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Original Article

Penetrating chest trauma: A prospective study of prognostic factors for worse outcome after emergency surgery

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Abstract

Background: Even though chest penetrating injuries are common as well as challenging to treat, most of the time they can be dealt without surgery. This study aimed to evaluate contemporary outcome following emergent surgical interventions for penetrating chest trauma and possible factors associated with poor prognosis.

Methods: This prospective study included 100 cases admitted to benha university hospital with either Stab Wound or Gunshot wound to the chest, with systolic blood pressure ≤90 mmHg and who underwent through Thoracotomy or sternotomy within duration of one hour of arrival.

Results: This study included 81 patients (77 stabbings, 4 gunshots) underwent a thoracotomy and 19 underwent median sternotomy within 60 minutes after the penetrating trauma, the mean period of surgery was 3 ±0.9, There were 94 male and 6 female cases and their mean age was 25 ±10.14 years, the mean Intensive care unit stay was 2 ±0.83 days in addition mean hospital stay was 6 ±1.06 days, the individuals who died had trauma at mid-clavicular line of the chest (100%) compared to survivors (5.5%), lesser systolic blood pressure on presentation in the emergency room (71 ±11 mmHg) equated with those who survived (90 ±9 mmHg, P<0.001) and lower hemoglobin level (6.4 ±0.5) compared with those who survived (8.4 ±1, P<0.001). As a whole, the mortality rate was 9% (n=9). individuals' Death Rates with stab wounds was 5/96 (5.2%) compared with 4/4 (100%) for patients with gunshot wounds. Right ventricular injury (P=0.03) was associated with mortality.

Conclusion: Early referral, within one hour, to emergency surgery results in acceptable postoperative mortality in patients with penetrating chest trauma. Anterior location of injury, initial hemodynamic instability, and gunshot wounds associated with poor prognosis.

KEYWORDS
Penetrating chest trauma; Stab wound; Gunshot wound; Thoracotomy; Emergency surgery; Prognosis

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Introduction

Thoracic injury is a common cause of mortality and major morbidity, and the leading cause of death from physical trauma after head and spinal cord injury [1]. It is the primary reason for death in twenty five percent of instances with multiple trauma, and the proportion jumps to fifty percent when it is accompanied by further injuries [2]. Penetrating chest trauma (PCT) accounts for almost 33% of total chest traumas [3].

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Irrespective of the mechanism by which they are induced, the principal outcomes of chest trauma are the combined impacts on respiratory and cardiovascular functionality. These impacts manifest as hypovolemia, hypoxia, and reduced cardiac output via direct mechanisms affecting the organs of the chest [4]. there is a wide range of injuries as well as degrees of severity associated with PCT [5].

The clinical outcomes are affected by the mechanism of damage, the site of injury, other injuries sustained, and preexisting conditions. Besides the intrathoracic contents, the intraperitoneal viscera, the retroperitoneal space, as well as the neck are all vulnerable areas [6]. Individuals' recovery from PCT depends on the severity of their injuries and how quickly they begin therapy [6].

By directly controlling intrathoracic injuries, decompressing pericardial tamponade, as well as controlling the aorta to prevent exsanguination, emergency thoracotomy (ET) is a surgery designed to temporize wounds and stabilize a patient. There are times when it makes sense to use ET. However, in such cases, this technique may prove to be lifesaving, buying the patient enough time to receive more permanent treatment [7].

Predictive factors associated with effective ET outcomes were related to the trauma mechanism, injury location, transferring time duration, the thoracotomy indication and response to resuscitation prior to thoracotomy [8,9].

Consequently, the Western Trauma Association formulated within their guidelines that a thoracotomy for patients with PCT, the indication is stretched to cardiac arrest < 15 min prior to arrival and witnessed arrest [10].

Survival rates after resuscitative thoracotomy are of 9-57% for patients with penetrating cardiac injuries and of 0-66% for patients with noncardiac thoracic injuries, but overall Survival rates are about 8% [11]. While survival rate after non-resuscitative thoracotomy is approximately 35% for patients with penetrating cardiac injuries and up to 15% for all patients with PCT [12].

