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Penetrating cardiac injuries: 28-year data analysis

Zymantas Jagelavicius[1,2], Mindaugas Budra[1], Vytautas Jovaisas[1], Gintaras Kiskis[1], Algis Kybartas[1], Arunas Zilinskas[1], Irena Liubertiene[1], Vygantas Gruslys[2], Ricardas Janilionis[1,2]

[1]Department of General Thoracic Surgery, Vilnius University Hospital Santariskiu Klinikos, Vilnius, Lithuania
[2]Clinic of Infectious, Chest Diseases, Dermatovenerology and Allergology of Vilnius University, Vilnius, Lithuania

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Abstract

Background: Penetrating cardiac injuries are a dramatic and lethal form of trauma. They are usually sustained by young people. The majority of victims die before reaching the hospital.

Aim of the study: The aim of the study was to establish prognostic criteria for the outcome of penetrating cardiac injury.

Material and methods: We retrospectively reviewed the records of 186 patients with penetrating cardiac injuries who were operated on during the first 24 hours after admission.

Results: The mean age was 33 (interquartile range (IQR): 26-44) years. 88.7% of victims were male. The mean time from the moment of trauma to arrival at the hospital in Vilnius city was 60 minutes (IQR: 50-91), whereas from the Vilnius region it was 240 (IQR: 82-390) minutes. The vast majority of patients (176/186, 94.6%) sustained stab wounds. Hemopericardium or cardiac tamponade (142/186, 76.3%) usually was found at the operation. Right ventricle was the most often injured heart chamber (75/186, 40.3%). Associated injuries were evaluated in 57.0% (106/186) of patients. The survival rate on discharge was 88.7%. Compared to non-survivors, the lucky patients had a higher systolic blood pressure on admission (94 mm Hg (IQR: 70-120) versus (vs.) 70 mm Hg (IQR: 0-80), $p < 0.001$). Survivors had all signs of life (SOL) more often (82.4% vs. 42.9%, $p < 0.001$), whereas more frequent findings in non-survivors were the following: tamponade (52.4% vs. 29.1%, $p = 0.031$), higher grade (IV-VI) of injury (90.5% vs. 29.7%, $p < 0.001$), injured right atrium (28.6% vs. 8.5% $p = 0.014$) or left ventricle (42.9% vs. 23.0%, $p = 0.049$) and an episode of heart arrest (85.7% vs. 7.9%, $p < 0.001$). Independent prognostic factors of survival were the presence of all SOL and younger age. Higher grade (IV-VI) of heart injury and heart arrest during surgery independently predicted mortality.

Conclusions: According to our data, lower arterial blood pressure and absence of one or more SOL on admission, cardiac tamponade, higher grade injury, injured right atrium and asystole during operation are true precursors of fatal outcome.

Key words: cardiac injury, cardiac trauma, heart wound, penetrating chest injuries.

Streszczenie

Wstęp: Rany kłute serca są dramatycznymi, prowadzącymi do zgonu urazami. Na ogół zdarzają się u ludzi młodych. Większość ofiar umiera przed przyjęciem do szpitala.

Cel pracy: Celem pracy było określenie czynników decydujących o wynikach leczenia i rokowaniu chorych z ranami kłutymi serca.

Materiał i metody: Retrospektywnej ocenie poddano dane 186 chorych z ranami kłutymi serca operowanych w ciągu 24 godzin od przyjęcia do szpitala.

