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A Clinical and Demographic Analysis of Patients with Flail Chest Injuries in a Tertiary Care Hospital –A Cross-Sectional Study

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Abstract

Background: *Flail chest is a severe thoracic injury most often caused by road traffic accidents and is associated with high morbidity and mortality. Central flail chest, due to its anatomical involvement, may present with greater clinical severity and poorer outcomes. This study aimed to compare the demographics, clinical characteristics, including associated thoracic injuries, treatment modalities, and outcomes of patients with flail chest injuries.*

Methods: *This cross-sectional study was conducted in the Department of Thoracic Surgery, National Institute of Diseases of Chest & Hospital (NIDCH), Dhaka, Bangladesh, from January 2010 to December 2010. This study included 60 patients with flail chest injuries divided into two groups: Group I (patients with central flail) and Group II (patients with other types of flails).*

Results: *Road traffic accidents were the predominant cause of injury in both groups. Patients with central flail had a significantly higher mean number of rib fractures (9 ± 2 vs. 5 ± 1; $p < 0.001$) and higher frequencies of cyanosis (40.9% vs. 15.8%; $p = 0.030$), lung contusion (59.1% vs. 23.7%; $p = 0.006$), and surgical emphysema (59.1% vs. 23.7%; $p = 0.006$). Although pneumonia and ARDS were more frequent in Group I, the differences were not statistically significant. Mortality was significantly higher in central flail patients (22.7% vs. 2.7%; $p = 0.023$).*

Conclusion: *Central flail chest is associated with more severe injury patterns and significantly greater mortality compared to other types of flail chest. Conservative management remains the cornerstone of treatment; however, heightened vigilance and aggressive supportive care are crucial in cases of central flail.*

Keywords: *Flail Chest, Central Flail, Thoracic Trauma, Rib Fractures, Injury Severity Score.*

1. Introduction

Severe blunt chest trauma remains one of the leading causes of morbidity and mortality across all age groups. Among these injuries, flail chest represents one of the most severe and life-threatening forms of thoracic trauma, and is the most frequently encountered major chest wall injury in clinical practice [1]. Flail chest is defined as two or more contiguous rib fractures, each with two or more breaks, resulting in a free-floating segment of the chest wall. Reported mortality rates range between 9% and 20% [2,3], largely attributable to concomitant injuries and respiratory compromise [2].

Although relatively uncommon, flail chest has a major clinical impact. It is estimated to occur in approximately 0.07% of hospitalized patients with rib fractures [4], with nearly 12% of cases resulting in death within 30 days [5]. Injury-related mortality in some regions, such as the

Eastern Mediterranean, has been reported to be higher than global averages [6]. According to the Abbreviated Injury Score (AIS), flail chest is graded as ≥3, depending on the extent of rib fractures and associated organ damage. The Injury Severity Score (ISS), a validated anatomical scoring system, is widely used to predict outcomes in polytrauma patients [7].

flail chest leads to an unstable segment that moves paradoxically relative to the intact thoracic cage. This mechanical disruption results in severe pain, lobar atelectasis, alveolar collapse, and impaired ventilation [8,9]. These changes predispose patients to acute respiratory distress syndrome (ARDS), prolonged ventilatory support, and a higher risk of complications [8,10]. Mortality rates vary widely, from 20% [11,12] to as high as 42% [13], and flail chest accounts for nearly 25% of deaths following blunt thoracic trauma [11]. Overall, approximately 10% of patients with blunt trauma sustain flail chest injuries, representing a significant burden on trauma care services [14].

Historically, mortality rates following flail chest were reported to be as high as 50% [15]. Over the past decade, management strategies have evolved substantially. While conservative treatment, mechanical ventilation combined with effective analgesia, remains the traditional standard [16,17], it is associated with multiple complications, including ventilator-associated pneumonia, barotrauma, sepsis, prolonged ICU stay, and increased healthcare costs [16,17]. Furthermore, long-term follow-up of conservatively managed patients often reveals persistent dyspnea, chest pain, and impaired pulmonary function [18].

The traditional gold standard for treating flail chest has been conservative, non-operative care, consisting of mechanical ventilation combined with adequate pain management. However, prolonged mechanical ventilation exceeding three weeks is often associated with various complications, including ventilator-related sequelae [19].

In recent years, surgical stabilization of rib fractures (SSRF) has emerged as an effective alternative in selected patients. Evidence suggests that SSRF can reduce the duration of mechanical ventilation, lower the incidence of pneumonia, shorten ICU and hospital stays, and improve long-term pulmonary outcomes [20]. Additional adjuncts, such as regional analgesia, have also gained popularity as part of a multimodal management approach for flail chest [15,21,22]. These evolving strategies highlight the importance of early intervention and stabilization to improve both short- and long-term outcomes in patients with severe chest wall injuries.

