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Penetrating Chest Injuries: Unusually High Incidence of High-velocity Gunshot Wounds in Civilian Practice

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Abstract. Penetrating chest injuries are a challenge to the thoracic or trauma surgeon. Penetrating thoracic trauma, especially that due to high-velocity gunshot wounds, is increasing at an alarming rate in our region. We report our experience with penetrating chest injuries mainly due to high-velocity gunshot wounds. During a period of 6 years we retrospectively reviewed the hospital records of 755 patients admitted to the Department of Thoracic and Cardiovascular Surgery, Dicle University School of Medicine, with the diagnosis of penetrating thoracic trauma. The mean age was 27.48 years, and 89.8% were male. The causes of penetrating injury were stab wounds in 45.3% and gunshot wounds in 54.7%. About 30% of the wounds were due to high-velocity gunshots; and among the gunshot wounds 56.2% were due to high-velocity shots. The most common thoracic injury was hemothorax ($n = 190$) followed by hemopneumothorax ($n = 184$). Isolated thoracic injuries were found in 53% of the patients. Nonoperative management was sufficient in 92% of the patients. Thoracotomy was performed in 8.1%. The mean duration of hospitalization was 11.2 days. The mean injury severity score (ISS) was 20.17 ± 13.87. The morbidity was 23.3% and the mortality 5.6%. Fifty percent of all deaths were due to adult respiratory distress syndrome. Altogether 17% of patients with an ISS >25 died, whereas only 0.9% of those with a score <16 died. The mortality due to firearms was 8.95%. We concluded that in civilian practice chest tube thoracostomy remains by far the most common method of treating penetrating injury to the chest. The easy availability of high-velocity guns will continue to increase the number of civilians injured by these weapons.

Thoracic injuries continue to be one of the most common reasons patients seek emergency medical care [1]. Penetrating wounds to the chest in civilian practice result mainly from gunshot or stab wounds [2]. The experience of many civilian centers continues to support the use of chest tube thoracostomy as the primary treatment of nonmediastinal chest injury with a low incidence of thoracotomy [2–6]. The mortality rate of isolated chest injuries is in the range of 4% to 12% but increases to 13% to 15% when another system is involved and to 30% to 35% when two or more systems are involved [7].

Because of the easy availability of hand guns and high-velocity guns, especially in rural settings of southeastern Turkey, the incidence of gunshot wounds of the chest has continued to rise at an alarming rate. Herein we report our experience with penetrating chest injuries mainly due to high-velocity gunshot wounds from southeastern Turkey.

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Materials and Methods

Dicle University Medical School Research Hospital serves people who live in 13 cities throughout the southeastern and eastern regions of Turkey. Most of the trauma patients are transferred to this center for their final diagnosis and treatment. The incidence of high-velocity gunshot wounds continue to rise at an alarming rate in this region (Fig. 1). Table 1 lists the most commonly used high-velocity firearms in our region [8].

Between January 1989 and December 1994 a total of 755 patients with penetrating chest injuries were hospitalized through the Department of Thoracic and Cardiovascular Surgery, Dicle University School of Medicine. The hospital records of these patients were reviewed retrospectively. Clinical data included age, sex, type of injury, associated injuries, management, length of hospital stay (LOS), morbidity, and mortality. An injury severity score (ISS) [9] was calculated for each patient. The relation between the ISS and mortality was evaluated.

All patients were initially seen at the emergency service by one of our thoracic surgery residents. After the initial physical examination and the stabilization of vital signs, chest radiographs were obtained for all patients. Consultation with other surgical departments was undertaken if required. Tube thoracostomy, if indicated, was performed in the emergency department, and the patient was then transferred either to our clinic or to the operating room according to his or her clinical status.

Prophylactic antibiotics were used in all patients. Those with stab wounds had a combination of penicillin and gentamicin or cephalosporin and gentamicin. For those with gunshot wounds, we used a combination of ceftriaxone, amikacin, and ornidazole.

Results

Of the 755 patients with penetrating chest injuries, 678 (89.8%) were male and 77 (10.2%) were female. The mean age was 27.48 ± 12.09 years (range 3–80 years).

