**ALBANIAN JOURNAL OF TRAUMA AND EMERGENCY SURGERY**
**Volume 10 | Issue 2 | July 2026**
**Pages:** 2157-2164
**DOI:** https://doi.org/10.32391/ajtes.v10i2.536

OPEN ACCESS JOURNALS

REVIEW ARTICLE

# Fixation of Anterior Flail Chest after Isolated Blunt Chest Trauma and Outcome.

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Received: 31 March 2026 • Accepted: 17 May 2026 • Published online: 20 July 2026

## ABSTRACT

**Background:** Anterior (stove-in) chest injury is a very rare but serious cause of chest wall instability. This study looked at how internal pneumatic stabilization compares to primary surgical fixation in patients with isolated blunt chest trauma.
**Methods:** We reviewed three cases treated at two trauma centers from January 2000 to January 2026. We used the Thoracic Trauma Severity Score (TTSS) and the Modified Shock Index (MSI) to assess severity. All patients were treated following ATLS guidelines, and management depended on injury severity, patient stability, and available resources. We compared outcomes between internal pneumatic stabilization (mechanical ventilation with PEEP) and open reduction with internal fixation (plates and screws).
**Results:** In the third case, early open reduction and internal fixation of both rib fractures and a transverse sternal fracture allowed the patient to return to normal activity sooner and leave the ICU by the third day after surgery. These results suggest that clinicians should review their treatment protocols for anterior flail chest and consider early surgical stabilization.
**Conclusion:** Internal pneumatic stabilization is a useful conservative treatment for anterior flail chest injury, but the small number of cases and the study's retrospective design limit how much we can conclude. In this series, patients who had early open surgical fixation needed fewer days on a ventilator, spent less time in the ICU, and had fewer ventilator-related complications than those treated with internal pneumatic stabilization.
**Keywords:** Blunt chest trauma; Flail chest; Surgical fixation; Thoracic Trauma Severity Score; Modified Shock Index

**How to cite this article:**
Elayouty, H. D., Hamed, M. S., Elayouty, A. H., & Hassan, H. S. (2026). Fixation of anterior flail chest after isolated blunt chest traumas and outcome. *Albanian Journal of Trauma and Emergency Surgery, 10*(2), 2157-2164. https://doi.org/10.32391/ajtes.v10i2.536

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## INTRODUCTION

Trauma is the main cause of death for young people and young adults, and it is the fourth most common cause of death worldwide. (1)

Chest trauma is common, and blunt chest trauma happens more often (70–80%) than penetrating injuries. Blunt trauma causes 20 to 25% of trauma deaths. In many low- and middle-income countries, penetrating trauma from stabbings or gunshots is at least as common as blunt trauma and is often deadly, with over 75% of people with stab wounds to the heart dying before reaching the hospital. (2)

Car accidents lead to more serious injuries and deaths, especially when seat belts are not used. Older patients often have worse outcomes because of frailty and other health problems. Even though blunt chest trauma is more common, less than 10% of these patients need surgery. In comparison, up to 30% of patients with penetrating chest trauma need surgery, which has a higher risk of death. (3-4)

Thoracic trauma and its complications cause about 25% of all trauma-related deaths. (5) Flail chest, which means three or more ribs are broken in at least two places, is not very common, and blunt trauma is usually the cause. It can seriously affect breathing and is often linked to other injuries, leading to problems like pneumothorax, hemothorax, and lung contusion. This condition has been well studied, and clear guidelines have helped lower its risks. (6,7) Patients with flail chest usually need to be hospitalized and are treated using best practices to improve their outcomes. (8)

A much rarer and less documented type of flail chest is the anterior stove-in chest (ASIC). First described in 1956, ASIC is when a large part of the front chest wall collapses during breathing (9, 10). Since then, only a few case reports have described ASIC, with the most recent in 2004. Although rare, studies suggest that ASIC has even higher rates of complications and death (10,11). Anterior stove-in chest is a rare type of flail chest, and has only been described in a few case reports (12,13).