In the present study, we aimed to compare the demographics, clinical characteristics, including associated thoracic injuries, treatment modalities, and outcomes of patients with flail chest injuries.

2. METHODOLOGY & MATERIALS

This cross-sectional study was conducted in the Department of Thoracic Surgery, National Institute of Diseases of Chest & Hospital (NIDCH), Dhaka, Bangladesh, from January 2010 to December 2010. In this study, we included 60 patients admitted with flail chest injuries who were consecutively enrolled and divided into two groups based on the type of flail chest: Group I (patients with central flail, n=22) and Group II (patients with other types of flails, n=38).

These were the following criteria for eligibility as study participants:

2.1. Inclusion Criteria

- Patients of either sex, aged ≥18 years
- Patients admitted with a radiologically and clinically confirmed diagnosis of flail chest injury
- Patients presenting within 24 hours of injury
- Patients who gave written informed consent

2.2. Exclusion Criteria

- Patients with pelvic and limb injuries
- Unconscious patients with chest injuries
- Patients with extensive burns with chest injuries
- Patients with pre-existing chronic respiratory disease (e.g., COPD, interstitial lung disease) or cardiac failure that could confound outcomes.

2.3. Data Collection Procedure

Informed written consent was obtained after an explanation of the study procedure. Data were collected prospectively using a structured questionnaire through interviews, observation, clinical examinations, and investigations. Baseline demographic details, cause of injury, clinical presentation, and associated thoracic conditions were recorded. Radiological

investigations, including chest radiography and computed tomography (CT) scans of the thorax (when indicated), were performed for diagnosis.

Management approaches were documented, such as conservative measures (analgesia, chest physiotherapy, oxygen therapy), chest drainage, mechanical ventilation, and surgical interventions. Clinical outcomes, including pneumonia, adult respiratory distress syndrome (ARDS), duration of hospital stay, and mortality, were noted.

2.4. Injury Severity Assessment

The Injury Severity Score (ISS) was used to quantify injury severity, following the method described by Copes et al. (1987). The ISS is derived from the Abbreviated Injury Scale (AIS-90). The three most severely injured body regions were identified, their AIS scores were squared, and the sums were obtained to calculate the ISS. In cases of multiple injuries, the grade was advanced by one level up to Grade III.

To specifically evaluate chest wall trauma, the Chest Wall Injury Scale was applied

Grade	Injury Type	Description	AIS-90 Score
I	Contusion	Any size	1
	Laceration	Skin and subcutaneous	1
	Fracture	< 3 ribs, closed; nondisplaced clavicle, closed	1–2
II	Laceration	Skin, subcutaneous, and muscle	1
	Fracture	≥ 3 adjacent ribs, closed	2–3
		Open or displaced clavicle	2
		Nondisplaced sternum, closed	2
		Scapular body, open or closed	2
III	Laceration	Full-thickness, including pleural penetration	2
	Fracture	Open or displaced sternum, flail sternum	2
		Unilateral flail segment (< 3 ribs)	3–4
IV	Laceration	Avulsion of chest wall tissues with underlying rib fractures	4
	Fracture	Unilateral flail chest (≥ 3 ribs)	3–4
V	Fracture	Bilateral flail chest (≥ 3 ribs on both sides)	5

[*] *This scale is confined to the chest wall alone and does not reflect associated internal thoracic or abdominal injuries.*

Based on ISS, patients were classified into three categories:

- **Moderate injury**: ISS 9–14
- **Severe injury**: ISS 16–24
- **Critical injury**: ISS >25

2.5. Statistical Analysis

All data were systematically recorded in a pre-designed data collection form. Quantitative data are presented as mean and standard deviation, while qualitative data are shown as frequency and percentage. The statistical tests used included the Chi-square or Fisher's Exact Probability Test and Student's t-Test. For all analyses, the significance level was set at 0.05, with p-values less than 0.05 considered significant. Statistical analysis was conducted using SPSS 19 (Statistical Package for Social Sciences) for Windows version 10. This study received ethical approval from the Institutional Review Committee of the National Institute of Diseases of Chest & Hospital (NIDCH).