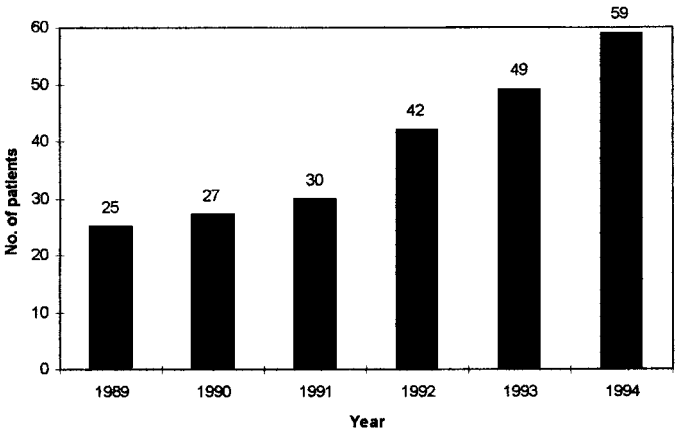

Fig. 1. Increasing incidence of high velocity gunshot wounds according to years.

Table 1. Commonly used high-velocity firearms in our region.

Brand	Missile diameter (mm)	Energy (joule)	Velocity (m/s)	Cyclic rate of fire[a]
Iraq				
Spiner-Tabuk	7.62 × 39	1993	740	30
AL Kadisa	7.62 × 54	4008	830	30
Short-Tabuk	7.62 × 39	1993	670	580
Tabuk	5.56 × 45	1789	700–710	600 + 60
USA				
M-16 A2	5.56 × 45	1789	1000	800
Carbine	5.56 × 45	1789	850	906
China				
Type 56 carbine	7.62 × 39	1993	710	600
Hungary				
AMD 65	7.62 × 39	1993	700	600
Russia				
Simonovshs	7.62 × 39	1993	735	?
Kalashnikov AK-47	7.62 × 39	1993	710	600
Kalashnikov AKM	7.62 × 39	1993	715	600
Dragunov SVP	7.62 × 54	4008	830	?
PK	7.62 × 54	4008	825	690–720
Spain				
MG-3	7.62 × 51	3276	820	700
Greece				
MG-3	7.62 × 51	3276	820	700

[a]In rounds per meter.

Table 2. Thoracic injuries in 755 patients.

Injury	No.
Hemothorax	190
Hemopneumothorax	184
Pneumothorax	144
Diaphragmatic rupture	121
Open hemopneumothorax	95
Pulmonary contusion	50
Open pneumothorax	24
Rib fracture	
< 2	16
> 2	13
Subcutaneous emphysema	14
Bilateral pneumothorax	9
Open bilateral hemopneumothorax	13
Pneumomediastinum	6
Thoracic wall lacerations	4
Bilateral hemopneumothorax	3
Open bilateral pneumothorax	3
Sternal fracture	3
Bilateral diaphragmatic rupture	2

The causes of penetrating injuries were stab wounds (n = 342, 45.3%), high-velocity gunshot wounds (n = 232, 30.7%), low-velocity gunshot wounds (n = 139, 18.4%), bomb injury (n = 21, 2.8%), and shotgun wounds (n = 21, 2.8%).

Altogether 400 (53%) patients had isolated thoracic injuries (Table 2). Hemothorax (n = 190) was the most common thoracic injury, followed by hemopneumothorax (n = 184). Of the remaining 355 patients (47%), 155 had one, 88 had two, 63 had three, and 49 had four associated injuries (Table 3). Neurologic sequelae were present in 28 patients: paraplegia in 18, quadriplegia in 3, and brachial plexus injury in 7. Only one patient with a brachial plexus injury had residual paresis, whereas the others had permanent sequelae.

