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Original Article

Penetrating Heart Injuries in Hospitals with Few Facilities: Not A Moment to Waste

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Abstract

Background: Penetrating heart injury is a genuine emergency that needs to be diagnosed and treated as soon as possible. Transport to a tertiary center with facilities such as a heart-lung pump and sternotomy can lead to loss of time. This study aimed to share the author's experiences in a private hospital with limited facilities.

Methods: A retrospective study was conducted at a private hospital. Eleven penetrating cardiac injuries, which were treated surgically by the at two small hospitals from 2005 to 2015, were evaluated retrospectively. Patients' age and sex, type of injury, damage site at the heart, duration between injury and surgery, presence of additional damage, and patient survival were all recorded.

Results: The most common form of injury was sharp object injury, while the most common site was the right ventricle. The period from injury to surgery, the additional injuries were found to be statistically significant in terms of survival ratios. The probability of patients' survival at intervention times 30, 60, and 120 minutes was 90.9, 54.5, and 27.3%, respectively.

Conclusion: Mortality in cardiac injuries can be reduced with early intervention. The risks of being transported to an advanced hospital and the risk of emergency surgery performed in a small less equips facility should be well weighed. Successful surgeries may be performed even in a small, well-organized hospital.

Keywords: Penetrating Cardiac Injury, Pericardial Tamponade, Emergency Thoracotomy.

Introduction

The thoracic region has many critical organs, and penetrating traumas can be fatal in a short time. Due to the location of vital organs, this area has been considered the fortress of the body, and the heart is supposed as an organ that must be intervened with caution [1]. In 1896, Ludwig Rehn's rescue of a patient by placing a suture in the penetrating cardiac injury encouraged physicians to intervene in the heart, and this intervention was considered the onset of cardiac surgery [2].

Penetrating cardiac injuries (PCI) represent 1% of all injuries, whereas 6% of the PCI reach the hospitals, and 50% of those result in mortality, despite intervention [3-6]. The two principal reasons for these cases are pericardial tamponade and hemorrhagic shock [5, 7-10].

The transfer of cardiac injuries to the health care facilities in the early period, with appropriate surgical interventions, has proven to be life-saving [7-9]. This study aimed to share the experiences of a sole thoracic surgeon in a hospital with limited facilities.

Methods

In this study, 11 penetrating heart injuries, which were treated surgically by a thoracic surgeon in two small hospitals between 2005 and 2015, were retrospectively evaluated. Patients' age and sex, type of injury, location of damage to the heart, duration between injury and surgery, presence of additional damage, and patient survival were all recorded.

The type of formation of the injury, its localization and heart rate, the deterioration level of vital functions (i.e., blood pressure, arterial and respiratory function), and the rate of clinical deterioration were determined as the most significant parameters shortly before

beginning surgery. In patients with stable vital functions, the diagnosis was confirmed by examinations, such as preoperative echocardiography and thorax tomography. Pericardiocentesis was not performed on the patients for diagnostic purposes.

All patients were implemented with central venous catheters from the subclavian or femoral region, before surgery or during surgery. Blood and fluid replacements were provided by the anesthesiologist as soon as possible. Left anterolateral thoracotomy or median sternotomy was applied as a surgical intervention method from the 5th intercostal space. After the pericardium was opened vertically, the injury site was detected and sutured with a double-needle Prolene or Teflon pledget suture, and the piece was taken from the pericardium was used as a patch over the injury site.

Patients who were transferred to the hospital in an expired state were excluded from the study, and only subjects who had the intervention were included.

Statistical analysis

The SPSS 25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) statistical package program was used to evaluate the data. Variables were introduced using percent and frequency, mean and standard deviation values. Categorical data were analyzed by Fisher's Exact Test and the Chi-Square Test. In cases where the expected frequencies were less than 20%, the evaluation was performed by the Monte Carlo Simulation Method to include these frequencies in the analysis. Estimation of Survival time was evaluated by the Kaplan Meier Survival analysis. ($p<0.05$ and $p<0.01$ values were accepted as the significance level of the tests.)

Result

Ten (90,9%) of the cases included in our study were male, and one (9,1%) was female. The mean age of patients was 27.45 ± 11,39. Demographic parameters, the type of surgery incision, injury type, place of injury, the time between the event and the beginning of the surgery, additional trauma existence, and survival status are summarized in Table 1.