This study aimed to evaluate contemporary outcome following emergent surgical interventions for PCT and possible factors associated with poor prognosis.

Patients and Methods

One hundred consecutive patients admitted to Benha University's hospital from April 2022 to April 2023 with a stab wound (SW) or gunshot wound (GSW) to the chest who received a Thoracotomy or sternotomy within sixty minutes of arrival were involved in a prospective trial.

Ethical consent

Benha University's hospital as well as the Ethics Committee gave its agreement to the research, MOHP No:0018122017/ Certificate No:1017, Code Number: MS3-4-2022.

Inclusion criteria:

- Patients with penetrating chest trauma indicated for emergency cardiothoracic surgery (within 24 hours of arrival to hospital) due to high initial intercostal tube (ICT) output more than 15-20 ml/Kg, massive air leak or pericardial effusion in the sitting of PCT.
- Patients with initial systolic blood pressure ≤ 90 mmHg.
- Patient with Previously witnessed cardiac activity (prehospital or in hospital).
- Patient with Unresponsive hypotension.
- Patient presents pulseless to the emergency department (ED) with signs of life after PCT.
- Patient with <15 min cardiopulmonary resuscitation (CPR).

Exclusion criteria:

- Blunt injury.
- Penetrating abdominal trauma.
- Nontraumatic arrest.
- Severe head injury.
- Severe multisystem injury.
- needed minor procedures as chest tube insertion.

Data collection:

The collected data were listed in data collection form for each patient and are presented in (Table 1).

Table 1: Data collection form

Emergency Unit Parameters:	Age, Sex, Date and time of arrival, Physiological parameters on admission, SBP, Pulse; palpable/non-palpable, Glasgow coma scale (GCS), Respiratory rate (RR), Spontaneous ventilation/intubation, clinical presentation; Stable/Unstable, Initial ICT output.
Emergency Unit Investigations Parameters:	Complete blood count, ABO system, PT, PTT, INR, Arterial blood gases (ABG), Chest x-ray (CXR)/ Chest Computed Tomography (CT), +/- Rapid assessment echocardiogram (ECHO).
Cause & Site of injury:	• SW/ GSW • Right/ Left / Bilateral
Location of Trauma:	Mid-clavicular line of chest, anterior/mid/posterior-axillary line of chest, scapular line of chest, Parasternal, Anterior Costal margin, others.
Theatre parameters:	Date and time of arrival in theatre, Type and time of surgery, Type and time of anaesthesia, Intraoperative findings (Lung injury, Cardiac chamber injury, Vascular injury, Diaphragmatic injury), Duration of surgery.
ICU parameters:	Ventilated; Yes/No, Duration, Extubation, Usage of Inotropes or Vasopressors, Days in ICU/outcome.
Further surgical intervention:	Yes/No
Outcome:	Morbidity, mortality, possible factors associated with poor prognosis.

Intravenous (IV) lines were inserted in all patients, and IV colloid replacement was used to increase IV pressure.

The surgical decision was made after a thorough evaluation that included a physical exam, emergency laboratory tests, as well as imaging studies.

All stable, non-shocked participants underwent an emergency CXR to provide a baseline for the degree of pleural collection and cardiac shadow.

All four individuals suffering from a bullet injury (n=4) underwent thoracotomy, while 77 (80.2%), seventeen (17.7%), and 2 (2.1%) of the ninety-six patients with a SW (n=96) underwent thoracotomy, median sternotomy, and lower mini sternotomy, respectively.

Thoracotomy or sternotomy was performed under general anesthesia, stopping the bleeding, and resuscitating the individual with colloids. One stabbing patient needed a left internal mammary artery (LIMA) coronary artery bypass graft (CABG) because of damage to the left anterior descending artery (LAD). After that, a thoracostomy tube and a retrosternal tube were placed.

Lung lacerations were repaired with a double layer of 3/0 proline or vicryl while air leaks were checked for. Clips as well as silk suture ligation were used to close the intercostal vessels, LIMA, and right internal mammary artery (RIMA).

Each patient was taken to the ICU until they were extubated (if still on mechanical ventilation (MV)) and stable, at which point they were moved to the ward for postoperative CXR as well as ECHO to check on any penetrating cardiac damage. Clinical status, wound care, and a repeat CXR were all assessed one week after people were released from the hospital's outpatient clinic.