Our study aimed to review how anterior flail chest injuries are managed and what outcomes result. Severe blunt chest trauma can cause an unstable front chest segment that moves in the opposite direction during breathing, leading to severe pain, low oxygen, shortness of breath, and possible respiratory failure.

Pain control is crucial for better breathing and to prevent complications. This can include using several types of pain relief and regional or thoracic epidural blocks. A chest CT scan with 3-D reconstruction should be done to show where the fractures are.

Several scores and indices can help predict outcomes and guide decisions, such as the Thoracic Trauma Severity Score (TTSS), shock index (SI), modified shock index (MSI), and serum troponin I.

- Mean arterial pressure = [(DBP x 2) + SBP] / 3.
- Modified Shock Index = Heart Rate / The Mean Arterial Pressure

The Thorax Trauma Severity Score (TTSS) is calculated by adding the points assigned to five specific parameters: age, number of rib fractures, pulmonary contusion, pleural involvement, and PaO2/FiO2 ratio. The PaO2 /FiO2 (P/F) ratio is a clinical metric used to assess oxygenation and lung function by dividing the partial pressure of arterial oxygen in mmHg) by the fractional inspired oxygen. A normal ratio is roughly 400–500 mmHg, while values <300 indicate acute respiratory distress syndrome.

Each parameter is assigned a score of 0 to 5, and the total score ranges from 0 to 25. TTSS ≥ 20: Indicates a high risk of mortality and the urgency for intervention.

Fixing a flail chest segment helps make the chest wall stable again, reduces abnormal movement, improves breathing, and lessens pain. Surgery is needed when there is a large flail segment (three or more ribs broken in two or more places), respiratory failure, long-term ventilation, pain that cannot be controlled, failed lung care, major chest wall deformity, or severe abnormal movement of the flail segments.

Minimally invasive surgery for anterior flail chest can use techniques like the Nuss procedure, which stabilizes sternal or cartilage fractures with a bar placed behind the sternum through small side incisions in selected cases. This method causes less surgical trauma, shortens the time on a ventilator, and can fix anterior flail segments more effectively than open surgery. There is still debate about whether internal fixation or external chest wall stabilization (using plates and screws) is better.

## CASE SERIES

The cases are presented in order from the earliest to the most recent.

**The first case:**

A 56- year- old man was carried into the Emergency Room in severe respiratory distress and hypoxia after a severe blunt chest trauma. The most significant manifestation was the paradoxical movement of the anterior segment of his chest wall; at the center of this flail segment was a large part of the obliquely fractured body of his sternum. On auscultation, we found a pansystolic murmur at the apex of the heart, radiating to the axilla. The TTSS was 16, and the Modified Shok index = 1.8. Arterial blood gases showed hypoxia, hypercapnia, and respiratory acidosis.

The patient was intubated and transferred to the ICU after blood samples were drawn to determine blood type, troponin I level, and renal and hepatic function.

In the ICU, mechanical ventilation was started because of persistent respiratory insufficiency. This improved tissue oxygenation and created internal

fixation of the anterior flail segment, resulting in the disappearance of the paradoxical movement. Chest x-ray films, echocardiography, and abdominal ultrasound examinations were done with portable equipment. There were bilaterally fractured ribs from the 3rd down to the 7th rib, and sites of fractures lie on the anterior axillary line and oblique transverse fractured sternum just below the angle of Lowes. Functional mitral regurgitation was confirmed.

The abdomen was free, and we inserted a nasogastric tube for Ryle feeding on the 2nd day. After hemodynamic stabilization, we added a PEEP of 8 ml. In the early morning of the 6th day, the patient extubated himself. On observation, the patient was not distressed; no hypoxia or paradoxical movements were detected.

There was no need for reintubation. The pansystolic murmur disappeared. On the 7th day, the patient was transferred to the ward. On the 9th day, we discharged the patient and scheduled follow-up visits. Our patient improved and began a physiotherapy regimen for rehabilitation (Table 1, 2).

**The second case:**

A 36-year-old woman was brought to the ER after a severe chest injury. She had severe pain and trouble breathing, using extra muscles to help her breathe. She was hemodynamically unstable. Her TTSS was 21, and her Modified Shock Index was 1.9.

