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Original Article

Median Sternotomy in Penetrating Cardiac Trauma: Does it make a difference?

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Abstract

Background: Studies comparing the outcomes of left lateral thoracotomy and median sternotomy in the management of penetrating cardiac trauma in the Egyptian setting are lacking, which motivated us to conduct the current study. This study aimed to compare the perioperative and short-term outcomes between median sternotomy and left anterior thoracotomy in the management of patients with penetrating cardiac injuries.

Methods: A total of 40 patients with penetrating cardiac trauma were included: 34 were males (85%), and 6 were females (15%). The mean age was 35.00 ± 10.83 years. Patients were allocated into two groups: Group A (n= 20) was managed with median sternotomy, and Group B (n= 20) was managed with left lateral thoracotomy. The study outcomes included operative time, intraoperative blood loss, postoperative pain score, duration of mechanical ventilation, length of ICU stay, postoperative complications and mortality.

Results: The right ventricle was the most common injury site (60% vs. 50%, p= 0.619 in Groups A and B, respectively). Left lateral thoracotomy was associated with longer operation times [3750 (1500 – 6000) vs. 185 (70 - 260) mins, p= 0.002]. Left lateral thoracotomy patients had longer ICU stays [5 (2 – 7) vs. 3 (2 – 5) days, p= 0.004] and hospital stays [7 (4 – 12) vs. 5 (4 – 7) days, p= 0.001]. There were no differences in wound infection, pericardial effusion, or mortality between the groups. The pain score was lower in the median sternotomy group postoperatively from day 2 to day 7.

Conclusion: Median sternotomy was associated with a significant decrease in operation time, blood loss, pain score, duration of ICU stay, and hospitalization period. The median sternotomy approach could be preferred over the thoracotomy approach in patients with penetrating cardiac injury.

KEYWORDS

Median sternotomy; Left lateral thoracotomy; Penetrating cardiac trauma

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Introduction

Clinicians must maintain a high level of suspicion for life-threatening cardiac injuries despite being rare. Among patients with penetrating thoracic injuries, approximately 6% experience cardiac injury [1, 2]. Stabbing or

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firearm accidents, such as gunshot wounds, are typical causes of penetrating cardiac injuries. The severity of cardiac injury depends on several factors, such as the size, speed, and trajectory of the shot or weapon. In rare cases, cardiac injuries can occur as a result of a fractured rib penetrating the heart. Left ventricular injuries account for 25% of cardiac injuries; however, 30% of cases involve more than one cardiac chamber injury [3]. Right ventricular injuries occur in 35% of patients who reach the hospital with stab wounds [4]. Other types of cardiac injuries include coronary artery lacerations, valve damage, and ventricular septal defects. Furthermore, missile injuries can lead to bleeding, cardiac tamponade, and shock [5].

After the initial assessment, patients are managed based on their hemodynamic status, the nature of the injury, and other associated injuries [6, 7]. Hemodynamically stable patients with traumatic injuries typically undergo computed tomography (CT) scans of the chest and/or abdomen, and CT angiography is commonly performed to evaluate the thoracic aorta [8]. A chest CT may reveal effusion, requiring prompt pericardial exploration. Confirming the diagnosis and determining the need for further chest exploration is achieved through a subxiphoid pericardial window showing the presence of blood or clots [9]. For hemodynamically unstable patients with penetrating cardiac trauma, fluid resuscitation and immediate transfer to the operating room are initiated. Emergency thoracotomy can be life-saving for patients with penetrating cardiac injuries, although this technique has limitations in adequately exposing the injury and requires skilled surgeons [5].

The urgency, approach, and technique for chest exploration depend on the patient's hemodynamic condition and the mechanism of injury. Once the indication for surgical exploration is established, the appropriate surgical approach is determined [10]. Patients in critical condition could undergo a left anterolateral thoracotomy to guarantee rapid and appropriate exposure for cardiac injuries. A left anterolateral incision is made in the fourth or fifth intercostal space, and it provides good exposure of the lung, descending aorta, and left mediastinum; however, it offers limited visibility of the heart and great vessels, often necessitating extension across the sternum [11, 12, 13].

