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Analysis of Outcome Between Isolated Flail Chest and Flail Chest with Polytrauma in a Busy Tertiary Care Centre

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ABSTRACT

***Background**: Flail chest is a severe manifestation of blunt chest trauma (BCT) often accompanied by pulmonary contusion and respiratory compromise. Outcomes vary depending on whether the injury occurs in isolation or as part of polytrauma, significantly influencing morbidity and mortality.* ***Objective**: To compare the outcomes of isolated flail chest (Group A) and flail chest associated with polytrauma (Group B) in terms of morbidity and mortality following blunt chest trauma.* ***Methods**: This prospective cohort study was conducted in the Department of Thoracic Surgery, Jinnah Postgraduate Medical Centre (JPMC), Karachi, from November 2022 to November 2023. Patients aged ≥12 years presenting with flail chest after blunt trauma were enrolled. Demographic, clinical, and radiological parameters were recorded. Data were analyzed using SPSS version 23. Associations between categorical variables were evaluated with the chi-square test, with $p < 0.05$ considered statistically significant.* ***Results**: Eighty-six patients met the inclusion criteria, including 66 (76.7%) males, with a mean age of 43.6 ± 14.1 years. Thirty (34.9%) had isolated flail chest and 56 (65.1%) had flail chest with polytrauma. Road traffic accidents were the predominant cause (72; 83.7%). Pulmonary contusion occurred in 65 (75.5%) patients. Tube thoracostomy and intravenous analgesia were performed in 80 (93.0%) and 75 (87.2%) patients, respectively, while 41 (47.7%) required mechanical ventilation. Respiratory failure and ARDS were significantly associated with mechanical ventilation and mortality ($p < 0.001$). The extent of rib fractures correlated with prolonged hospital stay ($p = 0.001$), pulmonary contusion ($p = 0.007$), and pneumonia ($p = 0.003$). In polytrauma cases, head and cardiac injuries were strongly associated with increased mortality and respiratory complications ($p < 0.001$).* ***Conclusion**: Flail chest, particularly when accompanied by polytrauma, is associated with higher morbidity and mortality. Isolated flail chest cases generally show better outcomes, underscoring the importance of early diagnosis, vigilant monitoring, and multidisciplinary management.*

Keywords
Flail chest, polytrauma, pulmonary contusion, mechanical ventilation, blunt chest trauma, respiratory failure, tube thoracostomy

INTRODUCTION

Flail chest (FC) is one of the most challenging thoracic injuries and remains a major cause of morbidity in blunt chest trauma (BCT), accounting for a substantial proportion of BCT presentations and a small but important fraction of hospitalized fracture patients (1). Anatomically, FC is classically defined as fractures of at least four adjacent ribs at two or more sites, producing a freely moving segment with paradoxical chest wall motion; functionally, it is an unstable chest wall segment that impairs ventilation (2).

The mechanism and severity of chest trauma critically influence the occurrence and clinical course of FC. High-energy impacts—most commonly motor vehicle accidents (MVAs) and falls—produce multiple rib fractures and chest wall instability, with reported mortality ranging from 10% to 30% in severe presentations (3). Concomitant pulmonary contusion further exacerbates gas-exchange impairment and is associated with higher mortality (4). The severity of FC correlates with the number and distribution of rib fractures as well as associated intrathoracic and extrathoracic injuries (5).

Patients typically present with pleuritic chest pain and dyspnea; examination may reveal chest wall tenderness, crepitus, and paradoxical motion (6). FC frequently coexists with hemothorax and/or pneumothorax, compounding respiratory compromise (4,5). Diagnosis is primarily clinical, supported by imaging. While chest radiography is often the first-line investigation, certain fractures—particularly anterior—may be missed; computed tomography (CT) more accurately characterizes rib fracture patterns, chest wall instability, and associated intrathoracic injuries (5,7).