Statistical analysis

The gathered information was analyzed using a Windows-based version of Microsoft Excel as well as a statistical program designed specifically for the social sciences called IBM-SPSS. For categorical variables, the values were presented as the frequency and percentage, whereas the mean ± standard deviation was utilized to represent continuous variables. Categorical data

Table 2: Baseline demographic and clinical characteristics

Variables		Penetrating thoracic injury (n=100)
Age (years)	Mean ±SD	25 ±10.14
Sex		
Males	n (%)	94 (94)
Females	n (%)	6 (6)
Cause of injury		
SW	n (%)	96 (96)
GSW	n (%)	4 (4)
Site of Injury		
Right	n (%)	34 (34)
Left	n (%)	62 (62)
Bilateral	n (%)	4 (4)
Location of trauma		
Parasternal	n (%)	19 (19)
Mid clavicular	n (%)	14 (14)
anterior/mid/posterior-axillary	n (%)	43 (43)
Scapular line	n (%)	5 (5)
Anterior Costal margin	n (%)	15 (15)
Other	n (%)	4 (4)
Clinical condition		
Stable	n (%)	18 (18)
Unstable and/or shocked:	n (%)	82 (82%)
Circulatory collapse	n (%)	9 (9)
Hemorrhagic shock	n (%)	63 (63)
Tamponade	n (%)	10 (10)
GCS	Mean ±SD	10 ±2.58
HR	Mean ±SD	127 ±8
RR	Mean ±SD	27.9 ±6
SBP	Mean ±SD	88 ±10
Diastolic blood pressure	Mean ±SD	58 ±7
PH	Mean ±SD	7.32 ±0.03
Hb (g/dl)	Mean ±SD	8.2 ±1.1
Presentation		
Hemopneumothorax	n (%)	43 (43)
HTX	n (%)	19 (19)
Pericardial effusion/tamponade	n (%)	27 (27)
CPR	n (%)	9 (9)
Initial ICT Output	Mean ±SD	1700 ±449.06
Operative Approach		
Thoracotomy	n (%)	81 (81)
Median sternotomy	n (%)	17 (17)
Mini sternotomy	n (%)	2 (2)
Duration of surgery (h)	Mean ±SD	3 ±0.9
Diaphragmatic injury	n (%)	20 (20)
Lung injury	n (%)	38 (38)
Surgical emphysema	n (%)	23(23)
Cardiac injury	n (%)	27 (27)
RV injury	n (%)	18 (18)

LV injury	n (%)	8 (8)
Left atrial appendage	n (%)	1 (1)
Vascular injury	n (%)	34 (34)
Intercostal vessels	n (%)	23 (23)
LIMA	n (%)	7(7)
RIMA	n (%)	3 (3)
LAD	n (%)	1 (1)

SW: stab wound; GSW: gunshot wound; GCS: Glasgow coma scale; HR: heart rate; RR: respiratory rate; SBP: systolic blood pressure; Hb: hemoglobin; HTX: hemothorax; CPR: Cardiopulmonary resuscitation; ICT: intercostal tube; RV: Right Ventricular; LV: Left Ventricular; LIMA: left internal mammary artery; RIMA: right internal mammary artery; LAD: left anterior descending

were compared using Ch-square or Fisher's exact test while continuous data were compared by T-test. P-value was considered significant if less than 0.05.