The most common form of injury was the stab wound injury (10/11, 91%), and the most common place of injury was the right ventricle (10/11, 91%). The relationship between the patients' postoperative survival regarding gender, type of incision, type of damage, time of intervention, and presence of additional injury was evaluated (Table 2).

The effect of the presence of additional injury on survival was statistically significant ($p<0.049$). The period from injury to surgery, considering the survival ratios, was found to be statistically significant. When the intervention time was assessed for survival, the probability of survival of patients in the first 30 minutes was 90.9%, the first 60 minutes was 54.5%, and 120 minutes was 27.3% (Table 3).

Table 1. Demographic values, types of injury and surgery of patients.

Id	Gender	Age	Type of Injury	Place of Injury	Incision	Surgery time	Add. injury	Blood loss mL	Postop
1	M	19	Stab wound	Right ventricle	Thoracotomy	quick	Yes	Less	Expired
2	M	18	Stab wound	Right ventricle	Thoracotomy	quick	No	Moderate	Recovery
3	M	16	Gunshot	Left auricle	Thoracotomy	quick	No	Moderate	Recovery
4	M	21	Stab wound	Right ventricle	Sternotomy	quick	No	Less	Recovery
5	M	34	Stab wound	Right ventricle	Sternotomy	early	No	Less	Recovery
6	M	33	Stab wound	Right ventricle	Sternotomy	quick	No	Less	Recovery
7	M	37	Stab wound	Right ventricle	Sternotomy	quick	No	Less	Recovery
8	M	25	Stab wound	Right ventricle	Thoracotomy	late	No	Moderate	Expired
9	M	54	Stab wound	Right ventricle	Sternotomy	quick	No	Moderate	Expired
10	M	27	Stab wound	Right ventricle	Thoracotomy	late	No	Excessive	Expired
11	F	18	Stab wound	Right ventricle	Sternotomy	early	Yes	Moderate	Expired

Quick: before 30 min. Early: before 60 min. Late: after 60 min. Less: <400 mL, Moderate :> 400>1000 mL, Excessive :> 1000 mL.

Table 2. Relations between other variables according to postop status.

	Postoperative expired	Postoperative recovery	p
Male	4(%40)	6(%6)	0,251¥
Female	1(%100)	0(%0)	0,251¥
Left thoracotomy	3(%60)	2(%40)	0,567¥
Sternotomy	2(%33,3)	4(%66,7)	0,567¥
Sharp object injury	5(%50)	5(%50)	0,338¥
Gunshot injury	0(%0)	1(%100)	0,338¥
Right ventricular injury	5(%50)	5(%50)	0,338¥
Left ventricular injury	0(%0)	1(%100)	0,338¥
İntervention in first 30 minute	1(%16,7)	5(83,3)	0,219¥
İntervention in first 60 minute	2(%66,7)	1(%33,3)	0,219¥
İntervention in first 120 minute	1(%100)	0(%0)	0,219¥
İntervention in first 180 minute	1(%100)	0(%0)	0,219¥
There is additional injury	2(%100)	0(%0)	0,049*¥
There is no additional injury	3(%33,3)	6(%66,7)	0,049*¥

*p<0,05
¥Expected frequencies are less than 20%, the evaluation was performed by Monte Carlo Simulation Method (Fisher's Exact Test)

Table 3. Relationship between intervention time and survival

	Time (minute)	Status	Estimate of cumulative proportion surviving at the time	Standard error of cumulative proportion surviving at the time	N of cumulative events	N of remaining cases
1	30	Expired	0,909	0,087	1	10
2	30	Recovery			1	9
3	30	Recovery			1	8
4	30	Recovery			1	7
5	30	Recovery			1	6
6	30	Recovery			1	5
7	60	Expired			2	4
8	60	Expired	0,545	0,206	3	3
9	60	Recovery			3	2
10	120	Expired	0,273	0,219	4	1
11	180	Expired	0,000	0,000	5	0
The probability of surviving the first 30 minutes of the patients is 90.9%, the probability of surviving the first 60 minutes is 54.5%, and the probability of surviving 120 minutes is 27.3%.						