A median sternotomy is the preferred incision for anterior cardiac injuries. It provides excellent access to the heart and anterior mediastinum but offers limited access to the thoracic cavities. Furthermore, it can be extended to a midline laparotomy or into the neck in trauma patients [14]. Recently, there has been an increasing trend toward using median sternotomy for pulmonary surgery, as it offers several advantages over thoracotomy. Many surgeons believe that a median sternotomy provides excellent access for pulmonary resection and is the preferred incision in certain situations [15, 16]. Median sternotomy is less painful than usual sternotomy and is associated with a shorter hospital stay [17]. However, the optimal surgical approach for repairing penetrating cardiac injuries is still controversial [18, 19]. There is a lack of studies comparing the outcomes of left lateral thoracotomy and median sternotomy for the management of penetrating cardiac trauma in the Egyptian setting, which motivated us to conduct the current study. This study aimed to compare the perioperative and short-term outcomes between median sternotomy and left anterior thoracotomy in the management of patients with penetrating cardiac injuries.

Patients and Methods

Study design

This prospective cohort study was performed in the Trauma Department and included 40 patients with penetrating cardiac trauma between January 2021 and December 2022. Patients were divided into two groups according to the surgical approach. Group A included 20 patients who underwent median sternotomy (mean age: 35.20 ± 11.54 years), and Group B included 20 patients who underwent left lateral thoracotomy (mean age: 34.80 ± 10.12 years).

The inclusion criterion was penetrating cardiac trauma in patients aged 15 to 50 years. Patients who presented with cardiac arrest, multiple penetrating injuries, chronic diseases, fractured ribs, or flail chests were excluded.

Table 1: Comparison of the preoperative characteristics of patients who underwent median sternotomy (Group A) vs. left lateral thoracotomy (Group B). The data are presented as the means and SDs or counts and percentages

	Group A (n = 20)	Group B (n = 20)	P value
Age (years)	35.20 ± 11.54	34.80 ± 10.12	0.908
Gender			
Male	18 (90%)	16 (80%)	0.376
Female	2 (10%)	4 (20%)	
Injury Cause			
Stab wound	15 (75%)	13 (65%)	0.490
Firearm injury	5 (25%)	7 (35%)	
HR (beat/min)	111.75 ± 10.79	114.75 ± 12.30	0.417
SBP (mmHg)	105.00 ± 26.01	99.95 ± 22.84	0.518
AAST scale			
III	4 (20%)	3 (15%)	0.915
IV	14 (70%)	15 (75%)	
V	2 (10%)	2 (10%)	

AAST: American Association for the Surgery of Trauma; HR: heart rate; SBP: systolic blood pressure

The local ethical and scientific committee of the faculty of medicine approved the study. Informed written consent was obtained from all participants.

Management protocol

The initial resuscitation was performed simultaneously with the initial assessment. When a life-threatening condition was identified, immediate corrective actions were taken, and the effectiveness of these interventions was evaluated before proceeding to the next step. The primary assessment followed the "ABCDE" approach and included evaluating the airway and cervical spine, breathing and ventilation, circulation and bleeding control, disability and neurologic assessment, and exposure and environment control.

After the resuscitation phase, a detailed history was obtained from all patients, including age, sex, mechanism and time of trauma, and arrival time. Patients were examined in the trauma room, and vital signs were recorded. A thorough general examination was performed to identify any associated injuries, and a local chest examination was also conducted.

Table 2: Comparison of intraoperative data between patients who underwent median sternotomy (Group A) and patients who underwent left lateral thoracotomy (Group B). The data are presented as the means and SDs or counts and percentages.

	Group A (n = 20)	Group B (n = 20)	P value
Location of injury			
Right ventricle	12 (60%)	10 (50%)	0.619
Left ventricle	7 (35%)	9 (45%)	
Right atrium	1 (5%)	1 (5%)	
Additional procedures			
Lung repair	3 (15%)	5 (25%)	0.429
Great vessel repair	2 (10%)	3 (15%)	0.633
Ligation of the internal mammary artery	2 (10%)	2 (10%)	>0.99
Operative time (min)	185 (70 - 260)	270 (70 – 400)	0.002
Blood loss	2250 (1000 – 4000)	3750 (1500 – 6000)	0.003
Blood transfusion units	1 (1 – 6)	5 (2 – 10)	0.004

After the examination, heat loss was prevented via the use of warming devices and warm blankets. Electrocardiography (ECG) and echocardiography were performed. If not contraindicated, a urinary catheter was inserted, and a nasogastric tube was used if necessary. The laboratory parameters included a complete blood count; cardiac troponin, blood urea, and serum creatinine levels; serum electrolytes; serum albumin; random blood glucose; and arterial blood gas levels. Radiological investigations, such as a focused assessment with sonography for trauma (FAST scan) and anteroposterior and lateral chest X-ray, pelvis, spinal, and extremity X-rays, were ordered for all patients. Chest computed tomography was also performed.

