, hospital treatment before death (thorax drainage, thoracotomy, cardiorrhaphy), complications, time interval between trauma and death, and, finally, the mechanism of death (cardiac tamponade or exsanguination).

The software used for data analysis was Epi Info™ 7.2 for Windows®. The significance level of the statistical tests was of 5%. In the analysis of the quantitative variables, accepting the normality hypothesis, with 5% significance, the mean and standard deviation (STD) were calculated. However, when the normality hypothesis was rejected, the median and quartiles Q1 (25%) and Q3 (75%) were calculated. In the analysis of the categorical data, we applied Pearson's chi-square test. As Pearson's test cannot be used for 2x2 tables, we used Fisher's exact test. In the comparison of median age, the non-parametric Mann-Whitney test was applied.

RESULTS

During a year of data collection, 2,306 necropsies were performed in IML-Manaus, registering 138 cases of cardiac trauma, which corresponded to a rate of 5.98%. Considering these 138 cases, 92% of the individuals were men and 8% were women. Age ranged from 14 to 83 years, with median of 27 years for males and 30 years for females. The majority (54.3%) were between 20 and 34 years. There was no statistical difference in median age between men and women (p=0.076).

Penetrating trauma was responsible for 92% of deaths: 62.3% caused by gunshot wounds (GSW) and 29.7% caused by stab wound (SW), as shown in table 1. Only 23 individuals (16.7% of the total) were removed to the Emergency Room. Thirteen of them (56.4%) underwent thoracotomy. Death at the trauma scene was described in 86.2% of the cases, and the median time between trauma and death was of 50 minutes (Table 1).

Regarding the anatomical site of lesion, the left ventricle (LV) was the most affected site, when only single lesions were considered. In multiple lesions, the association of right ventricle (RV) and LV was the most prevalent. In 36.2% of the reports, there was no description of the affected cardiac chamber (Table 1).

Table 1. *Distribution concerning trauma mechanism, hospital treatment, time between trauma and death, and site of cardiac injury.*

Variable	f_i	%
Trauma mechanism (n=138)		
Gunshot wounds (GSW)	86	62.3
Stab wounds (SW)	41	29.7
Car accident	7	5.1
Motorcycle accident	3	2.2
Fall	1	0.7
Hospital treatment (n=23)		
Thoracotomy	13	56.4
Thorax drainage	6	26.2
None	4	17.4
Time between trauma and death (n=138) (min.)		
On-site death	119	86.2
Q_1 - Median - Q_3	31 - 50 - 85	
Minimum - Maximum	18 - 7,200	
Anatomical site of lesion (n=138)		
Single chamber	60	43.5
LV	22	16.0
RA	13	9.4
RV	6	4.3
LA	3	2.2
Great vessels	16	11.6
Multiple chambers	28	20.3
RV + LV	17	12.4
LA + LV	5	3.6
RA + LA	3	2.2
RA + LV	1	0.7
RA + RV + LV	1	0.7
RA + LA + RV + LV	1	0.7
Without description	50	36.2
Total	138	100.0

f_i: absolute frequency, Q_i: Quartile, RA: right atrium; LA: left atrium; RV: right ventricle; LV: left ventricle.

A great part of the deaths were related to perforating and transfixing lesions (47.8% and 42%, respectively), with exsanguination accounting for the majority of deaths, while cardiac tamponade was present in second place (Table 2).

Table 2. *Distribution concerning cardiac lesion morphology, death mechanism, and hemothorax.*

Variables (n=138)	f_i	%
Cardiac lesion morphology		
Perforating	66	47.8
Transfixing	58	42.0
Laceration, rupture, or explosion	11	8.0
Tangential	2	1.5
Mural hematoma	1	0.7
Death mechanism*		
Exsanguination	113	81.9
Tamponade	40	29.0
Sepsis	1	0.7
TBI	2	1.5
Hemothorax	125	90.6

*f_i: absolute frequency, TBI: traumatic brain injury. * In 18 cases, there was more than one death mechanism.*

A total of 300 lesions were associated with cardiac trauma in the 138 deaths studied, with the lung representing the main affected viscera (121 cases, 57% unilateral and 43% bilateral), followed by the liver, injured in 19.6% of the cases, as shown in table 3.