Wyniki: Średni wiek chorych wynosił 33 lata [zakres międzykwartylowy (IQR): 26–44 lat]. Mężczyźni stanowili 88,7% ogółu chorych. Średni czasu transportu chorego do szpitala od momentu urazu na terenie Wilna wyniósł 60 min [*interquartile range* (IQR): 50–91], podczas gdy czas transportu z rejonu wileńskiego wyniósł 240 min (IQR: 82–390). Zdecydowana większość pacjentów (176/186, 94,6%) miała rany wynikające z pchnięcia nożem. W trakcie operacji stwierdzano zwykle obecność krwiaka śródpiersia lub tamponadę serca (142/186, 76,3%). Prawa komora była najczęściej uszkodzoną jamą serca (75/186, 40,3%). Przeżycie dla ogółu chorych wyniosło 88,7%. W porównaniu ze zmarłymi pacjenci, którzy przeżyli uraz, przy przyjęciu mieli wyższe wartości skurczowego ciśnienia tętniczego [94 mm Hg (IQR: 70–120) *vs* 70 mm Hg (IQR: 0–80), $p < 0,001$]. Chorzy, którzy przeżyli, częściej wykazywali wszystkie oznaki życia [*signs of life* (SOL): 82,4% *vs* 42,9%, $p < 0,001$], podczas gdy wśród chorych zmarłych częściej stwierdzano: tamponadę (52,4% *vs* 29,1%, $p = 0,031$), wyższy stopień urazu (IV–VI) (90,5% *vs* 29,7%, $p < 0,001$), uraz prawego przedsionka (28,6% *vs* 8,5%, $p = 0,014$) lub lewej komory (42,9% vs 23,0%, $p = 0,049$) i epizody zatrzymania krążenia (85,7% *vs* 7,9%, $p < 0,001$). Niezależnym prognostycznym czynnikiem przeżycia była obecność wszystkich czynników SOL oraz młodszy wiek. Wyższy stopień urazu (IV–VI) oraz zatrzymanie krążenia w trakcie operacji były niezależnymi czynnikami zgonu.

Wnioski: Prekursorami złego rokowania były niższe wartości ciśnienia tętniczego oraz brak co najmniej jednego z czynni-

Address for correspondence: Dr. Zymantas Jagelavicius, Department of General Thoracic Surgery, Vilnius University Hospital Santariskiu Klinikos, Santariskiu 2, 08406, Vilnius, Lithuania, e-mail: zymant@yahoo.com, tel. +370 686 69396

ków SOL, uszkodzenie prawego przedsionka i asystolia podczas operacji.

Słowa kluczowe: uszkodzenie serca, uraz serca, rana serca, rany kłute klatki piersiowej.

Introduction

The sad truth is that much of our knowledge of penetrating chest trauma has arisen from the unfortunate predilection of *Homo sapiens* to poke holes in the chests of his fellows. The most ancient data about cardiac injuries were found as early as in the Edwin Smith papyrus written by the Egyptian Imhotep more than 5000 years ago [1]. Numerous attempts were made to treat patients with heart injuries in ancient times but none of them were successful [2-6].

In 1868, Fischer [7] published a monograph on the natural history of cardiac wounds, documenting a 10% survival rate. Successful experimental suture of the heart was demonstrated in 1882 and 1895 [8] but suggestions that cardiac suture could be performed in human beings was an unpopular view. The statement "surgeon who would attempt to suture the wound of the heart would lose the respect of his colleagues", attributed to the well-known Viennese surgeon Theodor Billroth, reflected a widely held opinion [9]. The first attempt to repair cardiac injury was carried out by Axel H. Cappelen from Oslo (Norway) on September 4, 1895. However, on postoperative day 3 the patient died from sepsis [5, 10]. The second attempt to suture the heart was made in Rome (Italy) by G. Farina in March 1896. Unfortunately, it was unsuccessful as well [11].

A German surgeon from Frankfurt am Main, Ludwig Rehn, was the first to successfully perform cardiorrhaphy in September, 1896. Later he was able to collect 124 cases of heart suture with a survival rate of 40% [12].

In Lithuania the first successful cardiorrhaphy was performed in June 1926 [13].

The Department of General Thoracic Surgery in Vilnius University Hospital (as a separate unit) was established at the beginning of 1983. Since then general thoracic surgical service has been provided for patients from the city of Vilnius and its region.

Penetrating cardiac injury is a dramatic and often lethal form of trauma. The majority of patients are young persons. Numerous publications on the subject of injuries to the heart have been published; however, despite huge advances in medicine, only 6-30% of patients reach hospital alive [4, 14, 15]. Also, most often they reach the hospital in deep hemodynamic shock [4, 16, 17].

Nevertheless, prompt diagnosis and surgical repair can salvage patients who would otherwise be lost. Currently, most knowledge involving injuries of the heart and aorta comes from American studies or South Africa series, due to increased violence in these societies compared with Western Europe [14]. Since the transition to democracy in South Africa in 1994, there has been a gradual reduction in trauma [14]. Contrary to this, the transition to democracy in Lithuania in 1990 did not show such a tendency. Unfortunately, Lithuania and other parts of Europe are experiencing an increase in the incidence of penetrating traumas [18, 19].

