



Thoracic Gun-shot Injury: Single Institute Experience in Taiwan

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Objective: Firearm-related injuries pose a serious public health problem and are increasingly the focus of public health concern. We present our clinical experience of the management of thoracic gun-shot injury. **Methods:** We retrospectively reviewed 285 patients with gun-shot injuries who were admitted to our hospital via the Emergency Department between 1995 and 2010. Patients with thoracic gun-shot injury were included, but patients who died before admission were excluded. We reviewed the demographic data, management, and outcomes of all patients with thoracic gun-shot injury. **Results:** Of the total patients with gun-shot injuries, 45 (17.79%) had thoracic injuries. The mean age of the patients with thoracic gun-shot injury was 24.56 years and the median age range was 21–25 years. The most common type of weapon was a rifle (68.89%), followed by a handgun (17.78%). The motive was suicide in 42.22% of patients, and homicide in 28.89%. The most common imaging finding on chest radiography was haemopneumothorax (75.56%), followed by rib fracture (31.11%), and intrapulmonary haemorrhage (31.11%). Of these patients, 42.22% underwent a simple tube thoracostomy, 33.33% a thoracotomy, and 17.78% a thoracotomy combined with laparotomy. One patient underwent thoracoscopic surgery to check bleeding and wedge resection of the lung. The most common associated abdominal injury was an injured spleen. Three patients underwent emergency thoracostomy because of great vessel injury (right ventricle injury, dorsal scapular artery injury, and subclavian artery injury). All patients recovered well after surgery, except one who died (2.22%). **Conclusions:** Patients who experience gun-shot injuries are statistically likely to be young. The accurate diagnosis of associated injuries and aggressive management resulted in good prognosis.

Key words: gun-shot injury, thoracic trauma, treatment

Abbreviations: GSI, gun-shot injury, VATS, video-assisted thoracoscopic surgery

INTRODUCTION

The incidence of gun-shot injuries (GSIs) is increasing throughout the world. There is strong evidence of a link between firearm-related offences and the trade in illegal guns, gang culture, and areas with higher than average levels of deprivation and unemployment.¹ International evidence suggests a close correlation between gun ownership and rates of homicide or suicide.² Gun deaths disproportionately affect males and young people.³ In an analysis of the locations of GSIs, the extremities occurred frequently. However, thoracic GSIs resulted in a

high mortality rate.⁴ Most penetrating injuries to the chest can be managed with a tube thoracostomy, but 10%–15% of patients who present with thoracic trauma require definitive repair.⁵ However, a large proportion of firearm injuries require a variety of surgical skills, which can be challenging for even the most experienced surgeon.⁶ Here, we report the management of thoracic GSI patients in our hospital.

PATIENTS AND METHODS

We retrospectively reviewed the records of 285 patients who presented to our Emergency Department with GSIs between January 1995 and 2010. All these patients were initially successfully resuscitated and subsequently managed by the on-call trauma team. Patients with thoracic GSI were included. The definition of thoracic GSIs is based on the location of inlet of bullet. The exclusion criterion for the study was patient death on arrival at the hospital. We retrospectively reviewed the demographic (mechanism of injury, sex, age), physiological, and outcome data for all patients. We analyzed the demographic

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Table 1 Locations of GSIs in 285 patients

Head and neck	52	18.25%
Chest	45	17.79%
Abdomen	65	22.80%
Extremities	113	39.65%
Total	285	100%

Table 2 Age ranges of thoracic GSI patients grouped into 10-year categories

Age group (yrs)	Number of patients	Percentage (%)
11–20	2	4.44
21–30	34	75.56
31–40	5	11.11
> 40	4	8.89
Total	45	100

Table 3 Type of firearm used in thoracic GSI

Weapons	Perforation	Penetrating	Total
Rifle	24	7	31
Handgun	3	5	8
Carbine	1	0	1
Machine gun	1	1	2
Unknown	0	3	3
Total	29	16	45

data, including age, sex, gun used, and location of injury, and the surgical indication, type of surgery, associated injuries, and outcome in the thoracic GSI patients.

All these patients were followed-up at the Outpatient Department every three months for two years.