In 583 patients there were more than single thoracic injury diagnoses. Tube thoracostomy alone was required in 459 (60.8%) patients, which was the most common treatment modality in this series (Table 4). Thoracotomy (18 immediate, 43 delayed) was performed in 61 (8.1%) patients. Of 43 delayed thoracotomies, 34 were due to intrathoracic hematoma that resulted from inappropriate chest tube drainage. In the remaining 9 patients decortication was performed because of empyema thoracis. Eight of those patients had laparotomy performed by the general surgery department on admission. Immediate thoracotomy was performed in 18 patients. The surgical diagnosis was intercostal artery injury in eight, internal mammary artery injury in three, cardiac injury in two, descending aortic rupture in two, and bleeding from lung laceration in three. In one of these three patients with lung laceration, right upper lobectomy was performed because of severe destruction in the lobe.

Delayed hemothorax developed in 9 of 54 (16.7%) patients between 6 and 72 hours. Chest tube drainage was sufficient for successful treatment in these patients.

For the whole group, the mean length of hospital stay (LOS) was 11.2 days (range 1–134 days). The mean ISS was 20.17 ± 13.87 (range 1–75): 436 had an ISS <16, another 127 had a score between 17 and 25, and 192 had a score >25.

The morbidity rate in this series was 23.3% (176/755). The most common complications were septic problems (n = 69), atelectasis (n = 34), and intrathoracic hematoma (n = 34), followed by adult respiratory distress syndrome (ARDS) (n = 31) (Table 5).

Our mortality rate was 5.6% (42/755); 21 were due to ARDS, 14 to multiple organ failure (MOF), 1 to cerebral herniation, and 3 to acute myocardial infarction. Two patients died intraoperatively (aortic rupture). In the remaining patient the cause of death could not be determined. Among the group, 4 of 436 patients (0.9%) with an ISS <16 died; 5 of 127 patients (3.9%) with an ISS between 17 and 25 died; and 33 of 192 patients (17.2%) with a score >25 died. The mortality rate according to the type of injury was as follows: stab wounds 1.46% (5/342); low-velocity gunshot wounds 2.87% (4/139); high-velocity gunshot wounds 11.6% (27/232); bomb injuries 19% (4 of 21); and shotgun wounds 9.5% (2/21). The overall mortality due to firearms was 8.95% (37/413). Mortality rates according to type of treatment were as follows: tube thoracostomy 3.7% (17/459); tube thoracostomy and lapa-

Table 3. Associated injuries.

Intraabdominal		Orthopedic		Cardiovascular		Nervous system	
Type of injury	No.	Type of injury	No.	Type of injury	No.	Type of injury	No.
Liver	87	Radius fracture	12	Hemorrhage		GCS (8–10)	1
Colon	54	Ulna fracture	7	40–50%	24	GCS (5–7)	4
Stomach	52	Humerus fracture	5	20–30%	57	GCS (3–4)	1
Spleen	42	Clavicle fracture	7	10–20%	14	Subarachnoid hemorrhage	1
Small bowel	32	Scapula fracture	6	Arteria brachialis	1	Cranial fracture	1
Kidney	24	Metacarpal fracture	5	Arteria radialis	4	Spinal cord	
Pancreas	15	Traumatic upper extremity	3	Arteria femoralis	2	Paraplegia	18
Retroperitoneal hematoma	15	Pelvic fracture	2	Thoracic aorta	2	Quadriplegia	3
Gallbladder		Femur fracture	10	Vena jugularis interna	21	Plexus brachialis	7
Rectum	8	Tibia fracture	7	Arteria vertebralis	5	Nervous opticus injury	
Duodenum	4	Fibula fracture	3	Cardiac injury	2		
Esophagus	3	Thoracic vertebra fracture	19	Pericardial injury	4		
Urinary bladder	2	Lumbar vertebra fracture	2				
Ureter	2	Cervical vertebra fracture	7				
Intraabdominal vascular	1						
Arteria, vena	10						
mesenterica superior	2						
Arteria hepatica	1						
Vena porta	1						
Arteria, vena lienalis	1						
Vena cava inferior	5						

GCS: Glasgow Coma Scale.

Table 4. Type of treatment for 755 patients.