Blood samples were sent to the laboratory for blood typing, troponin I testing, renal and hepatic function tests, and ABG analysis.

We carried the patient to the CT unit. This showed bilaterally fractured ribs from the first to the 10th ribs; fractures were around the midclavicular line on each side; bilaterally fractured clavicles at their middle third; fractured 8th dorsal vertebra; and right-sided moderate hemothorax and left-sided hemo-pneumothorax (Figures 1,2,3).

We admitted the patient to the ICU. Oxygen by mask improved her oxygen levels, and we placed chest tubes on both sides to drain blood and air from her chest. Abdominal ultrasound and echocardiography were normal. That night, her breathing muscles became tired, and her oxygen levels dropped, so she needed to be intubated and put on a ventilator. On the fifth day, neurosurgeons decided to fix her fractured vertebra, and she needed to sleep in the prone position. We asked the anesthetist to keep a PEEP of 8 ml to keep her lungs fully inflated and support her chest wall. The surgery lasted 150 minutes without problems.

After surgery, she was sent back to the ICU. On the ninth day, she was taken off the ventilator and did well with just a mask for oxygen. On the eleventh day, she moved to the ward, and the chest tube was removed. She stayed in the ward for two days and was discharged on the thirteenth day.

We referred her to physiotherapy and the Pain Clinic for chest tightness and pain at the fracture sites (Tables 1 and 2). She had two months of follow-up and improved a lot. In Table 1, we are reporting three cases of isolated blunt chest trauma and anterior flail segments; they are arranged chronologically in the Table:

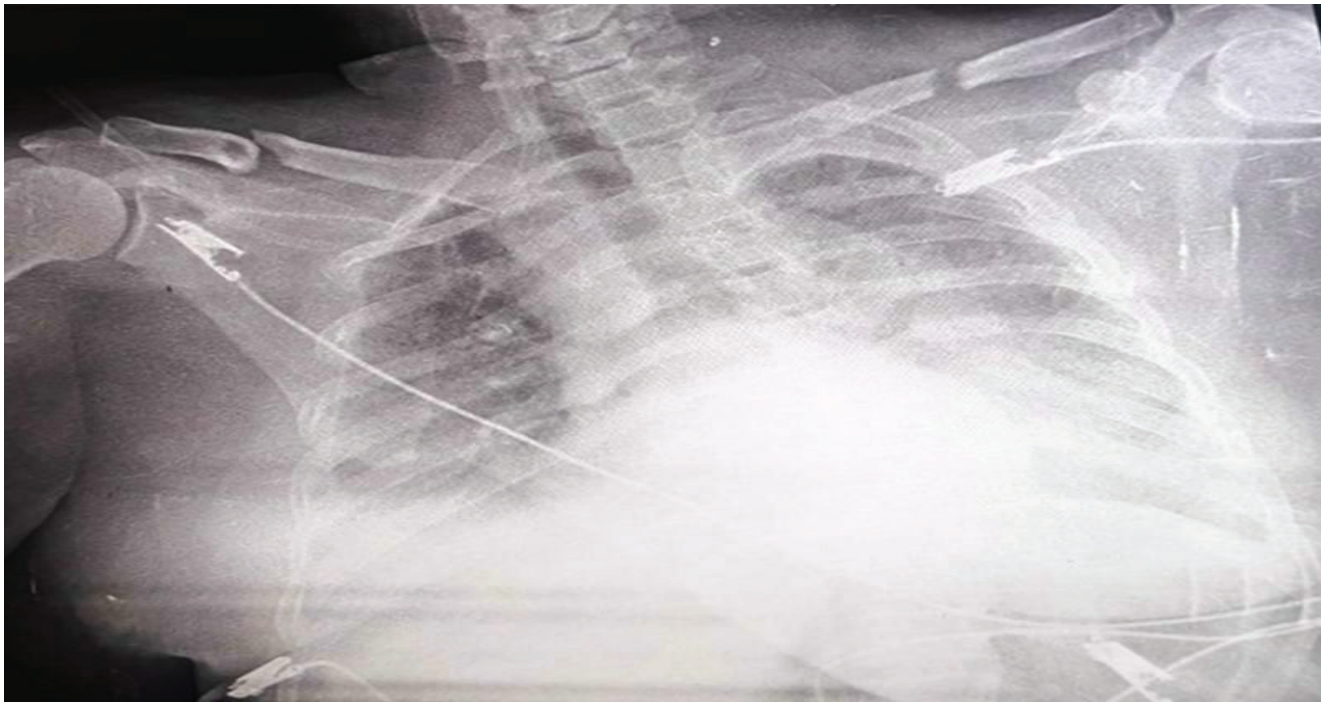

**Figure 1.** Plain X-ray of the chest shows bilaterally fractured clavicles and ribs from the 1st to the 10th ribs.

**Figure 2.** Axial section of CT-chest that shows bilaterally fractured ribs and hemothorax.

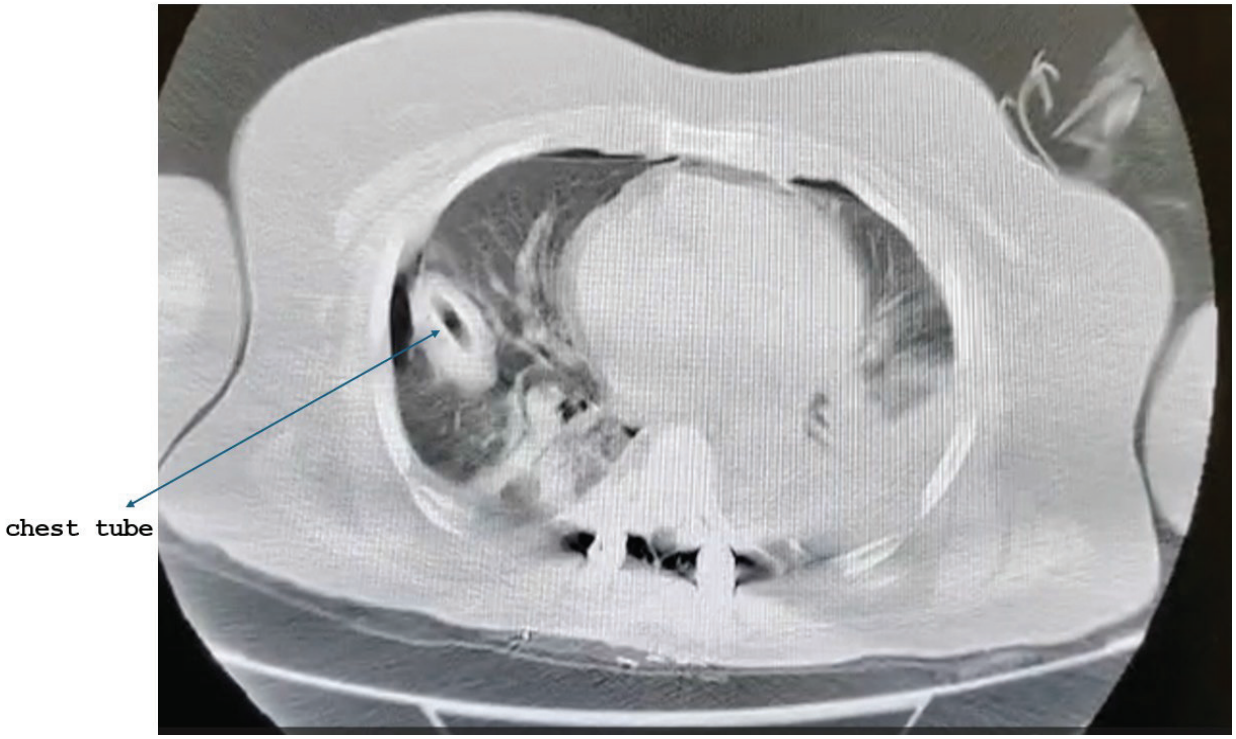


**Figure 3.** Axial section of the pulmonary window of the CT chest that shows the fixed 8th thoracic vertebra, bilaterally fractured ribs, hemothorax, and a chest tube inserted into the right pleural cavity.

