Trauma to the Thoracic Cage – An Autopsy Study

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Abstract

Background: Injuries of the chest causing disruption of the thoracic cage are increasing daily. Thoracic cage may be injured due to blunt trauma like blows, compression of chest or grinding force of automobile run over or due to penetrating injuries.

Method: This study analysed the pattern of injury thoracic cage in victims in trauma. 250 cases brought to a tertiary care institution for autopsy were studied from 1st January 2005 to 30th November 2005(1st July 2005-30th November prospectively, and 1st January-30th June 2005, retrospectively). A cross sectional study design including all cases of trauma to the thorax and heart with consecutive sampling was done. Data was collected in pro forma and analysed.

Results: 206 victims were males. 130 (52%) were victims of road traffic accidents Pedestrians constituted the majority (26.4%). External injuries were not found in 67 cases (26.8%). Involvement of rib alone constituted 93 cases (37.2 %) followed by combination of rib and lung 54 cases (21.6 %), rib and sternum 13 cases (5.2%), sternum and lung 12 cases (4.8 %) and combination of various other organs occurred in 67 cases (26.8%). Simple fractures were the common rib injury in both sides. 34 cases (13.6%) with vertebral injuries were observed and 19 were associated with spinal cord injury.

Conclusions: There is little that the autopsy surgeon can contribute to elucidate the factors leading to accidental deaths. Multiple regression is useful to correlate between predictor and outcome variables. Hopefully, future research will improve the methodology to predict the outcome of trauma to thoracic cage accurately.

Keywords*: fracture, rib, vertebrae, sternum, injury, chest, trauma, death*

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Introduction

Anatomy of Thorax

The thorax (chest) is the region of the body between the neck and abdomen. The frame work of the walls of the thorax, the thoracic cage, is formed by the vertebral column behind, the ribs and intercostal spaces on either side, and sternum and costal cartilages in front. Superiorly the thorax communicates with the neck and inferiorly it is separated from the abdomen by the diaphragm. The thoracic cage protects the lungs and heart and affords attachments for the muscles of the

thorax, upper extremity, abdomen and back[1].

The thoracic wall is covered on the outside by skin and muscles and lined inside with parietal pleura[1]. It is formed posteriorly by the thoracic part of the vertebral column, anteriorly by the sternum and costal cartilages, laterally by the ribs and intercostal spaces, superiorly by the suprapleural membrane and inferiorly by the diaphragm[1,2,3]. The sternum, a flat bone which lies in the middle of the anterior thoracic wall, consists of manubrium sterni, body and xiphoid process[1,2,3,4]. The xiphisternal joint lies opposite the body of the ninth thoracic vertebra[5]. There are twelve pairs of ribs, each with a head, neck, tubercle and body (shaft). Each one articulates posteriorly with the vertebral column. Thoracic vertebrae are twelve in number and can be recognized by the presence of at least one articular facet on the body for articulation with their ribs[6].

Fracture of sternum is rare. The fragments either remain in position or the upper portion passes backwards behind the lower, and are liable to damage the viscera behind it. The driver may be thrown forward and strike the chest on the steering wheel or upper abdomen on the wheel rim or the horn boss may strike the sternum and produce a transverse fracture[4]. Fracture of sternum is seen as a result of deceleration on to seat belts[7].

The most common blunt thoracic injury in both adults and children are rib fractures[8,9,10]. Rarely a rib may be partly or completely cut by a stab or it may form a part of projectile in fire arm injury[11]. Markedly elastic ribs of a child may escape fracture[12,13,14]. In children and in young adults, the chest wall is very mobile as the calcification is incomplete, fatal injuries may be inflicted upon the heart, lung and great vessels, without any fracture to the rib cage or breast bone[15]. In infants especially victims of child abuse, rib fracture (knobbing fracture) are common[8,16]. Many of the fractures in indirect violence are oblique[11,17]. Fractures of the ribs occur in the regions of maximum stretch, hence anteroposterior compression of chest causes fractures at the necks and costochondral junctions[18].

Shoulder restraints are responsible for fracture of ribs, cervical spine, lumbar spine and sternum; skin and subcutaneous tissue injury and deep organ lesions of larynx, liver, spleen, kidney, major vessels and diaphragm[1,2,9,14,19].