RESULTS

We reviewed 285 GSI patients, among whom the extremities were the most common sites of GSI. Forty-five patients (17.79%) had thoracic GSIs (Table 1). The mean age of patients with thoracic GSIs was 24.56 years, with a median age range of 21–25 years (Table 2). The types of guns used in the attacks were described either by the patients or by witnesses to the event. The most common type of weapon was a rifle (68.89%), followed by a handgun (17.78%) (Table 3). Of these 45 thoracic GSI patients, 19 patients (42.22%) had attempted suicide and 13 patients (28.89%) were the victims of attempted homicide. The most common imaging finding on chest roentgenograms of these GSI patients in the Emergency Department was haemopneumothorax (75.56%), fol-

Table 4 Chest roentgenograms results for patients with thoracic GSI

	Number of patients	Percentage (%)
Haemopneumothorax	31	75.56
Rib fracture	14	31.11
Intrapulmonary haemorrhage	14	31.11
Haemothorax	10	22.22
Scapular fracture	9	20.00
Subcutaneous emphysema	6	13.33
Clavicle fracture	1	2.22
Abscess formation	1	2.22
No significant finding	2	4.44

Table 5 Indications for thoracotomy in 21 thoracic GSI patients

	Number of patients	Percentage (%)
Persistent bleeding	10	47.62
Bleeding with hypovolemic shock	3	14.29
Fibrothorax and retained bullet near the diaphragm	4	19.05
Fibrothorax and unevacuated clotted haemothorax	1	4.76
Retained bullet near the spine	1	4.76
Retained bullet in bronchus with abscess formation	1	4.76
Open Pneumothorax	1	4.76
Total	21	100

lowed by pulmonary haemorrhage (31.11%) and rib fracture (31.11%). One patient developed a lung abscess in the right upper lobe bronchus seven years after GSI, resulting from the retained bullet (Table 4). The indications for surgery included persistent bleeding (47.62%), hypovolemic shock (14.29%), and fibrothorax with unevacuated clotted haemothorax (19.05%) (Table 5). Nineteen patients (42.22%) underwent a simple tube thoracostomy, 15 patients (33.33%) a thoracotomy, four patients (8.88%) a thoracotomy combined with laparotomy, and one patient (2.22%) a thoracostomy with a thoracoabdominal approach. One of these patients underwent video-assisted thoracoscopic surgery (VATS) with wedge resection of the lung for penetration of the lung parenchyma (Table 6). Three patients (6.67%) underwent an emergency thoracotomy: one patient for right ventricle repair and lung parenchyma repair; one patient for lobectomy, ligation of the dorsal scapular artery, and repair of the subclavian

Table 6 Surgical intervention in 45 GSI patients

Surgery	Number of patients	Percentage (%)
Tube thoracostomy	19	42.22
Exploratory thoracotomy	15	33.33
Thoracotomy + laparotomy	4	8.88
Thoracoabdominal approach	1	2.22
Laparotomy + thoracostomy	3	6.67
VATS	1	2.22
Other	2	4.44
Total	45	100

Table 7 Time of operation and detailed surgical approach in thoracic GSI patients

	Number of patients	Percentage (%)
Emergency thoracotomy	3	6.67
Repair of lung parenchyma and repair of RV	1	
Lobectomy (ligation of DSA + repair of SCA)	1	
Wedge resection	1	
Early thoracotomy	13	28.89
Repair of lung parenchyma	10	
Lobectomy	1	
Transposition of muscle and wound debridement	1	
Removal of bullet	1	
Delayed thoracotomy	5	11.11
Lobectomy	1	
Repair of lung parenchyma	1	
Removal of bullet and decortication	2	
Removal of blood clot and decortication	1	
Total	21	46.67

RV: Right ventricle; DSA: Dorsal scapular artery; SCA: Subclavicular artery

Emergency thoracostomy: operation immediately; Early thoracotomy: operation within 24-72 hours; Delayed thoracotomy: operation after 72 hours

artery; and one patient for wedge resection of the lung (Table 7). Thirteen patients (28.89%) underwent an early thoracotomy (less than 24 h after the injury) and five patients (11.11%) underwent a delayed thoracotomy (Table 7). Seventeen patients (37.78%) had associated abdominal injuries. The most common associated abdominal injury was diaphragm injury (nine patients), followed by

Table 8 Abdominal injuries associated with thoracic GSI

Organ	Number of patients	Percentage (%)
Diaphragm	9	20
Stomach	4	8.88
Spleen	5	11.11
Liver	3	6.67
Colon	2	4.44
Total	23	

spleen damage (five patients) (Table 8). The cause of the one case of intraoperative mortality was systemic air emboli from high ventilation pressure when a thoracotomy was performed for injured lung parenchyma. All patients recovered well after the operation, except one patient who died (2.22%).