Material and methods

A retrospective study of 186 patients with penetrating trauma to the heart was conducted over a period of 28 years (1983-2010). All the patients underwent surgery at the Department of General Thoracic Surgery of Vilnius University Hospital. Our facilities are located in the centre of Vilnius (the capital of Lithuania) with about 500 000 inhabitants. This hospital also provides medical services for the Vilnius region with a population of 100 000 inhabitants.

In order to evaluate factors influencing survival, data obtained for each patient included age, sex, time from the moment of trauma to admittance, and time "lost" in the hospital before emergency thoracotomy. Injury mechanisms, number of wounds, additional injuries, hemodynamic parameters and signs of life (SOL) on admission, as well as operative findings and presence of asystole were evaluated.

Signs of life were defined by the presence of any of the following: measurable blood pressure, palpable carotid pulse, pupillary response, spontaneous breathing efforts, and extremity movements (according to American College of Surgeons Committee on Trauma six estimated signs) [20]. However, we were unable to include the sixth sign, cardiac electrical activity, since this examination in some patients was not performed on admittance due to unknown reasons. Hemodynamic data were evaluated measuring systolic blood pressure and pulse rate.

Heart injury severity score was evaluated according to the American Association for the Surgery of Trauma (AAST) Heart injury scale, which includes six grades [15, 21, 22].

The statistical software SPSS 17.0 for Windows (SPSS Inc. Chicago, Illinois, USA) was employed. Due to the non-normal distribution of variables data are presented as median and interquartile range (IQR). Pearson Chi-square and Fisher exact tests were used to compare frequencies of categorical variables. To compare continuous variables Mann-Whitney test was used. Univariate and multivariate logistic regression analysis was used to calculate the impact of different factors on survival. Influence is shown by odds ratio (OR) and its 95% confidence interval (CI). Multivariate analysis was performed separately for the group of factors before surgery and for the group of factors identified during the operation. A value of $p < 0.05$ was considered to be significant.

Results

Over the 28-year period 193 patients were operated on for suspected cardiac injury. The detailed evaluation

of data was applied to 186 persons who were operated on during the first 24 hours after trauma.

There were 165 males and 21 females. Median age was 33 years (IQR: 26-44). The vast majority of patients (139/186, 74.7%) reached the hospital by Vilnius city ambulance while 24 patients were transferred by Vilnius region ambulance service and the remaining 23 arrived by routine vehicles. The average time from the wounding moment until the call to the ambulance service was 28 (IQR: 9-74) minutes. Approximately 44 (IQR: 33.8-59.3) minutes passed from the emergency call until the patient's arrival at the hospital. However, there was an extremely large difference between the city and regional ambulance characteristics observed: the average time from the wounding moment to arrival at the hospital in Vilnius city was 60 (IQR: 50-91) minutes, whereas in the Vilnius region it was 240 (IQR: 82-390) minutes. The transportation time of patients to the hospital in the city lasted approximately 41 (IQR: 31-53) minutes, whereas in the region it was 61 (IQR: 50.5-78) minutes.

One hundred and seventy-six patients sustained stab wounds and only ten had gunshot injuries. In 135 cases (72.6%) a single wound was found, while the remaining patients suffered from multiple wounds to the chest. In 34 cases (18.3%) heart injury was the result of a suicide attempt. Most patients (151/186, 81.2%) had wounds in the so-called "heart area" (precordium), which is shown in Figure 1. A similar dangerous area is shown by other authors [4, 22, 23].

All five SOL on admission were found in 145/186 (78%) patients. Forty (21.5%) patients had SOL from one to four, and only one patient had no signs of life on admission. The median blood pressure was 90 mm Hg (IQR: 60-111), and median pulse rate was 100 beats per minute (IQR: 86-118).

All 186 patients underwent operation for suspected heart injury. In 38 cases (20.4%) emergency thoracotomy was postponed. The main reasons for such delay were as follows: hemodynamically stable patients in relatively good general condition refused surgical intervention; in others laparotomy for intraabdominal bleeding was performed first. The most frequent operative approach was left anterolateral thoracotomy (157/186, 84.4%); right thoracotomy was used in 24/186 (12.9%) patients and longitudinal sternotomy in 5/186 (2.7%) cases. The mean time from admittance to emergency operation was 50 minutes (IQR: 30-80).