3. RESULTS

Table 1. *Baseline characteristics and clinical presentation of study patients*

Age	Group-I		Group-II		P-value
	N=22	P(%)	N=38	P(%)	
≤ 20 years	3	13.6	6	15.8	
21-30 years	5	22.7	5	13.2	
31-40 years	6	27.3	8	21.1	
>40 years	8	36.4	19	50	
Mean ± SD (years)	38.3 ± 14.4		41.4 ± 18.2		0.471
Sex					
Male	18	81.8	25	65.8	0.184
Female	4	18.2	13	34.2	
Clinical Presentation					
Chest pain	22	100.0	38	100.0	
Respiratory distress	16	72.7	22	57.9	0.251

Cyanosis	9	40.9	6	15.8	0.030
Number of fractured ribs	9 ± 2		5 ± 1		<0.001

Table 1 shows that the mean age of the patients was 38.3 ± 14.4 years in Group I and 41.4 ± 18.2 years in Group II, with no statistically significant difference between the two groups (p = 0.471).
In terms of age distribution, 36.4% of Group I and 50% of Group II patients were older than 40 years.
Males constituted the majority in both groups (81.8% in Group I and 65.8% in Group II), although the difference did not reach statistical significance (p = 0.184). All patients presented with chest pain (100% in both groups). Respiratory distress was more frequent in Group I (72.7%) compared to Group II (57.9%), but the difference was not statistically significant (p = 0.251). Cyanosis, however, was significantly higher in Group I (40.9%) than in Group II (15.8%) (p = 0.030). The mean number of fractured ribs was significantly greater in Group I (9 ± 2) compared to Group II (5 ± 1) (p < 0.001).

Table 2. *Comparison of causes of injury and injury severity score between groups*

Causes of injury	Group-I		Group-II		P-value
	N=22	P(%)	N=38	P(%)	
Road Traffic Accident	16	72.7	32	84.2	
Fall from Height	6	27.3	4	10.5	
Others	0	0	2	5.3	
Injury severity score (ISS)*					
Moderate (9 – 14)	0	0	2	5.3	0.248
Severe (16 – 24)	4	18.2	12	31.6	
Critical (>25)	18	81.8	24	63.2	

Table II shows that the most common cause of injury was road traffic accident (RTA), accounting for 72.7% of cases in Group I and 84.2% in Group II. Falls from height were more frequent in Group I (27.3%) compared to Group II (10.5%), while other causes were reported only in Group II (5.3%). Regarding the injury severity score (ISS), the majority of patients in both groups fell into the critical category (>25), comprising 81.8% of Group I and 63.2% of Group II. Severe injury (ISS 16–24) was observed in 18.2% of Group I and 31.6% of Group II. Only 2 patients (5.3%) in Group II had moderate injury (ISS 9–14), while none were recorded in Group I. The difference in ISS distribution between the groups was not statistically significant (p = 0.248).

Table 3. *Comparison of associated clinical conditions between groups*

Associated conditions	Group-I		Group-II		P-value
	N=22	P(%)	N=38	P(%)	
Haemothorax	5	22.7	11	29.7	0.559
Haemopneumothorax	17	77.3	26	68.4	0.671
Lung contusion	13	59.1	9	23.7	0.006
Surgical emphysema	13	59.1	9	23.7	0.006

Table III shows that among the associated conditions, haemothorax was observed in 22.7% of Group I and 29.7% of Group II patients, with no significant difference between the groups (p = 0.559). Haemopneumothorax was the most frequent condition, occurring in 77.3% of Group I and 68.4% of Group II (p = 0.671). However, both lung contusion and surgical emphysema were significantly more common in Group I (59.1% each) compared to Group II (23.7% each), with p = 0.006 for both comparisons.

Table 4. *Comparison of treatment modality and clinical outcomes between groups*

Treatment modality	Group-I		Group-II		P-value
	N=22	P(%)	N=38	P(%)	
Conservative treatment	22	100	38	100	
Chest drainage	21	95.5	35	92.1	0.532
Lung contusion	2	9.1	9	23.7	0.131

Tracheostomy & mechanical ventilation	2	9.1	0	0	0.131
Conservative treatment	22	100	38	100	
Clinical Outcomes					
Pneumonia	9	40.9	10	27	0.270
Adult respiratory syndrome	4	18.2	1	2.7	0.059
Hospital Stay	12.3 ± 1.5		12.1 ± 1.0		0.950
Mortality	5	22.7	1	2.7	0.023

Table IV shows that all patients in both groups were managed with conservative treatment (100%). Chest drainage was required in almost all cases, being performed in 95.5% of Group I and 92.1% of Group II, with no significant difference (p = 0.532). Regarding clinical outcomes, pneumonia developed in 40.9% of Group I and 27% of Group II patients (p = 0.270). Adult respiratory distress syndrome (ARDS) was more frequent in Group I (18.2%) compared to Group II (2.7%), showing a trend toward significance (p = 0.059). The mean duration of hospital stay was similar between the groups (12.3 ± 1.5 vs. 12.1 ± 1.0 days, p = 0.950). However, mortality was significantly higher in Group I (22.7%) than in Group II (2.7%) (p = 0.023).

