

# Choice of incision in penetrating cardiac injuries: Which one must we prefer: Thoracotomy or sternotomy?

Yüksel Beşir, M.D.,<sup>1</sup> Orhan Gökalp, M.D.,<sup>2</sup> Börteçin Eygi, M.D.,<sup>1</sup> Hasan İner, M.D.,<sup>1</sup>  
İhsan Peker, M.D.,<sup>1</sup> Gamze Gökalp, M.D.,<sup>3</sup> Levent Yılık, M.D.,<sup>2</sup> Ali Gürbüz, M.D.<sup>1</sup>

<sup>1</sup>Department of Cardiovascular Surgery, Katip Celebi University Atatürk Training and Research Hospital, Izmir

<sup>2</sup>Department of Cardiovascular Surgery, Katip Celebi University Faculty of Medicine, Izmir

<sup>3</sup>Department of Paediatric Emergency, Tepecik Training and Research Hospital, Izmir

## ABSTRACT

**BACKGROUND:** Penetrating cardiac injuries are high-risk, high-mortality injuries considering the outcomes. Therefore, it is important to choose the appropriate incision. In general clinical settings, thoracotomy and median sternotomy are choices of incisions to explore the injury. In this study, the results of median sternotomy and thoracotomy in penetrating cardiac injuries were compared.

**METHODS:** Between January 2003 and December 2013, forty patients, who underwent either thoracotomy or median sternotomy for penetrating cardiac injury, were retrospectively analyzed, and the collected data were compared. Twenty-six patients underwent thoracotomy (Group 1), and fourteen patients underwent median sternotomy (Group 2).

**RESULTS:** There was no statistically significant gender difference between the groups. However, the mean age in Group 2 was found to be significantly higher than the one in Group 1 ( $p < 0.05$ ).

**CONCLUSION:** There were no significant survival differences between the groups in the long term. Incision choice should be determined considering the site of injury and whether there is an accompanying pulmonary injury or not. On the other hand, thoracotomy has some drawbacks compared to median sternotomy.

**Key words:** Cardiac; median sternotomy; penetrating; thoracotomy.

## INTRODUCTION

Firearms and sharp weapons are general causes of penetrating cardiac injuries in most cases. Only 10.4% of the trauma cases in need of immediate surgical intervention happen to be in the thorax, and 1% of these cases are cardiac injuries.

<sup>[1]</sup> Although cardiac injuries are rare, they are highly fatal injuries compared to the other types. It is really important to transfer these patients to the nearest facility in time, make sure they get immediate diagnosis and proper resuscitation until they are ready to be taken into the operating room for exploration. Median sternotomy and thoracotomy are two

options to explore any trauma to the chest.<sup>[2]</sup> Surgeon generally decides the technique of approach in the operating room considering the site of injury and presence of an accompanying pulmonary injury. In this study, the results of thoracotomy and median sternotomy were compared.

## MATERIALS AND METHODS

Forty patients who underwent surgical intervention due to penetrating cardiac injury were retrospectively analyzed between January 2003 and December 2013. The data were collected from hospital archives. Twenty-six (65%) patients underwent thoracotomy (Group 1) while fourteen of them (35%) underwent median sternotomy (Group 2).

The data regarding demographics, etiology and perioperative findings were analyzed.

Computerized tomography, physical exam, chest x-ray and echocardiography were the tools of investigation in the pre-operative setting. On the other hand, some of these tools had to be ignored due to hemodynamic instability of the patients, and they were taken to the operating room right away.

Address for correspondence: Yüksel Beşir, M.D.