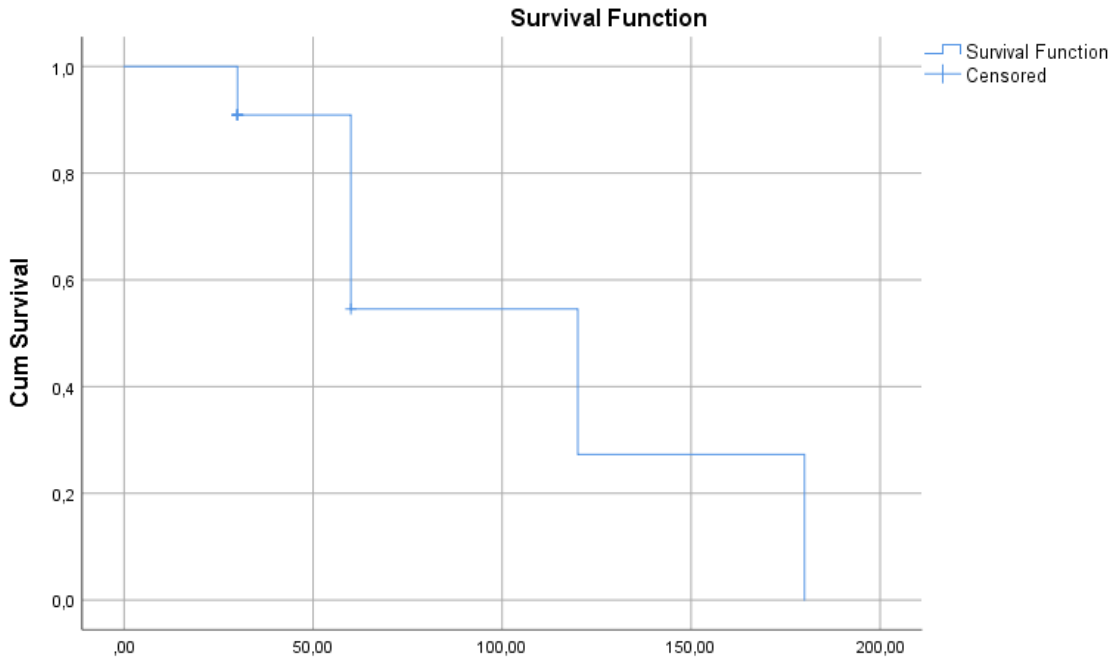

Figure 1: Kaplan-Meier estimator graph.

Discussion

With the development of the heart-lung pump, the possibilities of cardiac intervention have emerged, and many cardiac pathologies are now available to treat [1]. In selective heart pathologies, a heart-lung pump is essential in open heart surgery, but in heart injuries, it is often impossible to perform the pump due to the need for early intervention in the heart. The usage rate of heart-lung pumps in the intervention of cardiac injuries has been also reported to be low in the literature [11,12]. There was enough time to implement the pump in one case, however, unfortunately, the patient expired. As a result of the anatomical position of the heart, a large

part of the right ventricle is located near the anterior wall of the thorax. For this reason, most the sharp object injuries penetrating the thorax occur in the right ventricle [9,11,13]. By the literature, we can report respectable ventricle penetration in 10 of our 11 cases ($p < 0.0338$) in our study.

Echocardiography and thoracic CT examinations can be performed quickly in patients with systolic blood pressure above 100mm/Hg who have no evidence of active hemorrhage [14]. In some cases, the Focused Abdominal Sonogram for Trauma (FAST) in the emergency department is crucial for the rapid diagnosis of pericardial tamponade [8,11,15]. In other cases, the diagnosis should be made with a rapid anamnesis and physical examination, and the patient should be operated on without any time lost to investigations [7,12]. Before performing a thoracotomy or sternotomy on the patient, some surgeons recommend opening a subxiphoid window to strengthen their diagnosis [9,11]. In this study, there was no need to open the sub-oxford window to diagnose cases before entering the operating room, and no misdiagnosis was observed in patients.