Surgical approach

The choice of surgical exploration technique depended on the site of the injury and the possibility of pulmonary involvement. Thoracotomy was performed in patients with pulmonary involvement or when there was suspicion of involvement of the posterior cardiac wall. Median sternotomy was indicated for anterior cardiac involvement without suspected pulmonary injury. The two groups were compared in terms of operative time, intraoperative blood loss, and the number of blood units transfused.

Postoperative care and study endpoints

Patients were then transferred to the intensive care unit (ICU) and closely monitored for the duration of hospitalization, length of ICU stay, and duration of mechanical ventilation. Analgesia was maintained using intravenous acetaminophen (1 gm/8 hours) and intravenous ketorolac (30 mg/12 hours). Additional intravenous morphine was administered as needed (0.2 to 0.5 mg every three to four hours). After extubation, patients rated their pain on a 10-point numerical rating scale (NRS), ranging from 0 for no pain to 10 for the worst pain imaginable [19]. Pain scores were recorded every four hours during the day, and the mean of the recorded values was calculated. The following parameters were compared between the two groups: postoperative pain score, postoperative complications such as wound infection, and early mortality. Early mortality was defined as death within 30 days of the operation or death occurring during the same hospital admission, even if more than 30 days had passed.

Statistical analysis

The collected data were analyzed via SPSS software (Statistical Package for Social Sciences) for Windows (version 26, IBM Corp., Chicago, IL, USA). Categorical data are expressed as frequencies and percentages and were compared using the chi-square test or Fisher's exact test. Numerical data are expressed as the mean ± standard deviation (SD) or median ± range for normally and abnormally distributed data, respectively. The former data type was compared between the two groups using Student's t test, while the latter was compared using the Mann–Whitney test. A P value less than 0.05 was considered to indicate statistical significance.

Results

Baseline data

There was no difference in age between the two approaches (P= 0.908), and men composed the majority of the included participants (90% and 80% in Groups A and B, respectively). No significant difference was reported in sex between the groups (P= 0.367).

Compared with firearm injury, stab wounds were the most common cause of penetrating cardiac injury. No significant differences in heart rate or systolic blood pressure were observed between the two groups. According to the AAST, most patients had class IV injuries, with fewer patients having Class III or Class V injuries (Table 1)

Operative data

The right ventricle was the most common site of injury in both study groups, followed by the left ventricle and the right atrium. Additional procedures performed included lung repair (15% vs. 25%), great vessel repair (10% vs. 15%), and internal mammary artery ligation (10% in both groups). The operative time was significantly longer in patients who underwent left lateral thoracotomy (P = 0.002). Left lateral thoracotomy patients had significant increases in intraoperative

Table 3: Comparison of postoperative data between patients who underwent median sternotomy (Group A) and those who underwent left lateral thoracotomy (Group B). The data are presented as the means and SDs or counts and percentages

	Group A (n = 20)	Group B (n = 20)	P value
Mechanical ventilation (day)	1 (1 – 2)	1 (1 – 2)	0.530
ICU stay (day)	3 (2 – 5)	5 (2 – 7)	0.004
Hospitalization (day)	5 (4 – 7)	7 (4 – 12)	0.001
Wound infection	2 (10%)	3 (15%)	0.633
Pericardial effusion	3 (15%)	4 (20%)	0.677
Mortality	3 (15%)	5 (25%)	0.429

blood loss and intraoperative blood transfusion volume (p = 0.003 and 0.004, respectively) (Table 2).

Post Operative data

The duration of mechanical ventilation ranged between one and two days in the two study groups, with no statistically significant difference (p= 0.530). However, the ICU stay and hospitalization duration were significantly shorter in the median sternotomy approach group than in the thoracotomy group (p = 0.004 and 0.001, respectively). The two study groups showed no significant differences in wound infection occurrence, pericardial effusion, or mortality rate (Table 3).

Postoperative pain scores in the two studied groups were recorded from the 2nd postoperative day until the 7th postoperative day, and patients in the sternotomy group had significantly lower pain scores than did those in the thoracotomy group (Table 4).