İzmir Katip Çelebi Üniversitesi Atatürk Eğitim ve Araştırma

Hastanesi, Kalp Damar Cerrahisi Kliniği, İzmir, Turkey

Tel: +90 232 – 243 43 43 E-mail: yukselbesir@hotmail.com

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**Table 1.** Characteristics of age and gender

	Group 1		Group 2		p
	n	%	n	%	
Male Sex (n, %)	25	96.2	11	78.6	0.115
Age (Mean±SD)	30.12±12.54		40.86±17.06		0.026
	15–63		19–77		

Operating physicians decided the exploration technique according to the site of injury and presence of a possible pulmonary injury. In case of pulmonary involvement, they went for thoracotomy. When there was a suspicion of posterior cardiac wall involvement and an accompanying pulmonary injury, thoracotomy was the chosen technique. In case of any anterior cardiac involvement without suspicion of pulmonary injury, the chosen technique was median sternotomy. Some patients with thoracotomy had also received median sternotomy where the cardiac injuries could not be repaired through thoracotomy. Moreover, some patients with median sternotomy also received additional thoracotomy due to their pulmonary injuries. Hemodynamic instability was not a factor for choosing the exploration technique. There was no immediate thoracotomy in the emergency room. Cardiopulmonary bypass was never used in these patients.

Injuries other than in the thorax were assessed and treated after repairing the thoracic injuries.

Patients with cardiac arrest and the ones who were unresponsive to resuscitation were excluded from the study.

### Statistical analysis

Data analysis was performed using SPSS 15.0 for Windows with a 95% confidence interval. Pearson Chi-Square and Fisher's Exact test were used for analyzing the categorical data

comparison between the groups. Mann-Whitney U statistical analysis was used for the comparison of continuous variables.  $P < 0.05$  is accepted as the minimum statistical significant value.

### RESULTS

There were twenty-five (96%) male patients and one (4%) female patient in Group 1. The mean age of Group 1 was  $30.1 \pm 12.5$  (15–63) years; there were eleven (78%) male patients and three (22%) female patients in Group 2, and the mean age of this group was  $40.86 \pm 17.06$  (19–77) years. There was no statistically significant gender difference between the groups ( $p=0.11$ ). In Group 2, mean age was statistically significantly different than the mean age in Group 1 ( $p=0.02$ ) (Table 1).

In Group 1, twenty-one patients had sharp weapon injuries and five had firearm injuries. In Group 2, seven patients had sharp weapon injuries, two patients had firearm injuries and five patients had injuries due to medical interventions. There was a significant difference for medical interventional injuries in Group 2 ( $p=0.005$ ). There was no significant difference comparing the other etiologic factors. As for the additional operations in Group 1, there were eleven pulmonary repairs, three internal mammary artery ligations, four abdominal exploration, and two primary repairs of great vessels (descending aorta and pulmonary artery). In Group 2, one pulmonary repair, three abdominal explorations, and two repairs of great vessels (ascending aorta, right subclavian artery) were additionally performed. Statistically, the pulmonary repair rate was found significantly higher in Group 1 than in Group 2 ( $p=0.03$ ). Seventeen patients in Group 1 and four patients in Group 2 had additional surgical intervention, and this finding was statistically significant ( $p=0.026$ ) (Table 2).

Twenty-one patients received left antero-lateral thoracotomy, two received left postero-lateral thoracotomy and three received right anterior thoracotomy. In thoracotomy patients, three patients additionally received median sternotomy due

**Table 2.** Etiology and additional operations

	Group 1		Group 2		p
	n	%	n	%	
Etiology					0.005
Sharp weapon injuries	20	76.9	7	50	
Firearm injuries	6	23.1	2	14.3	
Complications of medical interventions	0	0	5	35.7	
Additional operation	17	65.4	4	28.6	0.026
Lung repair	11	42.3	1	7.1	0.030
Inter mamarian artery ligation	3	11.5	0	0	0.539
Great vessel repair	2	7.7	2	14.3	0.602
Abdomen exploration	4	15.4	3	21.4	0.679

**Table 3.** Localization of cardiac injuries

	Group 1	Group 2	p
Right ventricle	11	10	0.006
Left ventricle	11	4	0.392
Right atrium	8	2	0.446

to exposure problems of the injuries. In sternotomy patients, two received additional thoracotomy due to pulmonary injuries. Cardiopulmonary by-pass was never used in both groups.