**Table 1:** Clinical findings in the Emergency Room:

| Variables | The 1st case | The 2nd case | The 3rd case |
|---|---|---|---|
| **Age in years** | 56 | 36 | 42 |
| **Sex** | man | woman | woman |
| **Smoking, COPD, DM.** | non | non | non |
| **General condition before Trauma** | good | Good | Very good |
| **Heart rate b/min.** | 130 | 140 | 120 |
| **Breathing rate cycles/min** | 30 | 28 | 22 |
| **Systolic blood pressure mmHg** | 90 | 100 | 110 |
| **Diastolic blood pressure mmHg** | 60 | 60 | 70 |
| **Mean blood pressure mmHg** | 70 | 73 | 83 |
| **Modified Shock Index** | 1.8 | 1.9 | 1.48 |
| **Thorax Trauma Severity Score** | 16 | 21 | 8 |
| **Blood Hemoglobin gm%** | 13 | 11 | 12 |
| **Emergency room-duration in minutes** | 15 | 25 | 30 |
| **Fractured ribs** | Bilateral, from the 3rd down to the 7th rib | Bilateral, from 1st to 10th | Bilateral, from 4th to 7th. |
| **Fractured sternum** | Oblique transverse fracture | No | Transverse fracture |
| **Fractured Clavicles** | No | bilateral | no |
| **Fractured vertebra** | No | 8th dorsal vertebra | no |
| **Traumatic cardiac valve Lesions** | Mitral regurgitation | No | no |
| **Hemothorax** | No | Rt side then, late Lt. side | no |

*SBP: Systolic blood pressure, HR: Heart rate. COPD: chronic obstructive pulmonary disease, DM: diabetes*

**Table 2.** Intensive care Unit and outcomes

| Clinical Parameters | Case 1 | Case 2 | Case 3 |
|---|---|---|---|
| Duration of Mechanical Ventilation (Days) | 5 | 9 | Only during Surgical fixation |
| Duration of ICU Stay (Days) | 7 | 11 | 3 |
| Hospital Stay (Days) | 9 | 13 | 5 |
| PEEP (mmHg) | 5 | 6 | 3 |
| Fixation Method | Internal (Pneumatic) | Internal (Pneumatic) | Surgical (Plates/Screws) |
| Operative Intervention | Fixation of 8th vertebra | Insertion of chest tube | ORIF (Sternum/ Ribs) |
| Blood Transfusion | None | None | None |
| Postoperative Follow-up Months | 12.0 | 2.0 | 1.0 |
| Morbidity / Complications | None | Chest pain and tenderness at sites of fractures | None |
| Survival & Quality of Life | Good | Acceptable | Very Good |

MAP = [(DBP x 2) + SBP] / 3; *(DBP - Diastolic Blood Pressure; SBP - Systolic Blood Pressure; MAP: Mean Arterial Pressure; HR- Heart Rate)*
Modified Shock Index = HR /MAP

### The third case

The third case involved fractures of the 4th, 5th, 6th, and 7th ribs on both sides and a transverse fracture of the sternum, 2 cm below the angle of Louis. Transthoracic echocardiography was normal. She developed occasional extra heartbeats, so a cardiac MRI was done, which was also normal. Clinical details are in Tables 1 and 2. She had external fixation with plates and screws for the sternal fracture and the fractured 4th and 6th ribs. Fixing these key ribs restored the chest wall's function. Minimal invasive surgical fixation is not applicable as lines on fractured ribs were around the anterior axillary lines. She was discharged on the third postoperative day. Total hospital stay was 5 days. This reduced cost of hospitalization.

TTSS is calculated by summing the points assigned to five parameters: age, number of rib fractures, pulmonary contusion, pleural involvement, and PaO2/FiO2 ratio. Each parameter is assigned a score of 0 to 5, and the total score ranges from 0 to 25.

Operative Fixation of the anterior flail segment (for this patient): Indications in this case: transverse fracture of the body of the sternum, large anterior flail segment after falling of a heavy object on her chest, failed optimal

analgesia via an epidural catheter, severe hypoxia, and significant chest wall deformity.