Management is tailored to physiological status and injury burden, emphasizing vigilant respiratory monitoring and multimodal analgesia (intravenous and regional techniques) to facilitate ventilation and secretion clearance (3). Non-invasive ventilation (NIV) or invasive mechanical ventilation may be required to reduce work of breathing and maintain adequate alveolar ventilation in selected patients (1). Surgical stabilization of rib fractures can be beneficial in carefully chosen cases, reducing ventilator dependence and length of stay (3,4). Prompt recognition of FC and proactive treatment of complications are essential to optimize outcomes (7). Regional data from Pakistan remain limited despite the high burden of road traffic–related trauma. Asian cohorts suggest that mortality in isolated flail chest (IFC) is lower than in flail chest with polytrauma (FCPT),

where multiple-system injuries drive adverse outcomes (4,8). This study aimed to compare morbidity and mortality between IFC (Group A) and FCPT (Group B) following BCT in a high-volume tertiary care center.

MATERIAL AND METHODS

This prospective cohort study was conducted in the Department of Thoracic Surgery, Jinnah Postgraduate Medical Centre (JPMC), Karachi, from November 2022 to January 2024. The study was approved by the Institutional Review Board (IRB) and Ethics Committee (Ref: F.2-81/2022-GENL/326/JPMC, dated 26 December 2022). Written informed consent was obtained from all participants prior to inclusion. Patients of both genders aged 12 years and above who presented with flail chest following blunt trauma were included. Based on associated injuries, patients were divided into two groups: Group A: Isolated flail chest (IFC) and Group B: Flail chest with polytrauma (FCPT). Patients with penetrating chest injuries were excluded from the study.

A structured proforma was used to record demographic and clinical data, including age, sex, mode of injury, number and site of rib fractures, associated injuries, and clinical outcomes. Outcomes assessed were pneumonia, acute respiratory distress syndrome (ARDS), need for mechanical ventilation, duration of hospital stay, and mortality. All patients underwent standard diagnostic investigations, including chest X-ray, computed tomography (CT) scan, and arterial blood gas (ABG) analysis. Management included judicious intravenous fluid therapy, supplemental oxygen, and analgesia (intravenous or loco-regional). Tube thoracostomy was performed when indicated for hemothorax or pneumothorax. Loco-regional analgesia was administered in the form of paravertebral blocks, using bupivacaine 15 mg diluted in 20 mL normal saline, with approximately 2–3 mL injected at each level. Mechanical ventilation was instituted as required, based on ABG findings and respiratory distress.

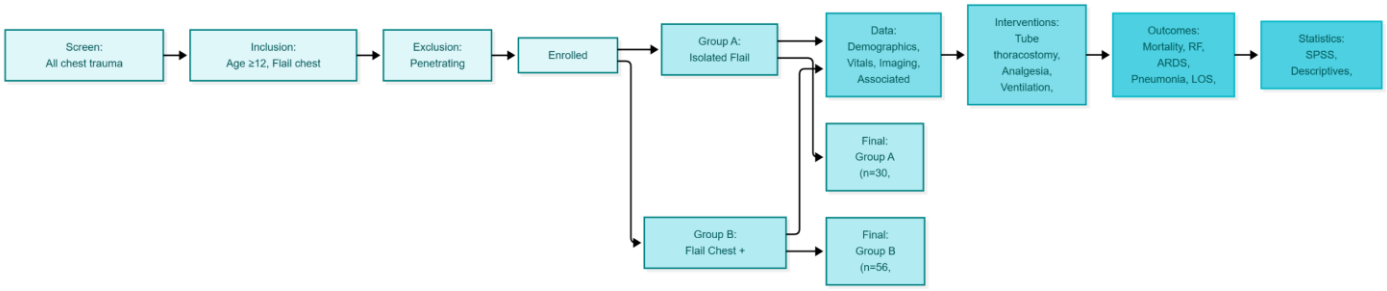

Figure 1 Study Flowchart

Data were analyzed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Associations between categorical variables were evaluated using the chi-square test, with a p-value < 0.05 considered statistically significant.