In Group 1, there were eleven patients with right ventricle injury, eleven with left ventricle injury, eight with right atrial injury, and four patients had multiple injury sites. In Group 2, there were ten right ventricle injuries, four left ventricle injuries, two right atrial injuries, and two patients had multiple injury sites. There was no left atrial injury at all. There was no statistically significant difference in the groups for injury sites ( $p>0.05$ ) (Table 3). The injuries of three patients in Group 1 and two patients in Group 2 were repaired with pericardial grafts and synthetic grafts. Injuries in all the other patients were repaired with immediate primary suturing.

The mean duration of operations in Group 1 was found significantly higher than the durations in Group 2 ( $p=0.020$ ). Total perioperative blood transfusions in Group 1 were higher than the total number of transfusions in Group 2 ( $p=0.003$ ). When the durations of ICU stays were compared, there was no statistically significant difference between the groups ( $p=0.662$ ). On the other hand, mean length of hospital stay was found significantly higher in Group 1 ( $p=0.008$ ). There were seven (26.9%) mortalities in Group 1 and two (14.2%) in group 2, but there was no statistical significance ( $p=0.453$ ). One patient in Group 1 had a reoperation due to bleeding (Table 4).

## DISCUSSION

Penetrating cardiac injuries make up 10% of all thoracic trauma cases though they are found to be the most common cause of mortality.<sup>[1,3,4]</sup> Patient profile in this group of trauma cases is generally young males.<sup>[3,4]</sup> In our study, the mean age

in Group 1 was  $30.1\pm 12.5$  and  $40.86\pm 17.06$  in Group 2, and that is slightly different from the data in the literature. The mean age was found higher in Group 2 than in Group 1, which is thought to be due to the higher rate of patients undergoing complicated percutaneous interventions in this group. In this study, there was a male predominance, which is concordant with the general literature.

Sharp object injuries and firearm injuries are general causes for penetrating cardiac injuries in many studies.<sup>[5,6]</sup> Most common cause of penetrating cardiac injuries in the United States is firearms, and in the rest of the world, the leading cause of penetrating cardiac injuries is sharp objects. There are also some rare causes like fracture of sternum and percutaneous interventions.<sup>[6]</sup> Most common reasons for iatrogenic cardiac injuries are implantation or explantation of pacemaker leads, radiofrequency ablation, percutaneous transluminal coronary angiography, central venous catheters, and pulmonary artery catheterizations.<sup>[6,7]</sup> In this study, also it was also found that the most common reasons for penetrating cardiac injuries are sharp objects and firearm injuries. In the sternotomy group; however, the rate of iatrogenic injuries was found to be higher. In our institution, operating theaters and angiography suits are on the same floor. In case of a complication, the patients can be transferred into the theaters immediately and such patients usually receive median sternotomy since the underlying pathology is expected to be heart related. These patients have almost always sole cardiac injuries so median sternotomy is the chosen technique.

Mortality in penetrating cardiac injuries is also closely related to adjacent organ injuries.<sup>[3,8]</sup> Rate of accompanying Intra-abdominal injuries that require laparotomy is 10% as stated by many authors.<sup>[9,10]</sup> Manduz et al. have reported in one of their studies that the extra cardiac injuries accompany 35% of cardiac injuries.<sup>[3]</sup> In this study, ten patients had pulmonary injuries, one patient had liver injury, and one patient had colon injury. Firearm injuries also possess greater risk for additional extra cardiac injuries.<sup>[4,11]</sup> In our study, extra cardiac injuries in the thoracotomy group were found higher than in the sternotomy group since eligible patients for this group generally admitted with pulmonary injuries already. Considering patients with non-pulmonary extra cardiac injuries, there was no statistical difference between the groups.