During the operation in 181 patients pericardiotomy was performed. Intrapericardial findings are presented in Table I. The heart injury, according to AAST, is graded from I to VI (Table II). No injury of the heart, pericardium or prepericardial fat at the operation was found in seven (3.8%) cases. They were all operated on for suspected heart injury but only injuries of other organs were found. In 17 cases (9.1%) during thoracotomy only prepericardial fat was injured, and in 24 cases (12.9%) only a wound of the pericardium was found (in three cases it was accompanied by cardiac tamponade). The right ventricle was the most often injured chamber – 75/186 (40.3%). Some patients had multiple wounds of the heart and 106 (57%) had associated injuries (Table III). In 22 patients laparotomy for intraabdominal bleeding was performed.

Cardiac arrest during the operation occurred in 31/186 (16.7%) persons. In 27 cases cardiac rhythm was restored by manual cardiac massage, whereas in four cases medications alone were enough. However, in 11 cases manual cardiac massage was ineffective and the patients died in the operating room.

Twenty-one out of 186 operated persons died: 11 in the operating theatre, 9 during the first 48 hours postoperatively and 1 patient seven days later. The overall survival rate was 88.7%. Survivors were compared to non-survivors with respect to the above survival predictors (Table IV). Univariate and multivariate logistic regression analysis were utilized to predict outcome for each clinical factor (Table V). Upon univariate analysis systolic blood pressure, all SOL on admission, and lower grade (I-III) of heart injury all predicted survival

Tab. I. Intrapericardial findings during operation

In the pericardium	*n* (%)
hemopericardium	83 (44.6)
cardiac tamponade	59 (31.7)
hydropericardium	9 (4.9)
no fluid in the pericardial sac	35 (18.8)

Tab. II. Heart injury severity score (according to AAST heart injury scale)

Grade*	Description	*n* (%)
	no injury of prepericardial fat, heart or pericardium evaluated	7 (3.8)
	prepericardial fat injury only	17 (9.1)
I	penetrating pericardial wound without cardiac injury, tamponade or herniation	21 (11.3)
II	penetrating tangential myocardial wound up to, but not extending through endocardium, without tamponade	50 (26.9)
III	penetrating tangential myocardial wound up to, but not extending through endocardium, with tamponade	23 (12.4)
IV	penetrating cardiac injury of the right ventricle, right atrium or left atrium	41 (22.0)
V	penetrating left ventricle perforation	23 (12.4)
VI	penetrating wound producing > 50% tissue loss of a chamber	4 (2.1)

* Advance one grade for multiple penetrating wounds to a single chamber or multiple chamber involvement

Tab. III. Associated injuries

Associated injuries	*n*
main vessels (vena cava superior/inferior, lung vessels, aorta)	4
vessels of the chest wall	30
lung	56
diaphragm	28
intraperitoneal and retroperitoneal organs	19

Tab. IV. Predictive factors in survivors and non-survivors

Parameter	Survivors *n* = 165 (%)	Non-survivors *n* = 21 (%)	*P* value
males	148 (89.7)	17 (81.0)	0.266*
median age (IQR) in years	32 (25.5-43)	42 (29-49.5)	0.129‡
transportation by Vilnius city ambulance	121 (73.3)	18 (85.7)	0.219†
single wound in the chest	120 (72.7)	15 (71.4)	0.900†
wound in precordium (heart area)	135 (81.8)	16 (76.2)	0.555*
median blood pressure on admission in mm Hg (IQR)	94 (70-120)	70 (0-80)	< 0.001‡
median pulse rate, beats per minute (IQR)	100 (88-117)	96 (80-120)	0.180*
all 5 SOL on admission	136 (82.4)	9 (42.9)	< 0.001*
intrapericardial findings:			
no pathology found or hydropericardium	40 (24.2)	4 (19.0)	0.787*
hemopericardium	77 (46.7)	6 (28.6)	0.116†
cardiac tamponade	48 (29.1)	11 (52.4)	0.031†
AAST heart injury severity score:			
no injuries found	24 (14.5)	0 (0.0)	0.081*
grade I-III	92 (55.8)	2 (9.5)	< 0.001†
grade IV-VI	49 (29.7)	19 (90.5)	< 0.001†
heart chamber injured:			
right atrium	14 (8.5)	6 (28.6)	0.014*
right ventricle	69 (41.8)	6 (28.6)	0.244†
left atrium	3 (1.8)	1 (4.8)	0.383*
left ventricle	38 (23.0)	9 (42.9)	0.049†
pericardium only	23 (13.9)	1 (4.8)	0.320*
associated injuries	93 (56.4)	13 (61.9)	0.629†
heart arrest during operation	13 (7.9)	18 (85.7)	<0.001*