Trauma mechanism, cardiac lesion morphology, and hospital treatment had no statistical significance in relation to death mechanism (Table 4).

Likewise, there was also no statistical significance of the trauma mechanism in relation to the number of injured cardiac chambers (Table 5).

DISCUSSION

The city of Manaus, capital of Amazonas state, with estimated population of over two million inhabitants, has experienced an increase of urban violence in recent years[11]. It is the in the third position of the most violent cities in Brazil and occupies the 11th place in the world ranking (considering just cities that do not experience wars or armed conflicts and which have more

Table 3. *Distribution concerning associated lesions.*

Variables (n=138)	fi	%
Thorax		
Lung (n=121)		
Unilateral	69	57.0
Bilateral	52	43.0
Sternum	5	3.6
Ribs	11	8.0
Clavicle	1	0.7
Thoracic aorta	12	8.7
Brachiocephalic trunk	1	0.7
Trachea	1	0.7
Pulmonary thread	3	2.2
Superior vena cava	2	1.5
Subclavian artery	1	0.7
Diaphragm	6	4.4
Head and neck		
Cranial skull fracture	14	10.1
Intracranial hemorrhage	14	10.1
Jugular vein / Carotid artery	2	1.5
Abdomen		
Liver	27	19.6
Colon	5	3.6
Small intestine	14	10.1
Stomach	15	10.9
Spleen	7	5.1
Kidney	6	4.4
Hemoperitoneum	14	10.1
Mesentery	2	1.5
Limbs		
Fracture of forearm and hand	5	3.6
Arm fracture	5	3.6
Femur fracture	4	2.9
Leg fracture	2	1.5

f_i: absolute frequency.

than 300,000 inhabitants[12]), with a rate of 70.37 homicides per 100,000 inhabitants.

A rate of 5.98% of fatal cardiac trauma was found in this study, when we reviewed 2,306 deaths in IML-Manaus, which correspond to the total necropsies due to external causes in Manaus. Two studies described in recent literature were carried out in Campinas, São Paulo, and Bursa, Turkey, analyzing both penetrating and blunt trauma[7,8]. Their populations resemble Manaus' population. In Campinas, a city with approximately 1.1 million inhabitants[13], the authors reported a frequency of 18.2% fatal cardiac trauma when analyzing 1,976 deaths, an index which corresponds to three times the result of this study[8]. In Bursa, a city with about 2.3 million inhabitants, the authors found a rate similar to the one verified in Manaus: about 6.4%, when analyzing 160 death cases due to cardiac trauma in a retrospective study which reviewed 2,487 necropsies in Bursa, between 1997 and 2001[8].

Studies which analyze survivors of cardiac trauma in hospital cases are frequent in literature[14-18]. However, publications involving fatal victims or necropsy studies are scarcer and, therefore, it is difficult to establish a prevalence or incidence of this type of trauma in a more comprehensive way, since articles portray the reality of each service. The rate of fatal cardiac trauma may be even higher, especially when studies just analyze closed or blunt injuries. Corroborating this result, a series reported a frequency of 21.1% cardiac trauma in 380 car occupants who were involved in fatal collisions in Adelaide (Australia) and Hamburg (Germany)[19]. Another article showed even greater numbers, about 35% of cardiac trauma, when retrospectively reviewing 881 fatal victims of blunt trauma in Los Angeles (USA)[20].

In our review, we showed that the majority of deaths occurred in men, with median age of 27 years, a similar result as the ones shown in studies performed both in Latin America[14,21-23] and in the United States[3,24,25]. GSW was the trauma mechanism in 62.3% of the deaths in our series.