RESULTS

A total of 86 patients met the inclusion criteria. The mean age at presentation was 43.6 ± 14.06 years, and 66 (76.7%) were males. The majority (45; 52.3%) were middle-aged (45–65 years). Of these, 30 (34.9%) had isolated flail chest (Group A), whereas 56 (65.1%) had flail chest with polytrauma (Group B). Chest X-ray was performed in 83 (96.5%) patients, and CT scan in 30 (34.9%). The mean number of rib fractures was 6.08 ± 1.60 (range 3–10). Unilateral involvement was predominant in both groups (93.3% in Group A and 89.2% in Group B).

Table 1. Demographic, Clinical, and Radiological Characteristics

Characteristic	Total (n = 86)	Group A (n = 30)	Group B (n = 56)
Age (years)	43.6 ± 14.06	45.1 ± 2.5	42.8 ± 1.9
Gender			
Male	66 (76.7%)	21 (70%)	45 (80.4%)
Female	20 (23.3%)	9 (30%)	11 (19.6%)
Heart rate (bpm)	121.2 ± 15.15	112 ± 2.7	125.8 ± 1.75
Oxygen saturation (%)	88.1 ± 7.21	90 ± 1.06	86.6 ± 1.0
Respiratory rate (breaths/min)	34.9 ± 9.75	34 ± 2.6	35.3 ± 0.82
Glasgow Coma Scale (GCS)	13.7 ± 1.5	14 ± 0.15	13.4 ± 0.22
Arterial Blood Gas (ABG) Findings			
pH	7.29 ± 0.67	7.32 ± 0.01	7.28 ± 0.009
pO_2 (mmHg)	69.8 ± 11.3	72 ± 2.0	68.5 ± 1.5
pCO_2 (mmHg)	37.1 ± 7.8	35 ± 1.1	38.1 ± 1.13
HCO_3^- (mEq/L)	20.9 ± 2.89	20 ± 0.48	20.9 ± 0.40
Oxygen saturation (%)	87.7 ± 6.92	89.8 ± 1.06	86.6 ± 0.96
Location of Rib Fractures			
Posterior	41 (47.6%)	15 (50%)	26 (46.4%)
Anterolateral	34 (39.5%)	10 (33.3%)	24 (42.9%)
Anterior	11 (12.7%)	5 (16.7%)	6 (10.7%)
Side of Rib Fractures			
Left	44 (51.2%)	13 (43.3%)	31 (55.4%)
Right	34 (39.5%)	15 (50%)	19 (33.9%)
Bilateral	8 (9.3%)	2 (6.7%)	6 (10.7%)
Number of Fractured Ribs	6.08 ± 1.60	5.41 ± 0.30	6.44 ± 0.18
Analgesia Used			
Intravenous	85 (98.8%)	29 (96.7%)	56 (100%)

Characteristic	Total (n = 86)	Group A (n = 30)	Group B (n = 56)
Double regimen	68 (79.1%)	19 (63.3%)	49 (87.5%)
Loco-regional block	75 (87.2%)	26 (86.7%)	49 (87.5%)
Hospital stay (days)	7.1 ± 2.52	5.8 ± 0.28	7.5 ± 0.34

Abbreviations: bpm = beats per minute; mmHg = millimeters of mercury; mEq/L = milliequivalents per liter; values are mean ± SD unless otherwise stated. The predominant mechanism of injury was road traffic accident (RTA), seen in 23 (76.6%) IFC and 49 (87.5%) FCPT cases. Falls accounted for 7 (23.3%) IFC and 7 (12.5%) FCPT cases. Among RTAs, crush injuries (15; 17%) and rollovers (5; 5.8%) were frequent subtypes (Figure 1).