*Fisher's exact test; †Pearson's χ^2 test; ‡Mann-Whitney test

Tab. V. Impact of different predictors of survival until hospital discharge

	Parameter	Univariate			Multivariate		
		OR	95% CI	*p* value	OR	95 % CI	*p* value
Preoperative findings	sex: male	2.048	0.617-6.796	0.241			
	age	0.972	0.944-1.001	0.06	0.966	0.935-0.998	0.038*
	transportation by Vilnius city ambulance	0.458	0.129-1.632	0.229			
	single wound in the chest	1.067	0.39-2.919	0.9			
	wound in precordium (heart area)	1.406	0.478-4.138	0.536			
	systolic blood pressure on admission	1.02	1.009-1.031	< 0.001*			
	pulse rate on admission	1.011	0.995-1.027	0.182			
	all 5 SOL on admission	6.253	2.412-16.212	< 0.001*	6.829	2.557-18.242	< 0.001*
Intraoperative findings	intrapericardially:						
	no pathology found or hydropericardium	1.36	0.432-4.278	0.599			
	hemopericardium	2.187	0.809-5.916	0.123			
	cardiac tamponade	0.373	0.149-0.936	0.036*			
	AAST heart injury severity score:						
	grade I-III	11.973	2.701-53.073	0.001*			
	grade IV-VI	0.044	0.01-0.198	< 0.001*	0.13	0.02-0.856	0.034*
	heart chamber injured:						
	right atrium	0.232	0.078-0.692	0.009*			
	right ventricle	1.797	0.664-4.865	0.249			
	left atrium	0.37	0.037-3.733	0.399			
	left ventricle	0.399	0.156-1.018	0.055			
	pericardium only	3.239	0.414-25.318	0.263			
	associated injuries	0.795	0.313-2.021	0.63			
	heart arrest during operation	0.014	0.004-0.055	< 0.001*	0.023	0.004-0.117	< 0.001*

until hospital discharge. Mortality was predicted by cardiac tamponade, higher grade (IV-VI) of heart injury, injured right atrium and heart arrest during surgery. Multivariate analysis revealed that younger age and the presence of all SOL were independent predictors of survival until hospital discharge. Higher grade (IV-VI) of heart injury and heart arrest during operation independently predicted fatal outcome.

Discussion

In our study the overall survival rate of operated patients was 88.7%. Such a high percentage of survivors might mean that a significant number of injured persons did not reach the hospital in time. Similar observations are also presented by other authors [4, 16, 24]. In fact, the number of casualties with fatal outcome prior to admission is not known to us; however, some authors suggest that only 6-20% of victims reach hospital alive. The overall survival rate of penetrating heart trauma is estimated to be 10-92% [3, 16, 21, 24-27]. It depends not only on the severity of the injury but on other circumstances as well (population area, median time taken from injury to emergency department admission, associated injuries, etc.).

Rhee *et al*. have described the following paradox: the more heavily injured persons reach the hospital alive, the higher is overall mortality [26]. Swedish authors present data from one of the busiest trauma centers in Sweden with the survival rate of 85.7%, and out of seven penetrating heart injuries only one was fatal [25]. On the other hand, if patients' general condition remains stable for a couple of days, it is likely that the survival rate after surgery will reach nearly 100% [28].