Treatment	Total no.	%
Tube thoracostomy	459	60.8
Tube thoracostomy and laparotomy	171	22.6
Thoracotomy	61	8.1
Immediate	18[a]	
Delayed	43[b]	
Observation[c]	54	7.2
Pericardiocentesis	3	0.4
Tracheal repair	5	0.6
Thoracentesis	2	0.3

[a]In 5 of these patients, thoracotomy and laparotomy.
[b]In 8 patients laparotomy was performed as an initial surgical treatment.
[c]In 9 of these patients delayed hemothorax developed.

Table 5. Morbidity in 176 patients.

Morbid condition	No.
Atelectasis	34
Intrathoracic hematoma	34
ARDS	31
Septic complications	69
Wound infection	28
Empyema	25
Pneumonia	9
Sepsis	6
Mediastinitis	1
Intraabdominal complications	24
Gastrointestinal system fistula	6
Gastrointestinal hemorrhage	3
Abscess	2
Bridge ileus	1
Pleural effusion	12
Multiple organ failure syndrome	14
Disseminated intravascular coagulation	5
Bronchopleural fistula	3
Recurrent pneumothorax	3
Acute renal failure	4
Pulmonary embolism	4
Cerebral herniation	1

rotomy 12.9% (22/171); immediate thoracotomy 11.1% (2/18); delayed thoracotomy 2.3% (1/43).

Discussion

The severity of, and approach to, penetrating chest trauma depends on the offending weapon and the energy involved [10]. Knife wounds are uncontrolled surgical events that may cause hemopneumothorax, hemoptysis, and direct injury to other intrathoracic structures. Small-caliber handgun injuries are characterized by much less primary tissue destruction than wounds caused by hunting or military weapons [10].

Thoracic surgeons generally agree that most patients with penetrating wounds of the chest can be managed successfully without operation [2–6, 11–15]. The proportion of those who can be treated without operation has been reported to vary from 62.1% to 91.4% [2–6, 13]. In our series, nonoperative treatment of penetrating chest injuries was successful in 92%. In a series by Zakharia [16], who reported the experience in the Lebanon war, definitive tube thoracostomy was required in 29% of 1992 patients, and 71% underwent thoracotomy.

The incidence of patients with penetrating chest injuries requiring thoracotomy constitute 5.8% to 71.0% in the literature of all patients [2, 6, 11–18]. Thoracotomy was required in 8.1% of our patients. The highest ratio, reported by Zakharia [16], was the experience of thoracic battle injuries in the Lebanon war, which reflected massive wounds of the chest (the mechanism of injury was mainly high-velocity missiles and shelling in urban battles). In our series about one-third of the injuries (56.2% among gunshot

injuries) were due to high-velocity gunshot wounds with a surprisingly low incidence of operative management. This low incidence is attributable to the absence or limited number of great vessel, bronchial, esophageal, and cardiac injuries. In our opinion, patients with such injuries die at the scene or en route to the hospital. The transportation system and initial management on the way to hospital is not as developed as in other countries, especially in our region compared to other regions of Turkey.

The mortality rate for gunshot wound of the chest varies from 14.3% to 36.8% [5]. Mandal and Oparah [5], reported a mortality rate of 24.5% for their patients with gunshot wound of the heart and 11.5% for those with stab wounds. Their mortality rate for noncardiac penetrating chest injury was 1.3% for gunshot wounds and 0.4% for stab wounds. Their overall mortality was 2.4%, with 1.3% for gunshot wounds and 3.8% for gunshot wounds. Zakharia [15] reported a mortality rate of 1.2% for all 1251 thoracic patients excluding those with great vessel injury. His reported mortality for open thoracotomy excluding great vessel injuries was 1.7% and including vessel injuries 3.1%. The lowest mortality (0.7%) was among the 570 patients treated by tube thoracostomy [16]. Robinson et al. [2] reported a mortality rate of 2.3% for all thoracic injuries, with 0.7% of those treated with chest tube alone. In our series the overall mortality was 5.6%, with 1.46% for stab wounds and 8.95% for gunshot wounds. For those with high-velocity gunshot wounds it was 11.6% and for bomb injuries 19%.