Table 4. *Distribution according to the frequency of trauma mechanism, lesion morphology, and hospital treatment in relation to death mechanism.*

Variables	Death mechanism				Total
	Exsanguination (n=113)		Tamponade (n=40)		
	f_i	%	f_i	%	
Trauma Mechanism					
Blunt	10	90.9	2	18.2	11
Stab wounds (SW)	33	80.5	13	31.7	41
Gunshot wounds (GSW)	70	81.4	25	29.1	86
p*	0.715		0.68		
Cardiac lesion morphology					
Perforation	53	80.3	23	34.8	66
Transfixing	47	81.0	16	27.6	58
Laceration, rupture, or explosion	11	100	1	9.10	11
Tangential	2	100	-	-	2
Mural hematoma	-	-	-	-	1
p***	-		-		
Hospital Treatment					
Yes	20	87.0	6	26.1	23
No	93	80.9	34	29.6	115
p**	0.767		0.807		

*fi: absolute frequency; * Pearson's chi-square test; ** Fisher's exact test; *** It was not possible to apply Pearson's and Fisher's tests due to Cochran's restrictions. Note: The statistical analysis of "Exsanguination" and "Tamponade" variables were performed separately, because there was a patient who presented both mechanisms, so the total does not refer to the sum of each mechanism.*

Table 5. *Distribution concerning the number of cardiac chambers in relation to the trauma mechanisms.*

Trauma mechanism	Number of chambers				Total
	One		More than one		
	f_i	%	f_i	%	
Blunt	5	71.4	2	28.6	7
Stab wounds (SW)	18	72.0	7	28.0	25
Gunshot wounds (GSW)	40	71.4	16	28.6	56
Total	63	71.6	25	28.4	88

f_i: absolute frequency; p=0.964 (Pearson's chi-square test).

These data reaffirm the intense frequency of this mechanism in necropsy studies, as demonstrated by other researchers, who reported a 65.5% penetrating trauma rate (59.7% of isolated GSW)[8]. These data contrast with our reality in Manaus, since Costa *et al*. reported that the majority of patients who arrived alive at Emergency Room (82%) had SW, which resulted in a 76% survival, demonstrating that white gun is associated with greater survival[14].

Gunshot is classically associated with higher mortality, both by its destructive power and by the kinetic energy transmitted to the cardiac muscle, as well as by its capacity to injure multiple organs[26]. This detail was verified in our study, when we found that 42% of patients had transfixing cardiac injuries. In addition, gunshot and transfixing injury were associated with a higher exsanguination rate. However, this difference was not statistically significant. As a death mechanism, exsanguination was described in 81.9% of the cases in this study, which led the majority of patients to immediate death at the trauma scene. These data are in agreement with literature[7,8]. The presence of cardiac trauma is associated with death at the trauma scene, both for penetrating and blunt lesions[8,20]. In this study, we observed that 86.2% of the patients had immediate death (at the trauma site).

It is known that cardiac tamponade has a protective effect (at least temporarily) by restricting massive volume loss, gaining sufficient time for transportation to the emergency unit and for surgical intervention[27]. In our series, cardiac tamponade was present in only 29% of the victims in the necropsy study, indicating that few victims had restricted volume loss.

In our series, 23 individuals were removed to ER. However, only 53.4% underwent thoracotomy for the treatment of cardiac injury. Similarly, in a study in Campinas, 50% of those who arrived alive at the hospital were treated by thoracotomy. In the other half, the diagnosis was performed after death[8]. In contrast, in this study, 43.6% of the individuals who arrived at ER were submitted only to thorax drainage (26.2%) or no effective treatment was instituted (17.4%). In these cases, the diagnosis of cardiac injury was performed after death in IML, a fact that makes us reflect on the necessity for a high rate of suspected cardiac injury in these patients, victims of thorax trauma.