Results

Baseline characteristics

The mean age of the studied patients was 25 ±10.14 ranging from 7 – 60 years. Males predominated in this study (94%). The SW was the most frequent cause of injury (96%). About two-thirds (62%) of the injuries were left-sided, the most frequent location of injury was at anterior/mid/posterior-axillary line of the chest (43%), Only four patients had multiple stabs, The patients presented unstable and/or shocked were 82%, while 18% were stable on presentation. The mean GCS was 10 ±2.58. The mean heart rate (HR) and RR were 127 ±8 and 27.9 ±6, respectively. The mean SBP and diastolic blood pressure were 88 ±10 and 58 ±7, respectively. The mean PH was 7.32 ±0.03. The mean hemoglobin (Hb) was 8.2 ±1.1 g/dl. The clinical presentations of the patients were as follows: hemopneumothorax (43%), vascular injury (34%), lung injury (33%), cardiac injury or tamponade (27%), diaphragmatic injury (20%), and hemothorax (HTX) (19%). CPR was needed for nine of the patients. The mean initial ICT output was 1700 ±449.06 cc. Thoracotomy was the most frequent surgical approach (81%). The mean duration of surgery was 3 ±0.9 hours. Intraoperative findings were as follows: lung injury (38%), vascular injury (34%), diaphragmatic injury (20%), right ventricular (RV) injury (18%), left ventricular (LV) injury (8%), and left atrial appendage (1%) (Table 2).

Postoperative characteristics

The mean ICU stay was 2 ±0.83 days. MV was needed for 20.9%. The mean duration for MV was 7 ±4.5 hours. Inotropes were needed for 26.4%. The mean hospital stay was six days, and the mortality was reported in 9 patients who died intraoperatively (Table 3).

Table 3: Postoperative characteristics of the studied cases. Quantitative variables are presented as mean ± SD. Qualitative variables are presented as frequency (percentage)

Postoperative characteristics	Penetrating thoracic injury (n=100)
ICU (days)	2 ± 0.83
MV*	19(20.9)
Duration of MV (hours)	7 ± 4.5
Inotropes or vasopressors*	24(26.4)
Hospital stay (days)	6 ± 1.06
Mortality	9 (9)

*Percentages were calculated based on a total of 91 patients, as nine patients died intraoperatively; ICU: intensive care unit; MV: Mechanical ventilation

Study group characteristic regarding mortality

This study showed that the Patients who died had trauma at mid-clavicular line of the chest (100%) compared to survivors (5.5%), lower SBP on presentation in the emergency room (ER) (71 ± 11 mm Hg) compared with those who survived (90 ± 9 mm Hg, $p < 0.001$) and lower Hb level (6.4 ± 0.5) compared with those who survived (8.4 ± 1, $P < 0.001$). The overall mortality rate was 9% (n = 9). Mortality for patients with SWs was 5/96 (5.2%) compared with 4/4 (100%) for patients with GSWs this is because GSWs not common in our society. RV injury ($P = 0.03$) was associated with mortality (Table 4).

Table 4: Study group characteristic regarding mortality

		Non-survivors (n = 9)	Survivors (n = 91)	P-value
Age (years)	Mean ±SD	23 ±4.8	24 ±8.3	0.218
Sex				
Males	n (%)	8 (88.9)	86 (94.5)	0.499
Females	n (%)	1 (11.1)	5 (5.5)	
Cause of injury				
SW	n (%)	5 (55.6)	91 (100)	**<0.001***
GSW	n (%)	4 (44.4)	0 (0)	
Laterality of Injury				
Right	n (%)	0 (0)	34 (37.4)	0.058
Left	n (%)	9 (100)	53 (58.2)	
Bilateral	n (%)	0 (0)	4 (4.4)	
Location of trauma				
Parasternal	n (%)	0 (0)	19 (20.9)	**<0.001***
Mid clavicular	n (%)	9 (100)	5 (5.5)	
Anterior/mid/posterior-axillary	n (%)	0 (0)	43 (47.3)	
Scapular line	n (%)	0 (0)	5 (5.5)	
Anterior Costal margin	n (%)	0 (0)	15 (16.5)	
Other	n (%)	0 (0)	4 (4.4)	
Clinical presentation				
Unstable and/or shocked:				
Circulatory collapse	n (%)	9 (100)	0 (0)	**<0.001***
Hemorrhagic shock	n (%)	5 (55.6)	58 (63.7)	
Tamponade	n (%)	0 (0)	10 (11)	0.63
Stable	n (%)	0 (0)	18 (19.8)	
GCS	Mean ±SD	5 ±3.5	10 ±3.4	**<0.001***
HR	Mean ±SD	130.4 ±1.1	127 ±5	**0.045***
RR	Mean ±SD	21.8 ±6.4	29 ±6	**<0.001***
SBP	Mean ±SD	71 ±11	90 ±9	**<0.001***
Diastolic blood pressure	Mean ±SD	46 ±5	59 ±7	**<0.001***
PH	Mean ±SD	7.32 ±0.03	7.32 ±0.03	0.909
Hb	Mean ±SD	6.4 ±0.5	8.4 ±1	**<0.001***
hemopneumothorax	n (%)	5 (55.6)	38 (41.8)	0.425
HTX	n (%)	0 (0)	19 (20.9)	0.128
CPR	n (%)	9 (100)	0 (0)	**<0.001***
Initial ICT Output	Mean ±SD	-	1700 ±433	-
Operative Approach				
Thoracotomy	n (%)	9 (100)	72 (79.1)	
Median sternotomy	n (%)	0 (0)	17 (18.7)	0.128
Mini sternotomy	n (%)	0 (0)	2 (2.2)	
Duration of surgery (h)	Mean ±SD	2 ±0.4	3 ±1.4	**<0.001***
Diaphragmatic injury	n (%)	0 (0)	20 (22)	0.116
Lung injury	n (%)	5 (55.6)	33 (36.3)	0.225
Surgical emphysema	n (%)	5 (55.6)	18 (19.8)	0.015
RV injury	n (%)	4 (44.4)	14 (15.4)	**0.03***
LV injury	n (%)	0 (0)	8 (8.8)	0.352
Left atrial appendage	n (%)	0 (0)	1 (1.1)	0.749
Vascular injury	n (%)	0 (0)	34 (37.4)	**0.024***