Steps: General anesthesia with single lung ventilation (double lumen endobronchial tube). The patient was positioned supine, preserving the periosteum as much as possible. We restored rib curvature and chest wall contour using bone-holding forceps. Fixation of the transversely fractured sternum with a stainless-steel wire. We inserted pre-contoured locking rib fixation plates 70 mm each, fixed with screws of 3.5 mm diameter and 10 mm length, three screws on each side of the fractured 4th and 6th ribs through small lateral incisions, one on each side.

## DISCUSSION

Over the last decade, the use of regional anesthesia and surgical rib fixation has increased in the management of flail chest (2,8). This resulted in lower requirements for and shorter durations of invasive mechanical ventilation and intensive care unit stay, but did not affect mortality in several studies (11,12).

TTSS is often used to assess the severity of thoracic injuries. The TTSS evaluates both anatomical and functional parameters to better predict outcomes. Higher scores indicate greater injury severity, increased probability of mortality, and morbidity. TTSS and Trauma and Injury Severity Score (TRISS) were developed for the purpose of predicting hospital mortality in thoracic trauma. Investigators noticed that TTSS had a direct correlation with need for oxygenation, mechanical ventilation, duration of hospital stay, mortality, or outcome in patients with chest trauma (13).

TRISS is not a specific scoring system for isolated thoracic trauma, e.g., hemothorax and pneumothorax (14). For our patient, the TTSS and the Modified Shok index indicated a severe degree of blunt trauma but a low risk of mortality. We calculated the Modified Shok index by dividing the patient's heart rate by the mean arterial pressure to assess hemodynamic stability. It is used to predict the severity of the condition, the need for massive blood transfusion, in-hospital mortality, and prognosis (15,16).

A TTSS score of 11 and above was associated with poor prognosis (ICU admission and need for mechanical ventilation) and fatal outcome. A higher score is associated with higher morbidity & mortality (Level of evidence: Level 2) (17). Both prehospital and Emergency Room MSIs can be used as predictive markers of clinical progression in these patients (18).

We present three cases of severe isolated blunt chest trauma from road traffic accidents, all with anterior flail chest.

The man was middle-aged and in good health before the accident. He spent only half the expected time in the ICU and on a ventilator, likely because of effective internal fixation, early diagnosis, and prompt treatment. His functional mitral valve regurgitation may have been caused by myocardial commotion (Commotio Cordis), which leads to swelling of the heart valves and surrounding tissue. This is similar to the temporary changes seen in a concussion of the brain.After several years of follow-up, he continues to have a good quality of life, as shown by the WHOQOL indices. As an adult, the woman also had a good quality of life. She had internal fixation and was on a ventilator in the ICU for nine days. She had surgery to fix her fractured dorsal vertebra (see figure 2) while lying in the prone position, which she tolerated well with 8 ml PEEP on the ventilator. It is generally true that the shape of the chest wall follows the shape of the lungs, since they develop together and interact throughout life (19).).

Some investigators reported that significant head injury was present in 15%, while 54% had lung contusion. Treatment practices included epidural catheters in 8% and surgical fixation of the chest wall in 0.7% of the patients. Mechanical ventilation was required in 59% of cases, for a mean of 12.1 days. ICU admission was required in 82% of cases, for a mean of 11.7 days.

Chest tubes were used in 44%, and 21% required a tracheostomy.

Complications included pneumonia in 21% of cases, adult respiratory distress syndrome in 14%, sepsis in 7%, and death in 16%. The evidence shows that many patients do better with good pain control and lung care (including medical treatment for lung injuries) than with mechanical ventilation. This is still the standard approach. Mechanical ventilation is used only for patients who continue to have breathing problems after pain is managed or if there are complications from too much narcotic use. Patient-controlled analgesia (PCA) machines, oral pain medicines, and epidural catheters are the main treatments now.

Two recent clinical reports, one from Turkey (prospective) (20)and one from Japan (retrospective),(9) showed that continuous positive airway pressure (CPAP) by mask may decrease mortality and nosocomial pneumonia in the ICU, but CPAP by mask does not appear to change the length of ICU stay. (21, 22)

Given the high rates of morbidity and mortality in patients with flail chest injury, alternate methods of treatment include more consistent use of epidural catheters for pain control and surgical fixation of fractures, as we did for the last patient in these few case series of 26-year duration.