Such a high survival rate in our country might be influenced by several reasons. Firstly, the call for an ambulance was delayed at the injury scene (the median time from injury to emergency call was 28 minutes!). Secondly, the median time taken for transferring the patient to the Emergency Department was 44 minutes (IQR: 33.8-59.3). The vast majority of patients who reached the hospital alive were transported by the city ambulance. This might mean that only a certain number of patients from the Vilnius region, predominantly in a stable condition, reached the hospital alive. According to Danish authors, the median time from injury to hospital admission was from 1 to 45 minutes [1]. A recent study in France by Pons *et al*. showed that the majority of injured persons reach the hospital during the first six hours and only a few of them during 24 hours [17]. In the data by Seamon from the USA, median time from injury to the emergency department was 19 minutes [27]. However, this time was limited to the area within a radius of 3.2 km. But according to the data from South Africa and India this time is usually about 2 hours [16].

In assessing the work of the ambulance service in our series, it is reasonable to point out that only one patient out of 186 was transported to the hospital already intubated and only in four cases was a central venous catheter inserted. The rest of the patients before entering the Emergency Department were treated routinely: infusion to peripheral vein, oxygen therapy, analgesics. In addition, some patients

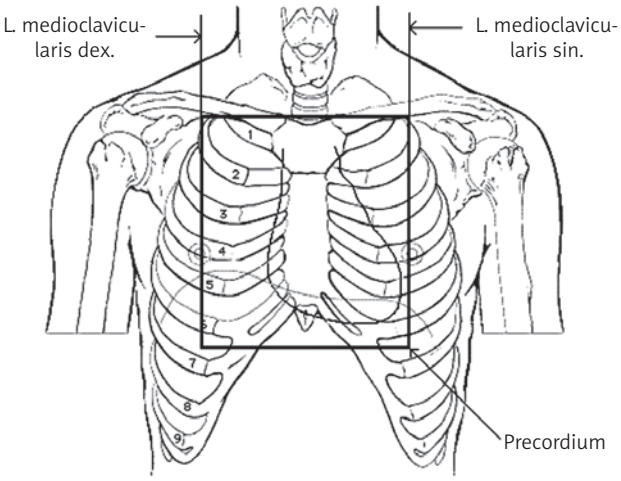

Fig. 1. Heart area (precordium)

arrived at a hospital which had no surgical service and no staff needed in order to treat suspected cardiac injuries. In these cases much time was spent on finding the right hospital. Our data show that there is still much work to be done to improve the work of ambulance services.

In agreement with others, our results have shown that victims of penetrating cardiac injuries are predominantly young males [1, 3, 14, 16, 20, 24, 25, 30].

One hundred and seventy-six patients were victims of stab wounds (94.6%) and only ten persons (5.4%) sustained gunshot injuries. Patients with stab wounds predominate among persons admitted to hospitals in Europe, South Africa and Brazil [1, 3, 14-17, 24, 25, 29]. However, studies from the USA have shown more gunshot injuries [4, 27]. According to Campbell *et al*. [16] gunshot injuries of the heart were found in 33.6% of cases (407/1198). In this study the mortality rate before reaching the hospital for gunshot injuries was significantly higher than for stab wounds. Among persons who reached the hospital alive, gunshot injuries were found only in 5.7% of cases (4/70).

In our study most of the patients (72.6%) sustained a single wound. It was not a significant predictor of survival (OR 1.067, $p = 0.9$). According to the American researchers, there was more than one wound in the chest in about 60% of victims. These circumstances paradoxically led to better survival [27]. This paradox might be explained by a suggestion that there is a slim chance to survive at the injury scene in multiple injury cases, especially when first aid is delayed.

Wounding to the precordium (81.2% of patients) had no influence on survival (OR 1.406, $p = 0.536$). This is also emphasized by Seamon *et al*. [27]. According to Degiannis *et al*. data, 46% of patients with a single stab wound had it in the precordium. The mortality rate among patients with precordium stab wounds was 4%, whereas among persons with non-precordium stab wounds it was 25%, with a statistically significant difference ($p = 0.03$) [14]. Navsaria *et al*. [15] reported that a stab wound in the precordium resulted in heart injury in 60% of cases (in our study – 71.5%);

on the other hand, 85% of the heart-injured persons had a wound in the precordium area (in our data – 81.2%).