*Significant P-value; SW: stab wound; GSW: gunshot wound; GCS: Glasgow coma scale; HR: heart rate; RR: respiratory rate; SBP: systolic blood pressure; Hb: hemoglobin; HTX: hemothorax; CPR: Cardiopulmonary resuscitation; ICT: intercostal tube; RV: Right Ventricular; LV: Left Ventricular; LIMA: left internal mammary artery; RIMA: right internal mammary artery; LAD: left anterior descending.

The causes of mortality were irreversible shock, uncontrolled bleeding, low cardiac output and sepsis, all mortality were intraoperative (Table 5).

Table 5: Causes of mortality. Data variables are presented as frequency (percentage)

Causes of mortality	Non-survivors (n=9)
Irreversible shock	4 (44.5)
Uncontrolled bleeding	2 (22.2)
Low cardiac output	2 (22.2)
Sepsis	1 (11.1)

The outcome of this study as follow ICU stay had a mean value of 2 ±0.83 days while hospital stay had a mean value of 6 ±1.06 days, there were two cases of superficial thoracotomy wound infection the death rate was 9% (n=9), all the mortality were intraoperative. Mortality rate with SWs was 5/96 (5.2%) compared with 4/4 (100%) for patients with GSWs this is because GSWs not common in our society. The most common cause of mortality was irreversible shock.

Discussion

Ten to fifteen percent of individuals who come with thoracic trauma require operational repair, in addition to the vast majority of these patients have received a penetrating injury. While most PCT are manageable with standard therapies as suturing of wound, pain control and/or tube thoracostomy, some complications may arise [13].

The majority of civilian thoracotomy indications are initial chest tube output of more than 15-20 ml/Kg, ongoing output of 3 to 4 ml/Kg per hour for three consecutive hours, massive HTX linked to shock, tamponade, massive air leak, as well as evidence of injury to a great vessel [14]. we instead consider initial blood loss of 1000-1500 ml to warrant immediate surgical intervention [15].

In order to improve the outcome of patients with PCT, efforts should be made to resuscitate them as soon as possible after the trauma, with early suspicion of danger of trauma by site of stab and inlet of bullet and early laboratory and imaging investigation, to decrease the time from the trauma till performing operation, and simultaneously correct any metabolic and laboratory abnormalities [13].

The findings of this study showed acceptable mortality rate following emergency cardiothoracic surgery for those referred within one hour of trauma. The surgical approach and type of injury did not significantly affect outcome, while preoperative hemodynamic instability, anterior location of injury, and gunshot injury negatively affect postoperative outcome.

We obtained that Mortality was reported in 9% cases who died intraoperatively, Karmy-Jones et al. [16] stated a mortality of 17 percent for an urgent thoracotomy because of hemorrhage after PCT.