A flail chest occurs when a segment of the chest wall does not have any bony continuity with the rest of the thoracic cage[20]. This condition usually results from automobile accidents. Flail chest results in independent and paradoxical movement of chest wall. Associated pain with restricted chest wall movement and underlying lung injury contribute to the patient's hypoxia[21]. External cardiac massage causes fracture at the costochondral junction, especially at the third to fourth ribs on the left side with minimum bruising[22,23].

Objectives

Primary Objective

To describe the pattern or profile of injury to thoracic cage.

Secondary objectives

1. To evaluate the nature and intensity of the injuries of sternum, ribs, vertebrae and spinal cord.

2. To analyse the medicolegal aspects of thoracic cage injuries.

Materials and Method

This study is part of a larger study including 250 cases of trauma to chest, which aimed at analyzing the pattern of injuries sustained to thorax following various types of trauma, with special reference to thoracic cage. 250 known dead bodies of both sexes with thoracic injuries brought for medicolegal autopsies to the mortuary of the Department of Forensic Medicine in a tertiary care institution were included in the present study. All cases from 1st July 2005 till 30th November were selected prospectively and from 1st January till 30th June 2005, retrospectively. Among the 250 cases, 236 were found to have thoracic cage injuries and have been included in this study. Descriptive study design was followed.

A meticulous external examination was made and details were entered in a proforma. Autopsy was conducted by modified Rokitansky's method of *in situ* dissection in part and *en masse* removal. All thoracic organs and bones were examined for injury and when present, details of injuries were recorded and photographed.

Observations

Of the 250 cases investigated, 67 (26.8%) did not have external injuries. Abrasion contributed 85 cases (34%), contusion 33 (13.2 %), lacerated wounds were rare (1; 0.4 %). Remaining 64 cases (25.6%) were a combination of various other injuries (Table 2). 45 cases showed sternal fracture (18%), of which 13(28.9%) were due to traffic accidents and 12(26.7%) were fall from height (Table 1). One (2.2%) incidence was due to cardiopulmonary resuscitation. The most vulnerable site of sternal fracture was found to be between manubrium and body of sternum (Table 3).

Fracture of rib was noted in 236 cases (94.4%). Majority were due to traffic accidents, in which 51 (21.6%) showed right side alone, 25 (10.6%) left side alone and 49 (20.7%) showed a bilateral involvement. Rib fracture was observed in fall from height in 46 (19.5%) cases, with right side in 15 (6.3%), left side 14 (5.9%) and bilateral in 17 (7.2%) cases. Cardiopulmonary resuscitation caused rib fracture in 3 (1.2%) cases and that was to the left side. Bilateral involvement of ribs was reported in 104 cases (41.6%). Involvement of right side alone was reported in 76 cases (30.4%) and that of left side was seen in 56 cases (22.4%). 14 cases (5.6%) did not have any fracture to the ribs.

129 cases (51.2%) had simple injuries to the right side and was the commonest type. Multiple injuries were reported in 34 cases (13.6%) followed by a combination of injuries in 16 (16.4%). Injury due to nick was reported in one case (Tables 3,4).

On the left side simple fracture is the commonest type of injury with 105 cases (42%). Multiple fractures occurred in 36 cases (14.4%). Both simple and multiple in 10 cases (4%). In 7 cases (2.8%) a cut or nick were noted. On the left side multiple site were affected in 32 cases (12.8%). Front aspect alone was affected in 30 (12%) and angle alone was affected in 17 cases (6.8%). In 52 (20.8%), single or other combinations of sites were noted. In 89 cases (35.6%) there was no fracture on the left side (Tables 3,4).

Regarding the total number of ribs affected in various types of injuries, the highest incidence is with 8 ribs, in 26 cases (10.4%) on right side and 20 cases (8%) on left side. Regarding the site, front aspect was found to be most vulnerable, in 38 cases (15.2%). Back aspect was affected in 34 (13.6%) and multiple sites were affected in 53 cases (21.2% %). 1st rib was injured in 64 cases on right side and 51 on left side. 16 cases and 10 cases on right and left sides showed whole ribs fractured. 3rd to 10th ribs showed maximum involvement (Table 13). 11th and 12th ribs seen fractured in 28 cases.

Thoracic vertebral injuries occurred in 34 cases (13.6%). Fractures of body T_5 and T_{10} occurred with equal frequency of 3 cases (1.2%). Fracture separation between T_2 and T_3 occurred in 5 cases and that between T_8 and T_9 in 4 cases. In 15 cases fractures occurred in other levels (Table 5). Spinal cord injuries were reported in 19 cases of which in 9 (3.6 %) were contusion, 2 laceration and transection in 8 cases (3.2 %) (Figure 1).