Excluding two patients with cardiac injuries who had been stabbed, this series was entirely constituted of noncardiac penetrating chest injury cases. Our mortality for stab wounds was three times greater, and for gunshot wounds nine times greater, than that of Mandal and Oparah's [5] series. Our overall mortality rate is also higher than that in other reports [2, 5, 16]. The cause of mortality was ARDS in 50% of the patients. This mortality rate is attributable to a lack of ventilator therapy and intensive care conditions. Improvement in surgical intensive care conditions and ventilator therapy may decrease our mortality rate in coming years.

Conclusions

The occurrence of high-velocity gunshot wounds among our penetrating trauma patients is 30.7% and among all gunshot wound injuries 56.2%. These figures represent a high incidence in civilian life. Thoracotomy was required in 8.1% of the cases, and this low incidence is attributable to the absence or limited number of cardiac and great vessel injuries. Our overall mortality rate was 5.6%. Mortality due to stab wounds was 1.46% and for high-velocity gunshot wounds 11.6%. Delayed hemothorax developed within 6 to 72 hours of the observation period in 16.6% of the patients. Thus to treat delayed hemothorax or pneumothorax on time, the observation period for penetrating chest injuries, especially gunshot wounds, should not be less than 72 hours.

Résumé

Objectif: Les lésions pénétrantes du thorax sont un «challenge» pour les chirurgiens. Le taux des traumatismes pénétrants, surtout en rapport avec des fusils d'assaut augmente à une allure alarmante dans nos régions. Nous rapportons ici notre expérience des plaies thoraciques pénétrantes en rapport avec des fusils d'assaut. Méthodes Pendant une période de six ans, nous avons revus les dossiers de 755 patients, admis avec le diagnostic de traumatisme thoracique pénétrant dans le département de Chirurgie thoracique et cardio-vasculaire de l'Ecole de Médecine de l'Université de Dicle. Résultats: L'âge moyen des patients était de 27.48 ans et 89.8% étaient des hommes. La plaie était en rapport avec une arme blanche dans 45.3% des cas et avec une arme à feu dans 54.7%. Environ 30% au total étaient en rapport avec des fusils d'assaut; cependant, parmi les plaies par arme à feu, ce taux a été de 56.2%. Les lésions les plus fréquentes ont été l'hémothorax (n = 190), suivi d'hémopneumothorax (n = 184). La lésion thoracique était isolée chez 53% des patients. Le traitement non-opératoire a été un succès chez 92% des patients alors que la thoracotomie a été nécessaire dans 8,1% des cas. La durée moyenne d'hospitalisation a été de 11,2 jours. L'ISS moyen a été de 20,17 + 13,87. Le taux de morbidité a été de 23.3%. Le taux de mortalité a été de 5,6%, 50% de ces décès en rapport avec un syndrome de détresse respiratoire de l'adulte. Dix-sept pourcent des patients ayant un score ISS supérieur à 25 sont décédés, alors que seulement 0,9% des patients ayant un score inférieur à 17 sont décédés. La mortalité en rapport avec des armes à feu a été de 8.95%. Conclusion: En pratique civile, l'insertion d'un tube de drainage thoracique reste le geste le plus fréquemment pratiqué pour plaie pénétrante du thorax. Le nombre de victimes civiles par fusils d'assaut ne cesse de croître en raison de la disponibilitè de plus en plus grande à ce type d'arme.