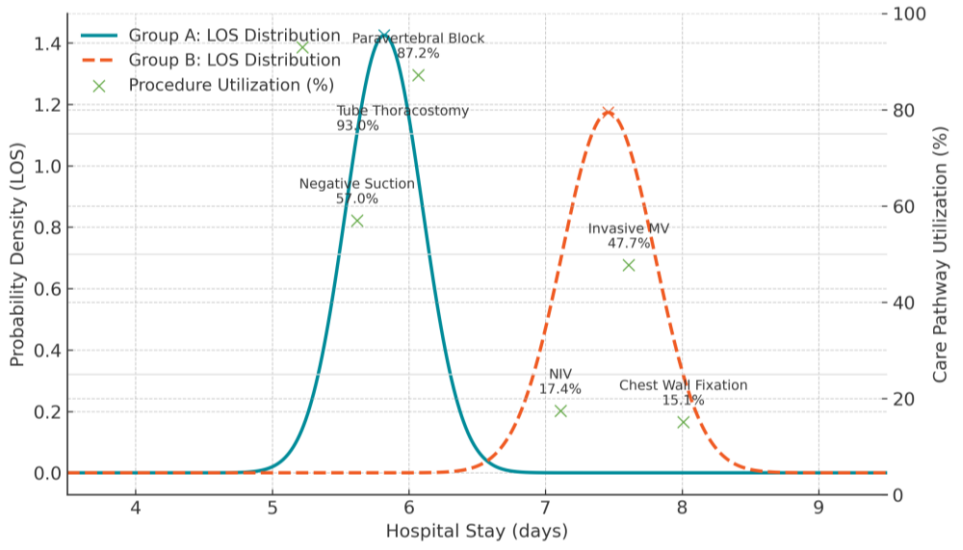

Figure 2 Hospital Stay Distributions by Group with Integrated Care Pathway Utilization

Hospital Stay Distributions by Group with Integrated Care Pathway Utilization displays overlapping normal curves for hospital stay in Group A (IFC; μ = 5.82 d, SD = 0.28) and Group B (FCPT; μ = 7.46 d, SD = 0.34), showing a rightward shift and broader variance in FCPT consistent with higher clinical burden. Superimposed scatter markers on a secondary axis summarize pathway utilization: tube thoracostomy 93.0%, paravertebral block 87.2%, negative suction 57.0%, invasive ventilation 47.7%, NIV 17.4%, and chest wall fixation 15.1%.

Table 2. Associated Injuries in Flail Chest Patients

Associated Injury	Group A (n = 30)	p-value	Group B (n = 56)	p-value	Total (n)
Pulmonary contusion	18	0.01	47	0.01	65
Emphysema	18	0.46	29	0.46	47
Hemopneumothorax	15	0.10	38	0.10	53
Hemothorax	9	0.49	13	0.49	22
Pneumothorax	4	0.029	1	0.029	5
Limb injury	—	—	47	< 0.001	47
Head injury	—	—	22	< 0.001	22
Cardiac injury	—	—	18	0.09	18
Liver injury	—	—	16	0.006	16
Pelvic injury	—	—	14	0.002	14
Splenic injury	—	—	9	0.024	9

Table 3. Clinical Outcomes and Mortality Stratification

Outcome	Group A (n = 30)	p-value	Group B (n = 56)	p-value	Total (n = 86)
Ventilatory support	7 (23.3%)	0.001 **	34 (60.7%)	< 0.001 **	41 (47.7%)
Respiratory failure	4 (13.3%)	0.047 *	18 (36%)	0.047 *	22 (25.5%)
Mortality	3 (10%)	0.03 *	17 (34%)	0.036 *	20 (23.3%)
Pneumonia	3 (10%)	0.41	3 (6%)	0.45	6 (6.9%)
ARDS	2 (6.6%)	0.31	9 (18%)	0.31	11 (12.7%)
Myocardial infarction	0 (0%)	0.016 *	9 (18%)	0.02 *	9 (10.4%)

Significance levels: $p < 0.05$ (*); $p < 0.005$ (**)