## CONCLUSIONS

In the past decade, regional anesthesia and surgical rib fixation have been used more often to treat flail chest. Using mechanical ventilation with PEEP for internal fixation appears to be an effective way to manage anterior flail chest. External fixation has also helped shorten ICU and hospital stays and lower the risk of complications.

**Editorial Statements**

**Ethics Approval and Consent to Participate**

This study involved the analysis of data from human participants. The research protocol was reviewed and approved by the Institutional Ethics Committee and was conducted in accordance with institutional regulations, the principles of the Declaration of Helsinki, and internationally accepted standards for biomedical research ethics.

**Data Availability Statement**

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

**Author Contributions (CRediT)**: Conceptualization & Methodology: EHD, MSH; Data Curation, Investigation & Writing – Original Draft: AHE: Formal Analysis: HSH, MSH: Writing – Review & Editing: EHD, AHE: Supervision: EHD. All authors have read and approved the final version of the manuscript.

**Artificial Intelligence (AI) Statement**

The authors used a generative artificial intelligence tool solely for language editing and grammar improvement. All scientific content, data analysis, interpretation, and conclusions were independently developed, verified, and approved by the authors.

**Funding:** This research received no specific grant from any funding agency in the public, commercial, or notfor-profit sectors.

**Conflict of Interest:** The authors declare that they have no competing interests or conflicts of interest related to this study.

**Acknowledgements:** The authors thank all the healthcare professionals at our institution whose work contributed to the development of evidence-based data, regarding our article.

## REFERENCES

1. Halvachizadeh S, Mariani D, Pfeifer R. Impact of trauma on society. Eur J Trauma Emerg Surg. 2025 Mar 26;51(1):155. doi: 10.1007/s00068-025-02824-8. PMID: 40140090; PMCID: PMC11946998.
2. Coccolini, F., Cremonini, C., Moore, E.E., et *al.*Thoracic trauma WSES-AAST guidelines.*World J Emerg Surg 20,* 78 (2025). https://doi.org/10.1186/s13017-025-00651-1
3. Jain A, Waseem M. Thoracic Trauma. [Updated 2026 Feb 15]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK482194/
4. Queensland Health. (2021).Blunt chest trauma: Clinical guideline. ClinicalExcellence Queensland. https://clinicalexcellence.qld.gov.au/sites/default/files/docs/clinical-networks/blunt-chest-trauma-guideline.pdf
5. Yimam, Abubeker Eshetua; Mustofa, Salh Yalewb,*; Gebregzi, Amare H/kirosb; Aytolign, Habtu Adaneb. Mortality rate and factors associated with death in traumatic chest injury patients: A retrospective study. IJS Open 37():p 100420, December 2021. | DOI: 10.1016/j.ijso.2021.100420
6. Perera TB, Alahmadi MH, King KC. Flail Chest. [Updated 2025 Jun 22]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK534090/
7. Sermonesi, G., Bertelli, R., Pieracci, F.M.*et al.*Surgical stabilization of rib fractures (SSRF): the WSES and CWIS position paper.*World J Emerg Surg***19**, 33 (2024). https://doi.org/10.1186/s13017-024-00559-2
8. Bloomer R, Willett K, Pallister I. The stove-in chest: a complex flail chest injury. Injury. 2004 May;35(5):490-3. doi: 10.1016/S0020-1383(03)00291-2. PMID: 15081326.
9. HENRY L. Case of stove-in chest injury. Br Med J. 1957 Aug 10;2(5040):339. doi: 10.1136/bmj. 2.5040.339. PMID: 13446475; PMCID: PMC1961988.
10. Meyer, C. H., Aworanti, E., Santos, A., Castater, C., Bauman, Z. M., Archer-Arroyo, K., Sola, R., Jr, Grant, A., Smith, R. N., Sciarretta, J. D., & Nguyen, J. H. (2024). Is Traumatic Anterior Stove-In Chest Truly so Rare? A Single Institution Experience. *The American surgeon*,*90*(4), 695–702. https://doi.org/10.1177/00031348231209530
11. Marasco, S. F., Nguyen Khuong, J., Fitzgerald, M., Summerhayes, R., Sekandarzad, M. W., Varley, V., Campbell, R. J., & Bailey, M. (2023). Flail chest injury-changing management and outcomes. European *journal of trauma and emergency surgery: official publication of the European Trauma Society*,*49*(2), 1047–1055. https://doi.org/10.1007/s00068-022-02152-1
12. El-Aziz, Tamer F.A.a; El Din Abdallah, Abdallah S.a; Abdo, Alaa G.A.b,; El-Hag-Aly, Mohammed A.c. Thorax trauma severity score and trauma injury severity score evaluation as outcome predictors in chest trauma. Research and Opinion in Anesthesia and Intensive Care 9(2):p 112-118, Apr–Jun 2022. | DOI: 10.4103/roaic.roaic_6_21
13. Ziegler, D. W., & Agarwal, N. N. (1994). The morbidity and mortality of rib fractures.*The Journal of Trauma,37(6),* 975–979. https://doi.org/10.1097/00005373-199412000-00018
14. Dogjani, A., Haxhirexha, K., Gjata, A., & Subashi, K. (2023). Optimizing Chest Trauma Management: Strategies and Guidelines.*Albanian Journal of Trauma and Emergency Surgery*,*7*(2.7), 32-33. https://doi.org/10.32391/ajtes.v7i2.7.370
15. Liu, Y. C., Liu, J. H., Fang, Z. A., Shan, G. L., Xu, J., Qi, Z. W., Zhu, H. D., Wang, Z., & Yu, X. Z. (2012). Modified shock index and mortality rate of emergency patients.*World journal of emergency medicine*,*3*(2), 114–117. https://doi.org/10.5847/wjem.j.issn.1920-8642.2012.02.006
16. Gupta SK, Mishra SP, Mishra M, et al. Determining