Assessing hemodynamic data in patients at the Emergency Department, we found hypotension or immeasurable blood pressure in 84 cases (45.2%). Evaluating the possibility to survive, it was found that higher systolic blood pressure significantly predicts survival (OR 1.02, 95% CI: 1.009-1.031; $p < 0.001$). In the group of survivors, median systolic blood pressure on admission was 94 mm Hg, whereas in non-survivors it was estimated to be 70 mm Hg, $p < 0.001$. The same results were presented by Rodrigues *et al*. [3].

In our study pulse rate on admission had no prognostic value. In the American series it was found that normal pulse rate or tachycardia was estimated to be a true precursor of survival [27].

Our data showed that 145 (78%) patients had all five SOL on admission. It was an independent predictor of survival (OR 6.829, 95% CI: 2.557-18.242; $p < 0.001$). It was found in 82.4% of survivors and 42.9% of non-survivors, $p < 0.001$. Some authors also conclude that the more SOL found on admission the greater opportunity to survive [20, 22, 27].

Emergency surgical repair remains the single procedure which enables victims' lives to be saved [4, 24]. In our series 148 patients (79.6%) were operated on immediately after admission for suspected cardiac injury. For the rest the operation was delayed due to numerous reasons. In some clinics and hospitals patients with suspected heart injury were being operated on at the emergency department operating room [4, 14, 20, 22, 27]. All the patients in our series were operated on in the operating theatre of the Department of General Thoracic Surgery. It takes only a few minutes to reach it from the Emergency Department (some operations were started within 10 minutes after the patient's arrival). There is a 24-hour general thoracic surgeon on duty at our hospital, so the delay is minimized. In our opinion, there is no strong necessity to spend a huge amount of money in order to arrange an emergency department operating room, having well-equipped operating rooms nearby. According to Asensio *et al*., the survival rate is higher in patients operated on in a routine way in comparison with emergency department surgery [22]. This might be explained by the fact that most patients operated on at the emergency department are in a critical condition, and emergency room thoracotomy is often considered a controversial "last chance" method of resuscitation.

What incision should be chosen when operating on a patient with suspected cardiac injury? The data in the literature are controversial. Some authors prefer longitudinal sternotomy [14, 15, 21, 24], while others advocate for thoracotomy, especially for patients in a terminal condition [3, 22, 23, 25, 27, 29]. According to Kang *et al*. [4], the easiest way to reach the heart is longitudinal sternotomy. However, we performed sternotomy only in a few cases. In all other cases preference was given to anterolateral thoracotomy.

The most frequent finding during the operation was hemopericardium or cardiac tamponade. However, in nine cases hydropericardium was found. According to Pons *et al*., two cases of hemopericardium and three cases of hydropericardium were found out of 13 patients with precordium stab wounds who arrived in a stable general condition, and thoracotomy was performed for suspected heart injury [17]. Danish authors found hemopericardium in all the reported cases [1]. Campbell *et al.* [16] reported that in 9.8% of cases (117/1198) hemopericardium was found without visible injury of the heart or coronary vessels [in our series it was found in 9.1% (17/186) of cases].

Cardiac tamponade led to significantly worse prognosis in our series. It was found in 29.1% of survivors and in 52.4% of non-survivors ($p = 0.031$). The influence of this symptom on survival rate according to the published data is ambiguous [16, 22, 25]. Some authors presume that in case of cardiac tamponade acute exsanguination does not occur. This situation provides some stability in the patient's general condition. However, there is no information concerning the duration of the above condition available. But some authors [4, 14, 16] did find a better survival rate in patients with verified cardiac tamponade. However, when this "bright period" ends, the cardiac function deteriorates immediately [22]. Evaluating our data, it became evident that most patients with cardiac tamponade did not reach the hospital in the shortest time (in the so-called "golden minutes"). It was on rare occasions that severely injured persons with cardiac tamponade reached the hospital in due time, which explains the lowest survival rate in this group. The right ventricle was the most frequently injured cardiac chamber (40.3%). The same data are provided by other authors [4, 16, 21, 24].

Conclusions

One must suspect heart injury when there is a wound in the precordium. Delay in calling the ambulance and long transportation time worsen the prognosis for survival. Our data have shown that all SOL on admission and younger age are independent predictors of survival, whereas higher grade of heart injury and heart arrest during surgery independently predict fatal outcome.

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