**Table 4.** Perioperative data

	Group 1	Group 2	p
Duration of operation (minute)	160.38±89.35 (55–385)	103.93±28.16 (60–180)	0.02
Blood transfusion (unit)	4.73±2.69 (2–11)	2.43±1.7 (1–6)	0.003
Length of hospital stay (day)	6.5±2.25 (4–12)	4.56±1.01 (3–6)	0.008
Duration of intensive care unit (day)	3.17±3.55 (1–17)	2.62±0.96 (2–5)	0.662
Mortality	7 (26.9%)	2 (14.2%)	0.453

As reported by many authors, the most commonly involved chamber is the right ventricle (RV), followed by the left ventricle (LV), and the left atrium (LA) has been found to be rarely involved.<sup>[6,12]</sup> Kang et al. have reported the following involvement rates: RV 43%, LV 34%, RA 18%, LA 5%. Involvement of multiple chambers is 18–35%.<sup>[4,6]</sup> In our study, the most commonly involved chamber was RV, followed by LV and RA, respectively. These findings also correlate with the published data. Involvement rates of multiple cardiac chambers in our study are as follows: 15% in Group 1, 14% in Group 2.

Incision and approach to injuries vary among institutions. There are numerous publications about different approaches as published data though there is no consensus. There are studies showing significant survival rates in emergent antero-lateral thoracotomy for cardiac injuries admitted to emergency room.<sup>[1,13]</sup> On the other hand, some authors have reported that thoracotomy for penetrating cardiac injuries should only be performed by experienced and well-equipped teams to achieve favorable results.<sup>[6,14]</sup> In our study, the patients were transferred to the operating rooms immediately since the ER is located in close proximity to ORs. There are some studies suggesting median sternotomy in the first place for hemodynamically stable patients admitted to the ER.<sup>[1]</sup> When sternum saw is available, sternotomy can be managed very fast and effectively yielding great exposure to the heart and great vessels.<sup>[1,6,15]</sup> Sternotomy results in less pain compared to thoracotomy so pulmonary functions are minimally depressed and patient can be weaned easily. Sternotomy, on the other hand, can be very disadvantageous in cases of descending aortic injuries and esophageal injuries, in these cases, cardiopulmonary by-pass is generally established.<sup>[1,15]</sup> In suspicion of posterior cardiac injury or/and esophageal injury, thoracotomy can be chosen in the first place. The initial plans for the approach cannot yield proper exposure to the injury site and an additional sternotomy or a thoracotomy can be needed sometimes. Mitchell et al. have reported 20% sternotomy in thoracotomy patients and a 3% thoracotomy in sternotomy patients in their study.<sup>[15]</sup> In our study, 11% of the thoracotomy patients needed additional sternotomy and 14% of the sternotomy patients needed additional thoracotomy. Additional incisions are unfavorable due to excessive pain and cosmetic issues so it is important to avoid extra incisions. It is to our belief that preoperative imaging is the key point and should be carefully performed as long as the patient is hemodynamically stable enough. In some cases; however, it is inevitable to perform additional incisions no matter how hard imaging modalities have been instituted to make a decision.

Survival rates in penetrating cardiac injuries can vary between 3% and 84% in published studies.<sup>[6,16]</sup> Tyburski et al. have reported the following variables as mortality factors: hemodynamic instability, mechanism of injury (firearm injuries are the most fatal injuries), presence of cardiac tamponade at admission, presence of great vessel injury and presence of multiple injuries.<sup>[16]</sup> The best prognosis is reported for the right ven-

tricle injuries.<sup>[4,17]</sup> In published studies, authors have generally compared thoracotomies performed in the ER and the thoracotomies performed in the OR for prognosis. In our study, the mortality rates between the thoracotomy group and the sternotomy group were compared, and no statistically significant difference was found. Similar comparisons were not found in the literature as published studies. On the other hand, duration of operation, transfusions and length of hospital stay were found significantly different in two groups. The thoracotomy group showed increased rates for transfusion, hospital stay and duration of operation because this group had additional injuries to primary cardiac injuries. Number of patients and retrospective nature of this study are the general limitations along with the inhomogeneous etiologies of injuries for the two groups.

Thoracotomy and sternotomy are two different approaches in suspected penetrating cardiac injuries. There is no significant difference in prognosis between the groups. Even though thoracotomy is generally considered favorable in multiple injuries, we believe thoracotomy can be disadvantageous in yielding proper operative exposure in some cases.