Discussion

The mortality rate for patients with penetrating cardiac injuries who arrived at hospitals ranged from 22% to 67% [14, 20]. While there have been a few Egyptian studies on the management of penetrating cardiac trauma [21, 22], there is limited research comparing median sternotomy and left lateral thoracotomy for cardiac trauma. This knowledge gap motivated us to conduct our study to compare the perioperative outcomes of these two surgical approaches. In our study, stab wounds were the most common cause of penetrating cardiac injury in both groups, followed by firearm injuries. These findings are in agreement with those of Onat and colleagues [23], who reported a greater prevalence of stab wounds than gunshot wounds. However, other authors have reported different distributions of penetrating wounds according to etiology, with gunshot wounds being the most common cause, followed by stab wounds [18].

Regarding the injury site, the right ventricle was the most commonly affected chamber in both groups, followed by the left ventricle. The right atrium was affected in only one patient in each group (5%). These findings align with previous reports stating that the right ventricle is the most commonly injured chamber due to its anterior location and exposure to penetrating injuries. The left atrium, which is smaller and posteriorly located, has a lower likelihood of injury [24, 25, 26]. Our study revealed that the operation time was significantly longer in the thoracotomy group than in the sternotomy group. These findings are consistent with those of a previous study by Beşir and coworkers [13]. Additional procedures, such as lung repair, great vessel repair, and internal mammary artery ligation, were more frequently performed in the thoracotomy group. Beşir and collaborators [13] reported similar findings, highlighting the advantages of median sternotomy in providing access to associated injury management.

The thoracotomy group required a significantly greater number of blood transfusion units than did the sternotomy group. This observation aligns with previous studies that reported an increased need for blood transfusion with the thoracotomy approach [13]. However, the duration of mechanical ventilation did not

Table 4: Comparison of postoperative pain scores between patients who underwent median sternotomy (Group A) and those who underwent left lateral thoracotomy (Group B). The data are presented as medians (25th-75th percentiles)

	Group A (n = 20)	Group B (n = 20)	P value
2nd day	6 (4 – 7)	7 (5 – 9)	0.002
3rd day	5 (3 – 6)	6 (4 – 8)	0.001
4th day	4 (3 – 6)	6 (4 – 7)	0.002
5th day	4 (3 – 5)	5 (3 – 7)	0.006
6th day	3 (2 – 5)	4 (2 – 6)	0.032
7th day	3 (2 – 5)	4 (2 – 5)	0.046

significantly differ between the two groups in our study, in contrast with the findings of several previous reports that favored the sternotomy approach [17, 27]. Regarding postoperative outcomes, the sternotomy group demonstrated a significantly shorter duration of ICU stay than did the thoracotomy group. These findings align with those of Bugaev and associates [25] and another study that reported similar results [14]. The sternotomy group also had lower pain scores throughout the postoperative period, which is consistent with the findings of previous studies emphasizing reduced pain occurrence with sternotomy [13]. The duration of hospitalization was significantly longer in the thoracotomy group than in the sternotomy group, as observed in our study and reported by other studies [17, 18]. This can be attributed to the critical conditions of the patients and the nature of the procedure itself.

Wound infection rates were not significantly different between the two groups in terms of complications. However, our study revealed a lower incidence of pericardial effusion than did another study [28], which could be attributed to differences in the procedures and follow-up periods. Mortality rates were slightly greater in the thoracotomy group than in the thoracotomy group, although the difference was not statistically significant. In patients with penetrating cardiac injuries, mortality is closely related to associated organ injuries, which may explain the slightly greater mortality rate in the thoracotomy group due to the greater incidence of associated intrathoracic injuries. These findings are consistent with previous studies that did not find a significant difference in mortality between sternotomy and nonresuscitative thoracotomy approaches [13, 17, 27].

Limitations

It is important to note that our study has limitations, including a small sample size from a single trauma center and the heterogeneity of the patient population, which included both stab and firearm injuries. Additionally, this study lacked intermediate and long-term follow-up. These limitations should be addressed in future studies. Studies including more patients from different trauma centers should be carried out in the future. These studies should evaluate intermediate- and long-term outcomes.

Conclusion

Compared to thoracotomy, the median sternotomy approach was associated with a shorter operation time, less blood loss, lower pain scores, shorter ICU stays, and shorter hospitalization periods. However, the incidence of morbidity and mortality was comparable between the two approaches. The median sternotomy approach could be preferred over the thoracotomy approach in patients with penetrating cardiac injury.

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