This result is in contrast to Alam El-Din et al. [17] stated that no deaths documented in the PCT group as the study was only on 28 cases, Elkhonezy BA et al. [13] stated that there was no mortality in all patients during their study within hospital follow up of patients.

The location of trauma significantly differed according to mortality, with the location of trauma at mid-clavicular line being higher in non-survivors (100%) compared to survivors (5.5%). In contrast, other positions were higher in survivors, including the scapular line of the chest (5.5%), anterior costal margin (16.5%), parasternal (20.9%), anterior/mid/posterior-axillary line of the chest (47.4%), others (multiple stabs) (4.4%) compared to 0% in non-survivors. Additionally, the cause of injury significantly differed ($P < 0.001$), with gunshot being higher in non-survivors (44.4%) than survivors (0%), our findings are contrary to Ekpe and Eyo [18] as their study showed that chest injury kind did not show to be connected to death

and bilateral chest involvement connected positively with death.

The non-survivors demonstrated significantly lower GCS (5 ±3.5 vs. 10 ±3.4, P < 0.001), RR (21.8 ±6.4 vs. 29 ±6, P < 0.001), SBP (71 ±11 vs. 90 ±9, P < 0.001), diastolic blood pressure (46 ±5 vs. 59 ±7, P < 0.001), Hb (6.4 ±0.5 vs. 8.4 ±1, P < 0.001), and vascular injury (0% vs. 37.4%, P = 0.024) than survivors. In contrast, non-survivors had significantly higher HR (130.4 ±1.1 vs. 127 ±5, P 0.045) and CPR (100% vs. 0%, P < 0.001) than the survivors. Additionally, clinical condition significantly differed (P < 0.001), with circulatory collapse being higher in non survivors (100%) than survivors (0%).

The non-survivors had low hemodynamic status at admission as they had major injuries with massive blood loss which was uncontrollable.

Arreola et al. identified Mean arterial pressure < 50 mmHg to be connected with poor results, but not as a predictor of mortality. SBP < 90 mmHg was not a predictor of poor result in their research [19]. Research by Rodrigues et al. also establish SBP <50 mmHg upon arrival at the hospital a predictor of result [20]. Asensio et al. identified absence or presence of initial cardiac rhythm (sinus, ventricular fibrillation asystole) on arrival in ER or when the pericardium was opened as a strong predictor of result [21].

The non-survivors demonstrated significantly higher RV injury (44.4%) than survivors (15.4%) (P =0.03). Moreover, non-survivors demonstrated significantly shorter duration of surgery (2 ±0.4 vs. 3 ±1.4 hours, P < 0.001) and lower vascular injury (0% vs. 37.4%, P = 0.024) than survivors.

In the present study, non-survivors had initially lower GCS than survivors. Similar studies have found that GCS is a reliable indicator of outcome [22], however, Asensio et al., the GCS is not a good independent predictor of prognosis because it is dependent on hemodynamic stability [23]

Our data showed that the mean age of our patients was 25 ±10.14, with a range that included people as young as seven and as old as sixty. The vast majority of our individuals were male (94%) as well as had sustained SWs (62 percent were to the left side, 19 percent were parasternal, 63 percent were shocked, 19 percent were approached via median sternotomy, along with 1 percent required CABG off pump (LIMA to LAD), Our findings are similar to others as regard age and sex [18,24,25].

In the present study, postoperative data showed that ventilation time had a mean value of 7 ±4.5 hours and ICU stay had a mean value of 2 ±0.83days while hospital stay had a mean value of 6 ±1.06 days, our findings are similar to Elkhonezy BA et al. [13] and contrary to Robison et al.[24] as their study reported lower ICU stay (0.36 ± 0.91 days).

Limitations

This study has potential limitations including the small sample size and being single-center experience, however, the prospective nature of the study is a strength point avoiding the selection and data interpretation bias of retrospective studies.

Conclusion

Early referral, within one hour, to emergency surgery results in acceptable postoperative mortality in patients with PCT. Anterior location of injury, initial hemodynamic instability, and GSWs associated with poor prognosis.

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