4. DISCUSSION

This cross-sectional study was conducted at the Department of Thoracic Surgery, NIDCH, Dhaka, Bangladesh, from January to December 2010, including 60 consecutive patients with flail chest injuries. Patients were categorized into Group I (central flail, n=22) and Group II (other flail types, n=38).

In the present study, the mean age of patients was 38.3 ± 14.4 years in Group I and 41.4 ± 18.2 years in Group II, with no statistically significant difference between the two groups (p = 0.471). In terms of age distribution, 36.4% of Group I and 50% of Group II patients were older than 40 years. Overall, chest trauma tends to affect younger age groups, with a mean age of 37 ± 16 years in this study. The most commonly affected age group was 21–30 years (30.43%), followed by 41–50 years (23.91%). These findings are consistent with those reported by Kant et al., who observed a mean age of 36.25 years among chest trauma patients [23], and by Ibrahim et al., who noted the highest incidence in the 20–30-year age group, with decreasing frequency in older age groups [24]. Walia et al. reported a similar trend, with a decline in cases after the 41–50-year age group [25].

Males constituted the majority of patients in both groups (81.8% in Group I and 65.8% in Group II), though this difference was not statistically significant (p = 0.184). A male predominance is consistently reported in the literature. Walia et al. observed a male-to-female ratio of 2.4:1, Liman et al. reported 70.6% males, and Kant et al. and Ekpe et al. reported ratios of 3.5:1 and 4:1, respectively [23,25-27].

In the present study, 36.7% of patients had central flail chest injury, while 63.3% had other types of flail chest injuries. Road traffic accidents (RTAs) were the most common cause of injury, accounting for 72.7% of cases in Group I and 84.2% in Group II, while falls from height were more frequent in Group I (27.3%) compared to Group II (10.5%). Other causes were reported only in Group II (5.3%).

This pattern aligns with previous studies: Walia et al. reported RTAs as the predominant mode of injury (58.69%) followed by assaults (42.39%),[25] while Kant et al. and Anisuzzaman et al. also found RTAs (63%) to be the leading cause, followed by assaults [23,28]. Liman et al. and Mathangasinghe et al. similarly reported RTAs (67.79%) as the most common cause, followed by falls [26,29]. Motor vehicle accidents remain the most common cause of flail chest injury, reported in 79% of cases by Dehghan et al. [2] and 76% by Borman et al. [30] in registry-based studies.

Regarding the pattern of injuries, the most common associated conditions in this study were haemothorax, followed by haemopneumothorax, lung contusion, and surgical emphysema. These findings are comparable to those reported by Walia et al., where the majority of patients had associated head injuries, and only 30.97% had exclusive chest injuries [25]. Anisuzzaman et al. and Mathangasinghe et al. found extremity injuries to be the most common associated injury, followed by abdominal and head injuries [28,29].

All patients in both groups were managed conservatively (100%), with chest drainage required in almost all cases (95.5% in Group I and 92.1% in Group II). Similar observations have been reported in the literature: Kant et al. reported 82% managed conservatively and 15%

requiring drainage [23]. Walia et al. managed most patients conservatively (55.43%), with only 39.69% requiring chest tube drainage [25]. Kulshrestha et al. found that only 18.32% of chest trauma patients required chest tube insertion, and 2.6% required thoracotomy [31]. In contrast, Ibrahim et al. reported that 58% of patients required surgical interventions [24].

In the present study, the overall mortality rate was 10%. Alanwer et al. reported a mortality of 19.9%, Walia et al. (1.63%), Kulshrestha et al. (9.41%), Ibrahim et al. (18%), and Kant et al. (2%) [23-25,31,32].

Overall, the findings highlight that flail chest predominantly affects younger males, with road traffic accidents being the leading cause. Conservative management remains the cornerstone of treatment, while mortality is driven primarily by associated clinical conditions and comorbidities rather than patient age or the type of flail chest.

5. Limitations of the Study

This study has certain limitations. First, the study was a single-center study. Second, the sample size was relatively small, which may limit the generalizability of the findings. Third, the cross-sectional design did not allow long-term follow-up to evaluate functional recovery, quality of life, and late complications.

6. Conclusion and Recommendations

Flail chest remains a serious clinical problem, most commonly resulting from road traffic accidents and frequently associated with significant thoracic complications. In this study, patients with central flail chest were found to have a greater number of rib fractures, higher rates of cyanosis, lung contusion, and surgical emphysema, as well as a significantly increased risk of mortality compared to those with other types of flail injuries. While conservative management remains the cornerstone of treatment, these findings underscore the need for aggressive supportive care in cases of central flail. Further multicenter prospective studies with larger sample sizes and long-term follow-up are warranted to validate these observations and refine management strategies.

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Conflict Of Interest

None declared

Ethical Approval

This study was ethically approved

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