The visualization highlights that the FCPT distribution centers ~1.6 days longer than IFC, while high rates of drainage/analgesic interventions and nearly half requiring invasive ventilation align with the prolonged stay density; fixation remains selectively applied (~15%), suggesting targeted use despite substantial respiratory support needs. The most frequent associated lesion was pulmonary contusion (65; 75.5%), followed by hemopneumothorax (53; 61.6%) and subcutaneous emphysema (47; 54.6%). Pulmonary contusion showed a significant correlation with the need for mechanical ventilation ($p < 0.001$). Tube thoracostomy was performed in 80 (93%) patients, and negative suction was applied in 49 (57%). The mean estimated blood loss was 496 ± 440 mL (range 0–1300 mL). Air leaks occurred in 44 (51.2%) cases and were significantly associated with the use of suction ($p < 0.001$).

Analgesia included intravenous agents in 85 (98.8%) patients, supplemented with paravertebral blocks in 75 (87.2%). Mechanical ventilation (MV) was required in 41 (47.7%) patients, while non-invasive ventilation (NIV) was used in 15 (17.4%). MV was strongly associated with respiratory failure, pneumonia, ARDS, and mortality ($p < 0.001$).

Of the 20 total deaths, 17 (85%) occurred in patients who developed respiratory failure ($p < 0.001$). Surgical fixation of the chest wall was performed in 2 (6.6%) IFC and 11 (22%) FCPT cases. The overall hospital stay averaged 7.1 ± 2.52 days (range 1–13 days): 2–8 days for IFC and 1–13 days for FCPT. Patients with > 4 rib fractures had significantly longer hospital stays ($p = 0.001$) and higher rates of pulmonary contusion ($p = 0.007$) and pneumonia ($p = 0.003$). Anterolateral and posterior rib fractures were both associated with increased mortality ($p = 0.003$; $p = 0.03$), need for mechanical ventilation ($p < 0.001$; $p = 0.004$), myocardial infarction ($p = 0.002$), and respiratory failure ($p = 0.01$). In Group B, head and cardiac injuries were strongly associated with mortality ($p < 0.001$), respiratory failure ($p < 0.001$), and ARDS ($p = 0.002$, 0.03 respectively). Abdominal and limb injuries significantly prolonged hospital stay ($p = 0.033$). Mechanical ventilation was more frequently required in patients with head and abdominal injuries ($p < 0.001$). Myocardial infarction correlated significantly only with cardiac injuries ($p < 0.001$).

DISCUSSION

Flail chest (FC) remains a serious thoracic injury requiring a comprehensive, multidisciplinary management approach to prevent life-threatening complications (9). In the present study, isolated flail chest (IFC) accounted for 34.9% of cases, consistent with previous reports indicating proportions below 40% (10). A clear male predominance (76.7%) was observed, in agreement with Marasco et al. (11), likely reflecting the higher exposure of males to outdoor and high-velocity trauma. The predominance of middle-aged adults (52.3%) further supports evidence that this group is at increased risk due to occupational and vehicular factors (5).

Blunt trauma from road traffic accidents (RTAs) emerged as the leading mechanism of injury, accounting for 76.6% of IFC and 87.5% of FC with polytrauma (FCPT). These findings align with global data, where RTAs contribute to 40–75% of FC cases (10,12,13). Falls represented the second most frequent cause, consistent with Naidoo et al. (14). As observed by Caragounis et al., fall-related injuries more commonly produced isolated flail chest (23.3%) compared with FCPT (12.5%), reflecting a lower impact mechanism (5). Motorcycle and car accidents were the predominant subtypes of RTA, the latter often leading to polytrauma due to higher-energy transfer (15). Although crush injuries were less frequent, they involved multiple organ systems and carried a higher risk of complications (16). The most common associated intrathoracic injuries were pulmonary contusion (75.5%), hemopneumothorax (61.6%), and subcutaneous emphysema (54.6%), similar to prior studies (17). Pulmonary contusion strongly correlated with the need for mechanical ventilation ($p < 0.001$), underscoring its role in respiratory failure and hypoxemia (9).