Resumen

Objetivo: Las heridas penetrantes del tórax constituyen un serio desafío para el cirujano de tórax. El trauma penetrante del tórax por heridas por armas de fuego, especialmente por las de alta velocidad, está aumentando a una tasa alarmante en nuestra región. Queremos informar nuestra experiencia con esta clase de heridas. Métodos: Se hizo la revisión retrospectiva de las historias clínicas de 755 pacientes admitidos al Departamento de Cirugía Torácica y Cardiovascular de la Universidad de Dicle con el diagnóstico de trauma penetrante del tórax en un periodo de 6 años. Resultados: La edad promedio fue 27.48 años y 89.8% eran hombres. Las causas de la lesión penetrante fueron heridas por arma blanca en el 45.3%, y por arma de fuego en 54.7%. Aproximadamente 30% del grupo total se debió a heridas por arma de fuego de alta velocidad, pero en el subgrupo de las heridas por arma de fuego, esta causa representó el 56.2%. La lesión torácica más común fue el hemotórax (190), seguida del hemoneumotórax (184). Se encontraron lesiones torácicas aisladas en 53% de los pacientes. El manejo no operatorio fue suficiente en el 92% de los casos; se practicó toracotomía en 8.1%. la duración promedio de la hospitalización fue 11.2 días. El índice promedio de gravedad (injury severity score, ISS) fue 20.17 ± 13.87. Las tasa de morbilidad y mortalidad fueron 23.3% y 5.6% respectivamente. El síndrome de dificultad respiratoria del adulto causó el 50% de todas las muertes. El 17% de los pacientes con un ISS mayor a 25, falleció, mientras que sólo el 0.9% de aquellos con ISS menor de 16, fallecieron. La mortalidad por armas de fuego fue 8.95%. Conclusión: En la práctica civil la toracostomía de tubo sigue siendo, con amplitud, el método más común de tratamiento de las lesiones penetrantes del tórax. La facilidad en disponer de armas de fuego de alta velocidad habrá de incrementar continuamente el número de personas lesionadas por este tipo de armas.

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Invited Commentary

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This paper reports on the epidemiology of penetrating chest wounds as seen in southeastern Turkey during the early part of this decade. The authors found that wounds made by high-velocity bullets have become common and account for more than half of the patients admitted with penetrating missile wounds of the chest. Hospital mortality in these patients was about one in ten, and by far the most common therapeutic intervention was insertion of a chest tube. In fact, only 8.1% of admissions required a thoracotomy. When thoracotomy was performed, the most common indications were for evacuation of a clotted or infected hemothorax or control of bleeding from a lacerated vessel in the chest wall. Operation for repair of a thoracic visceral injury was uncommon.

The central theme of this paper is the prevalence and management of "high-velocity" bullet wounds of the chest. Is there something special about injuries made by high-velocity missiles? Certainly high velocity means higher kinetic energy and the *potential* for greater energy transfer, which if realized means greater tissue damage and higher mortality and morbidity. One fact reported here that lends credence to the view that velocity is important is the observed difference between the hospital mortality for low- and high-velocity wounds: 2.9% and 11.6%, respectively.

Knowledge of the likelihood that a thoracotomy is necessary is of practical importance to the surgeon caring for a patient with a gunshot wound of the chest. The low prevalence of thoracotomies in this series is in keeping with the historical norm for military surgery (20% or less); however, it is very much less than that reported by Zakharia in the papers describing his remarkable experience in Beirut (71%).

How can such a huge difference be explained? The authors of this paper state the obvious reason: Whereas Zakharia was situated in the center of a war zone and operated on patients within minutes of wounding, the Turkish patient population did not present until hours to days after being wounded. It is probable that most of the Turkish victims of gunshot wounds of the chest who might have benefited from thoracotomy died before they could be hospitalized.

The authors do not tell us what percentage of those who had died prior to hospitalization had gunshot wounds of the chest. However, the U.S. Army's Vietnam War experience indicates that if only bullet wounds are considered (almost all of which were made by assault rifles or machine guns), *four-fifths* of all chest casualties either were killed in action or died of their wounds. Thus it seems certain that the overall prevalence of high-velocity bullet wounds of the chest is much greater than that reported by the authors.

It is also probable that more rapid evacuation would not only have increased the percentage of patients requiring thoracotomy but would also have changed the indications for operation. I suspect that control of exsanguinating hemorrhage from mediastinal viscera would be more common. Similarly, there will probably be more pulmonary resections to control massive air leaks and shunting from lung parenchymal injury caused by cavitation resulting from high-velocity bullets. There is anecdotal evidence from the U.S. Army's experience in the Persian Gulf War that supports this view.