the cutoff for the thoracic trauma severity score for predicting the outcome following blunt thoracic trauma in an Indian population presenting to a level 1 trauma center. *Trauma*. 2025; 27(3):196-204. doi:10.1177/14604086241308715

17. Cannon, C. M., Braxton, C. C., Kling-Smith, M., Mahnken, J. D., Carlton, E., & Moncure, M. (2009). Utility of the shock index in predicting mortality in traumatically injured patients.*The Journal of Trauma,67(6),* 1426–1430. https://doi.org/10.1097/TA.0b013e3181bbf728
18. Donley ER, Holme MR, Loyd JW. Anatomy, Thorax, Wall Movements. [Updated 2024 Mar 13]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-.Available from: https://www.ncbi.nlm.nih.gov/books/NBK526023/
19. Gunduz, M., Unlugenc, H., Ozalevli, M., Inanoglu, K., & Akman, H. (2005). A comparative study of continuous positive airway pressure (CPAP) and intermittent positive pressure ventilation (IPPV) in patients with flail chest.*Emergency medicine journal: EMJ*,*22*(5), 325–329. https://doi.org/10.1136/emj.2004.019786
20. Andrikopoulou, C., Selmani, E., Leivaditis, V., Antzoulas, P., Tasios, K., & Liolis, E. et al. (2026). Operative management of unstable sternal fracture in polytrauma: a case report and literature review. Kardiochirurgia i Torakochirurgia Polska/Polish Journal of Thoracic and Cardiovascular Surgery, 23(1), 56-63. https://doi.org/10.5114/kitp.2026.160556
21. Tanaka, H., Tajimi, K., Endoh, Y., & Kobayashi, K. (2001). Pneumatic stabilization for flail chest injury: an 11-year study.*Surgery today*,*31*(1), 12–17. https://doi.org/10.1007/s005950170213
22. Althausen, P. L., Shannon, S., Watts, C., Thomas, K., Bain, M. A., Coll, D., O'Mara, T. J., & Bray, T. J. (2011). Early surgical stabilization of flail chest with locked plate fixation.*Journal of Orthopedic Trauma*,*25*(11), 641–647. https://doi.org/10.1097/BOT.0b013e318234d479