The mean number of fractured ribs (6.08 ± 1.6) parallels findings by Golic et al. and Choi et al. (18,19). Several studies have highlighted that more than three fractured ribs increase the likelihood of severe respiratory compromise and mortality (9,20). In this study, > 4 rib fractures were significantly associated with pulmonary contusion ($p = 0.007$), pneumonia ($p = 0.033$), and longer hospital stay ($p = 0.001$). Rib-fracture location also influenced outcomes. Haines et al. reported that lateral fractures increase mortality risk by 1.13-fold (21), consistent with our findings where anterolateral fractures correlated significantly with mortality ($p = 0.003$), mechanical ventilation ($p < 0.001$), myocardial infarction ($p = 0.02$), and respiratory failure ($p = 0.01$). Similarly, posterior fractures were associated with higher rates of mortality ($p = 0.03$) and ventilatory support ($p = 0.004$), corroborating the results of Mvoula et al. (22).

Flail chest with extra-thoracic injuries markedly worsened prognosis. Alanwer et al. found that concurrent head injuries significantly increased mortality risk (1), consistent with our results where head trauma showed strong associations with mortality, respiratory failure, ARDS, and prolonged hospitalization ($p < 0.001$). Cardiac injury similarly demonstrated significant correlations with mortality, myocardial infarction, and respiratory failure ($p < 0.001$). These findings affirm that the systemic inflammatory and hemodynamic burden of polytrauma substantially aggravates thoracic injury outcomes (9).

Tube thoracostomy was the most frequently performed procedure (93%), reflecting the high prevalence of pneumothorax and hemothorax, as also reported by Ayoub et al. and Lodhia et al. (12,23,24). Air leaks occurred in 51.2% of cases and were effectively managed with negative suction, a finding supported by Feenstra et al., who demonstrated improved outcomes with suction drainage ($p = 0.001$) (25).

Nearly half of the patients (47.7%) required mechanical ventilation, lower than the 61.8% reported by Naidoo et al. (14). MV was needed more frequently in FCPT cases (60.7%) than IFC (23.3%), indicating the additive respiratory burden of multi-system trauma. MV also showed strong associations with respiratory failure, ARDS, and mortality ($p < 0.001$), consistent with Marasco et al., who reported ventilator-related complications as key predictors of adverse outcomes (11).

The overall mortality rate of 23.2% in this study aligns with previously reported ranges of 15–25% (3–7). Mortality was significantly higher among FCPT patients (30.4%) compared with IFC (10%), confirming that extrathoracic injuries amplify fatal outcomes (26). Among the 20 deaths, 85% were preceded by respiratory failure, emphasizing its pivotal role in prognosis.

Surgical stabilization of the chest wall was performed in 13 patients (15%), primarily those on ventilatory support, with only one death recorded post-fixation. This supports evidence that early rib fixation reduces mechanical ventilation duration, pneumonia, and ARDS (24). Mean hospitalization lasted 7.1 ± 2.52 days, shorter for IFC (≈6 days) than FCPT (> 7 days), though still less than durations reported by Alanwer et al. (1). The principal limitation of this study was the exclusion of patients with severe multi-system injuries or hemodynamic instability, many of whom were unsuitable for early surgical stabilization. Long-term functional and pulmonary outcomes were also not assessed.

CONCLUSION

Flail chest, most often resulting from blunt chest trauma, demands prompt multidisciplinary evaluation and coordinated management. Thoracic and extra-thoracic injuries substantially influence patient outcomes, with morbidity and mortality rising in proportion to the number of fractured ribs and the severity of associated injuries. Patients with isolated flail chest generally demonstrate a more favorable prognosis and shorter hospital stay, whereas those with polytrauma experience higher complication rates and prolonged recovery. Early and aggressive medical management remains the cornerstone of treatment, while surgical chest wall fixation in appropriately selected patients significantly improves respiratory stability, reduces ventilatory dependence, and lowers both morbidity and mortality.

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