DISCUSSION

GSI is not only a health issue but also a public issue, as the rate of illegal gun ownership increases. The most common penetrating thoracic injuries caused by firearms include pulmonary disruption with contusion, haemothorax or pneumothorax, and chest wall damage. Most penetrating thoracic injuries can be managed with simple procedures, but 10%–15% of patients who present with thoracic trauma require surgery and the vast majority of these have sustained a penetrating injury.^{5,7} A thoracotomy performed within the first few hours of injury is considered an urgent thoracotomy.⁸ The indications for urgent thoracotomy include the presence of cardiac tamponade, high chest tube output, persistent air leak, and evidence of injury to a greater vessel.^{9,10} Many authors have reported an initial chest tube drainage volume of 1500 mL as warranting mandatory chest exploration¹¹⁻¹³, whereas others suggest that the volume of blood loss via the chest tube is an unreliable indicator of the severity of chest trauma.^{8,14}

Gun-shot wounds can traverse multiple structures and are more complex than stab wounds. Most stab wound incisions are treated with an antero-lateral thoracotomy, whereas gun-shot wounds are treated with a posterolateral thoracotomy. An antero-lateral thoracotomy is suitable for most cardiac injuries.¹⁴ Penetrating wounds to the heart can be repaired with a median sternotomy or anterior thoracotomy. A sternotomy allows better exposure to right-sided cardiac structures and the right hilum, and permits the cannulation for cardiopulmonary bypass if this is required for the repair. If there is concern for

concomitant injuries, then a left thoracotomy may be preferable.¹⁵

In cases of deep central injury, bleeding from central pulmonary vessels of moderate size may be uncontrollable, and blood may flood the alveoli in the segment, lobe, or entire lung. This can lead to internal blood aspiration in the damaged parenchyma, with consequent reductions in alveolar membrane diffusion and compliance. This results in worsening atelectasis, intrapulmonary shunting, and hypoxemia, which roughly parallel the extent of parenchymal involvement in a pulmonary contusion. Deep central injuries to the lung predispose communication between the airways and the pulmonary venous plexus. When the ventilation pressure exceeds 60 mmHg, a pulmonary venous air embolism may occur, allowing air into the coronary arteries and cerebral vessels.¹⁶ In our series, one patient died during surgery. Air emboli from a deep laceration of the lung parenchyma, accompanied by positive pressure mechanical ventilation, was the possible cause of death. Rapid control of the injured parenchyma or hilar vessel could avoid mortality.

Overall, 6% of penetrating thoracic trauma victims require some degree of pulmonary parenchymal resection.^{13,17,18} The higher mortality associated with a lobectomy or pneumonectomy after traumatic lung injury has prompted the development of quicker and less extensive resection techniques.¹⁹⁻²¹ Among our patients, 35.56% required some pulmonary parenchymal procedure at thoracotomy, which is consistent with the incidence of 40% reported in the literature.²² Repair of the lung parenchyma (75%) and lobectomy (18.75%) were used for their management. In our study, three patients underwent lobectomy for management, and one patient underwent wedge resection. The type of procedure did not affect the mortality rate. The mortality rate for thoracic GSI is 13.8%¹⁴, whereas our mortality rate was 2.22%. Hirshberg *et al.*²³ reported a 41% mortality rate in 82 patients who required combined laparotomy and thoracotomy. An increase in mortality from 5.3% to 26.3% in patients with associated abdominal injuries should alert trauma surgeons to the complexity of penetrating injuries to the chest, and the need for flexibility and surgical creativity in their management.¹⁴ In our study, four patients underwent thoracotomy combined with laparotomy, and one of these patients was treated with a thoracoabdominal approach because of associated abdominal injury.

In our study, one patient underwent VATS with wedge resection of the lung parenchyma in response to haemothorax after thoracic GSI. His postoperative recovery was uneventful. Improvements in instrumentation, espe-

cially endoscopic surgical techniques, have expanded the indications for VATS in the diagnosis and treatment of diseases within the chest. Although VATS may be a reasonable alternative to a standard thoracotomy in selected stable patients²⁴, the use of VATS in trauma patients remains controversial because a relatively stable thoracic trauma patient may become extremely unstable at any moment, necessitating an immediate thoracotomy. VATS is an accurate, safe, and reliable operative technique for lung trauma complications, including posttraumatic pleural collections⁹, and may be an alternative modality for the evaluation of isolated diaphragmatic lacerations resulting from penetrating wounds.

The limitation of this retrospective study is heterogeneous group of patient source, including acute and chronic status, Team work and aggressive surgical intervention may play the role in management of thoracic GSI. Patients with thoracic gun-shot injury were included, but patients who died before admission were excluded). It is the possible reason why lower mortality in our series.

CONCLUSION

Patients who experience GSIs are statistically likely to be young. The accurate diagnosis of associated injuries and aggressive management resulted in lower mortality rate.

DISCLOSURE

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