Table 1 Causes of Trauma to chest

Cause of Injury	No. of cases	Percentage
Traffic	130	52.0
Fall from height	46	18.4
Stab	10	4.0
Railway occurrence	27	10.8
Fall of heavy objects	11	4.4
Fall from Boat	3	1.2
CPR	4	1.6
Blow	3	1.2
Industrial Accident	1	0.4
Run over (Road)	5	2.0
Run over (Rail)	10	4.0
Total	250	100

Table 2 Showing Distribution of External Injuries

Injury	No. of Cases	Percentage
Abrasion	85	34
Contusion	33	13.2
Laceration	1	0.4
Combination of Injuries	64	25.6
No injury	67	26.8
Total	250	100

Table 3 Showing Distribution of site of Sternal Fractures

Site	Penetrating	Blunt Direct	Blunt Indirect	Total	%
No injury	9	179	17	205	
Manubrium / Body	1	13	0	14	82
1st -2nd	0	6	4	10	5.6
2nd- 3rd	0	6	2	8	4
3rd- 4th	1	4	1	6	3.2
4th- 5th	0	0	1	1	2.4
Man/body & 2nd- 3rd	0	1	0	1	0.4
Man/ body & 4th -5th	0	3	0	3	0.4
Fragmentation	0	2	0	2	1.2
					0.8
Total	**11**	**214**	**25**	**250**	**100**

Table 4 Distribution of Injuries to ribs and side affected

Side	Penetrating	Blunt direct	Blunt Indirect	Total	%
No injury	3	11	0	14	5.6
Right	0	69	7	76	30.4
Left	6	43	7	56	22.4
Bilateral	2	91	11	104	41.6
Total	11	214	25	250	100

Table 5 Distribution of Vertebral Injury

Site of fracture	Vertebral body fracture	Fracture between two vertebral	Multiple fracture	Total	%
T_3	1	0	0	1	0.4
T_5	3	0	0	3	1.2
T_{10}	1	0	0	1	.4

Cont... **Table 5 Distribution of Vertebral Injury**

T_{12}	3	0	0	3	1.2
T_2/T_3	0	5	0	5	2
T_8/T_9	0	4	0	4	1.6
Others	0	15	0	15	6.0
Multiple fracture	0	0	2	2	0.8
No Injury	0	0	0	216	86.4
Total	8	24	2	250	100