Median sternotomy is usually the most appropriate incision that can be performed for all types of surgical heart interventions with this approach, all areas of the heart that have the potential for damage can be easily accessed, and the pump can be operated. Patient comfort is preferable over the thoracotomy, as less pain has been reported with the sternotomy in the postoperative period [5,7-10]. However, the main reason for the superiority of thoracotomy over sternotomy, which makes it almost the first choice method in an emergency, is the fact that it is a viable intervention, even in an emergency. The absence of the sternum saw and other apparatus required to perform a sternotomy in such circumstances, perhaps even sometimes in the hospital's operating theatre itself, eliminates the possibility of a sternotomy. Therefore, in cases where there is no possibility of sternotomy, a left thoracotomy is a life-saving intervention in heart injuries [7,16]. Another important reason for preferring the thoracotomy over the sternotomy is that with the former, in our experience, the thoracotomy incision provides more rapid access to the heart compared to median sternotomy. For this reason, a thoracotomy may again be a more appropriate choice out of the necessity for immediate intervention in patients with PCI, who usually have a severe level of hemodynamic impairment or present with an arrest.

We were able to discharge three (27%) of five (45%) patients on whom we had intervened with a left thoracotomy with a complete recovery. Two of our patients expired, while four of our six sternotomy-performed patients (55%) were able to be discharged with entire recovery, whereas two of these patients passed.

The time of intervention in cardiac injuries is one of the most significant factors determining mortality [11]. The majority of patients who have been correctly intervened within the first 60 minutes following the injury can be rescued [9]. In six (55%) cases, the intervention was performed in the first 30 minutes after injury, and five patients (45%) were discharged with recovery. Whereas one of the three patients who was intervened with in the first 60 minutes resulted in survival, other patients that intervened with in the first 120 and first 180 minutes resulted in mortality. It is an indication that early and effective intervention contributes significantly to the survival rate. We have found that the patients that intervened had 90.9%, 54.5%, and 27.3% survival rates in the first 30 minutes, 60 minutes, and 120 minutes, respectively. In their case series with 240 patients, Andres Isaza-Restrepo et al. intervened with 73.6% of their cases in the first 60 minutes and reported survival rates of 85.5%. In the same study, evaluating the autopsy cases in a retrospective manner in 127 cases revealed that 71% of the patients with PCI resulted in expired in the first 60 minutes and that 51% of these patients had access to health care institutions.

Aside from the heart, it is well-known that additional injuries increase the risk of mortality. These include several injuries which lead to bleeding [5,9]. In line with this, two (18%) patients with cardiac and abdominal aortic injuries expired after our intervention. In the literature, it has been reported that mortality is increased in penetrating cardiac injuries accompanied by coronary artery and valve injuries [10]. In our cases, there were no coronary artery and valve injuries.

The early and effective replacement of the volume during the surgery is one of the critical factors increasing the success rate of the surgery. In patients with cardiac injuries, the central catheter should be opened from a suitable site immediately before or during the operation. In patients with hemorrhagic shock, fluid replacement, in distinct blood replacement, should be administered as soon as possible. In patients with tamponade, since the increased intravascular

volume will not increase cardiac output, massive replacement should be avoided until the tamponade is eliminated [7]. In all of the patients we intervened with, we inserted a central venous catheter from the femoral or subclavian region before the intervention and started the fluid replacement as soon as possible. During the study period, we avoided massive replacement in our cases with tamponade.

Mortality rates reported in the literature have ranged from 24% to 60%, even in penetrating cardiac injury patients who were able to achieve healthcare organizations with the signs of life and were operated on swiftly [11]. In the 11 patients, the mortality rate was 45%.

Limitations

The main limitation of this study is the relatively small sample size. However, a more extensive series is required for societal results. Data obtained from small series will facilitate the planning of a more comprehensive data analysis. Another limitation is that it does not include the results of a specialized center for traumatology. Although there is no particular center, the obtained data are compatible with the results of the literature.

Conclusion

Patients who come to the health facility early and think they have suffered a heart attack should be intervened as soon as possible to prevent the risk of mortality.

The patient should be monitored very quickly to determine if there is a fluid or hematoma between the heart and the pericardium on echocardiography as a promising sign that the patient has undergone surgery.

It is inferred that left posterior lateral thoracotomy is a viable alternative to save the lives of patients whose initial repair of heart damage cannot be performed by sternotomy. With these considerations, successful emergency surgeries can be conducted, even in a hospital with few facilities.

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Authors' contributions

All stage of the article was carried out by the corresponding author.

Conflict of interest

The author declared no potential conflict of interests with respect to the research, authorship and/or publication of this article.

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Ethical Consideration

The study was approved by the Local Ethics Committee of Alanya Alaaddin Keykubat University (Protocol № 22-09 of 14.08.2020).

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