Conflict of interest: None declared.

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## KLİNİK ÇALIŞMA - ÖZET

### Penetran kalp yaralanmalarında insizyon seçimi: Hangisini tercih etmeliyiz? Torakotomi mi sternotomi mi?

Dr. Yüksel Beşir,<sup>1</sup> Dr. Orhan Gökcalp,<sup>2</sup> Dr. Börteçin Eygi,<sup>1</sup> Dr. Hasan İner,<sup>1</sup> Dr. İhsan Peker,<sup>1</sup> Dr. Gamze Gökcalp,<sup>3</sup> Dr. Levent Yılık,<sup>2</sup> Dr. Ali Gürbüz<sup>1</sup>

<sup>1</sup>İzmir Katip Çelebi Üniversitesi Atatürk Eğitim ve Araştırma Hastanesi, Kalp Damar Cerrahisi Kliniği, İzmir □

<sup>2</sup>İzmir Katip Çelebi Üniversitesi Tıp Fakültesi, Kalp Damar Cerrahisi Anabilim Dalı, İzmir □

<sup>3</sup>Tepecik Eğitim ve Araştırma Hastanesi, Çocuk Acil Kliniği, İzmir

**AMAÇ:** Penetran kalp yaralanmaları klinik sonuçları sebebiyle yüksek mortaliteye sahip ciddi yaralanmalardır. Bu yaralanmalardaki en önemli problemlerden biri ekplorasyon için uygun yöntemi seçmektir. Genel olarak yaralanma bölgesine göre torakotomi ya da mediyan sternotomi yöntemlerinden birisi kullanılarak ekplorasyon gerçekleştirilir. Bu çalışmada penetran kalp yaralanması olan hastalarda yapılan mediyan sternotomi ve torakotomi sonuçları karşılaştırılmıştır.

**GEREÇ VE YÖNTEM:** Ocak 2003 ile Aralık 2013 arasında kliniğimizde penetran kalp yaralanması sebebiyle ameliyat edilmiş toplam 40 hasta geriye dönük olarak incelendi. Bu hastaların 26 tanesine torakotomi (Grup 1) 14 tanesine de mediyan sternotomi (Grup 2) uygulandı. Her iki grup ameliyat öncesi ve ameliyat sırasında veriler açısından karşılaştırıldı.

**BULGULAR:** İki grup arasında cinsiyet açısından fark yoktu. Ancak yaş ortalaması Grup 2'de diğerine göre istatistiksel olarak daha yüksek idi ( $p<0.05$ ). Etiyolojik faktörlere bakıldığında ise Grup 1'de delici kesici alet ile yaralanma oranı Grup 2'den yüksek, Grup 2'de de girişimsel işlem komplikasyonuna bağlı yaralanma oranı Grup 1'den yüksek bulundu ( $p<0.05$ ). Ameliyat sırasında verilerden ise ek olarak akciğer yaralanması ve diğer başka bölgede cerrahi müdahale oranı Grup 1'de Grup 2'ye göre istatistiksel olarak daha yüksek bulundu ( $p<0.05$ ). Kullanılan kan miktarı, operasyon süresi ve hastaneden taburcu olma süresi de Grup 1'de istatistiksel olarak daha yüksek bulundu ( $p<0.05$ ).

**TARTIŞMA:** Penetran kalp yaralanmalarında ekplorasyon için kullanılacak yöntem karar verilirken dikkate alınan esas parametreler yaralanma bölgesi ve akciğer yaralanması olup olmadığıdır. Bununla birlikte etkinliği çok iyi bilinen torakotomi ve mediyan sternotomi arasında sağ kalım açısından herhangi bir fark yoktur. Ancak torakotominin mediyan sternotomiye göre bazı ameliyat sırasında parametreler açısından dezavantajları olduğu da akıldadır bulunmalıdır.

**Anahtar sözcükler:** Kalp; mediyan sternotomi; penetran; torakotomi.

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