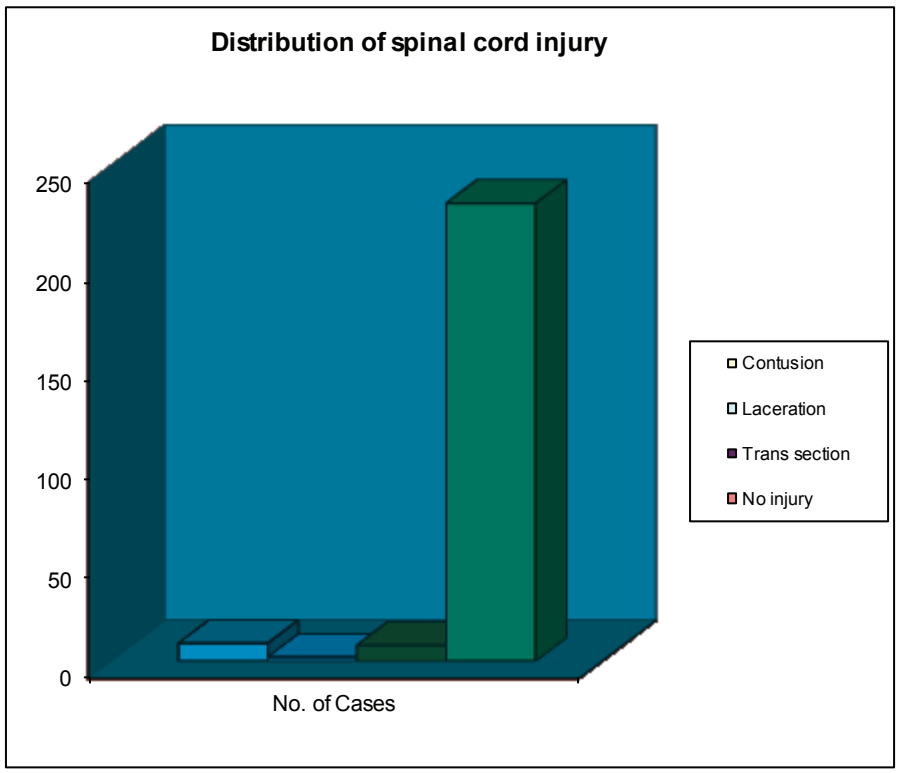

Figure 1 Distribution of spinal cord injury

Discussion

Motor vehicle accidents and fall from height account for 28.9% each of all sternal fractures in our studies. Ribs were the most commonly traumatized bone and injury to it was seen in 236 cases (94.4%) and our findings are in near agreement with the previous observation by Sudeshini (90.5%)[21]. It was found that direct violence caused rib fractures in majority of cases (203;81.2%) and blunt indirect violence caused injuries to ribs in 25 (10%) and penetrating injuries in 8 (3.2%).

Out of 130 cases of traffic accidents, 125 were reported with rib injury. In short, 96.14% of traffic incidences caused rib fractures as observed by Geetha (2001) who reported 96.1% rib fractures. 47 cases of fall from height were reported and 46 (97.87%) showed rib fractures (Sudeshini; 98 .05%)[14].

Of the 10 cases of stab injury, 7 (70%) were reported with rib fractures. Among 27 cases of railway occurrence, 26(96.3%) showed with rib fractures. All 3 cases with the history of fall from boat showed rib injury (100%).

All 3 cases with the history of CPR showed rib injury. Of 250 cases, 129 (51.6%) showed simple fractures at the right side and 105 (42%), on the left side. Multiple rib fractures were observed in 33 cases (13.2%) on the right side and 36 (14.4%) on the left. Combination of simple and multiple fractures were reported in 16 cases (6.4%) on the right side and 10 (4%) on the left. Among the penetrating injuries a cut on the rib on right side occurred in a single case and a similar injury on the left side occurred in 7 cases.

The common sites of fractures situated anteriorly, on the right side 33 cases (13.2%), left side 21 cases (8.4%) posteriorly on the right side with 32 cases (12.8%) and 26 cases (10.4%) on the left side, These prevalence of occurrence of rib fractures could be due to the higher incidence of traffic accidents with pedestrian involvement (50.7%). Rib fractures occurred on the outer aspects in 18 cases (7.2%) on the right side and 16 (6.4%) on the left, in agreement with Guharaj[5].

First rib was injured in 64 cases on right side and in 51 on left side. 11th and 12th ribs involved in 27 cases on right side and 19 cases on left side, the lower occurrence due to high mobility and yielding nature of the floating ribs[12,24]. Majority of rib fractures occurred through 3rd to 10th ribs, in 166 (66.4%) on right and 159 on left side (63.6%), which is in agreement with Tedeschi[12].

34 cases (13.6%) with vertebral injuries were observed and 19 were associated with spinal cord injury, contusion observed in 9 cases (3.6%) and transection in 8 cases (3.2%). The most common level of fracture of thoracic spinal column was between 2nd and 3rd vertebrae (2 %). Multiple fracture sites were obtained in 2 cases (0.8 %). In a previous investigation P. Rema (1988) reported commonest sites of injury as 3rd and 12th vertebrae with equal frequency[23].

Conclusions

1. External injuries were not found in 67 cases (26.8%). Subcutaneous emphysema was noted in 14 cases (5.6%),13 due to blunt injury and 1 due to penetrating injury.
2. One case (0.4 %) was reported with external injuries without any internal thoracic injury. Involvement of rib alone constituted 93 cases (37.2 %) followed by combination of rib and lung 54 (21.6 %), rib and sternum 13 (5.2%), sternum and lung 12 (4.8 %) & combination of various other organs occurred in 67 (26.8%).
3. Motor vehicle accidents and fall from heights account for 28.9% each of all sternal fractures.
4. Rib fractures were due to direct violence in majority of cases (203 cases; 81.2%) and blunt indirect violence in 25 cases (10%) and penetrating injury in 8 cases (3.2%).
5. Simple fractures were the common rib injury in both sides (51.6% in right and 42% in left side respectively).
6. 34 cases (13.6%) with vertebral injuries were recorded and most common level of fracture of thoracic spine was between 2nd and 3rd vertebrae (2.0 %).

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