Despite the impossibility of analyzing objective physiological data, such as blood pressure and pulse, this portion of patients who died after being treated only with closed thorax drainage represented cases of individuals who arrived at ER with some sign of life. These data point us to the importance of early diagnosis and decision-making in cardiac trauma in the sense of preserving life. The surgical team treating such patients (even stable or asymptomatic ones), particularly victims of penetrating trauma with transfixing thorax injuries in the Ziedler area, should actively seek the diagnosis of cardiac injury. Constant clinical reassessment and the use of non-invasive diagnostic methods, such as Focused Assessment with Sonography in Trauma (FAST), could help in making an operative decision and saving many lives.

However, it is known that there are many variables that determine if the person will arrive alive at ER, such as rapid transport, trauma mechanism, and associated injuries[22,25,28]. Depending on the prehospital service, 10% to 30% of the victims arrive at the hospital, where the surgeon will play a fundamental role in reducing the time for operative intervention, increasing the survival of these patients[28,29]. In this context of the surgeon's decision, one study observed a tendency to decrease mortality from 20.3% to 10.3% when the "surgical observation period" was not adopted, emphasizing that the speed in indicating a thoracotomy is decisive for saving lives[22]. Because of its position in the anterior mediastinum, ventricular lesions, particularly of the right ventricle, are described quite frequently in literature, similarly to our study[7,22,30]. In addition, multiple lesions of cardiac chambers are associated with higher mortality and are usually caused by GSW[3].

Literature shows that the five most common associated lesions to fatal cardiac trauma are: lung (71.3%), abdominal solid organs (46.3%), abdominal hollow viscera (26.9%), thoracic vessels (14,4%), and extremity (9.4%)[7] lesions. In our sample, the lung and liver were the most frequently affected viscera, in about 57% and 19.6% of the cases, respectively, demonstrating a profile of associated lesions, similar to previously published studies[14,31].

Although this work contributes to the description of the epidemiological profile of individuals who die due to cardiac trauma in the city of Manaus, its retrospective nature and the review of medical records impose some limitations, such as the difficulty of data collection due to incomplete data (for example, the site of the cardiac lesion, which made it impossible to stratify individuals using the Organ Injury Scale/American Association for the Surgery of Trauma - OIS-AAST). In addition, the authors were not directly involved in the necropsies, which made it difficult to standardize the anatomical description of the lesions.

R E S U M O

Objetivo: *determinar o índice de trauma cardíaco fatal na cidade de Manaus e esclarecer os mecanismos de trauma e de morte, o tratamento hospitalar prévio, assim como as lesões associadas ao trauma cardíaco.* **Métodos:** *estudo retrospectivo, observacional, transversal, que revisou os laudos de necropsias do Instituto Médico Legal de Manaus entre novembro de 2015 e outubro de 2016, cuja causa mortis foi lesão cardíaca.* **Resultados:** *o índice de trauma cardíaco foi de 5,98% (138 casos) dentre 2306 necropsias realizadas no período do estudo. Homens foram afetados em 92%. A mediana de idade foi de 27 anos (14 a 83). A arma de fogo foi o mecanismo de trauma em 62,3% e a arma branca em 29,7%. A exsanguinação foi responsável pela maioria das mortes e o tamponamento cardíaco esteve presente em segundo lugar. Óbito no local ocorreu em 86,2%. Os ventrículos foram as câmaras mais lesionadas. O hemotórax foi descrito em 90,6%. Apenas 23 (16,7%) doentes foram removidos até o pronto socorro, porém seis deles (26,2%) não foram submetidos à toracotomia, apenas à drenagem de tórax. O pulmão foi acometido em 57% unilateralmente e 43% bilateralmente.* **Conclusão:** *o trauma cardíaco fatal representou um índice de 5,98% na cidade de Manaus. A maioria dos doentes morre na cena do trauma, geralmente devido à exsanguinação causada por ferimento de arma de fogo. Cerca de um quarto dos pacientes que chegaram ao pronto socorro e morreram, não foram diagnosticados com trauma cardíaco em tempo hábil.*

Descritores: *Traumatismos Cardíacos. Tamponamento Cardíaco. Exsanguinação. Mortalidade.*

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