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ORIGINAL ARTICLE

Emergency department management of patients with thoracic trauma: PRISMA scoping review

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ABSTRACT

The prognosis for patients with thoracic trauma depends largely on the management presented in the emergency department (ED), along with other major factors. This PRISMA scoping review explored ED management for patients with thoracic trauma. A systematic review study was conducted and initially, 157 articles were identified through database research. After screening, following the inclusion and exclusion criteria, and checking for other eligibility conditions, the studies were reduced to 11 articles. Each included study was assessed for quality independently by two reviewers using a modified form of the quality assessment of diagnostic accuracy studies (QUADAS-2). The survival rate following emergency thoracotomy is approximately 9%-12%, whereas, for blunt trauma, the survival rate is 1%-2%. 85% of patients may be treated by emergency physicians after employing minor procedures. The frequency of hospitalization reduced to 24% from 49% along with a decline in the duration of hospitalization. The diagnostic accuracy for ultrasonography (US) is 80% with sensitivity and specificity for any rib fracture, whereas the efficacy of computed tomography scans for independent use is controversial. The findings outlined that the management given in the ED to the patients with thoracic trauma is significantly effective witnessing the decline in the rate of hospitalizations as well as hospital re-admissions, duration of hospital stay, and mortality rate. However, diagnostic tools are still surrounded by controversies and contradictory results, which need intensive investigation to guarantee the validation of the diagnosis.

Keywords: Thorax, trauma, emergency departments, ultrasonography.

Introduction

Trauma poses a significant global health challenge and it is ranked as the third leading cause of death among adults worldwide [1]. Among trauma-related fatalities during the early stages of life, thoracic trauma accounts for 24% of all trauma-related deaths. Managing patients with thoracic trauma in the emergency department (ED) involves rapidly assessing the airway, breathing, and circulation. Imaging tests such as chest X-ray, computed tomography (CT) scan, and ultrasound can help identify the extent and severity of the injury. Also, pain control and oxygen therapy are essential to improve respiratory function and comfort the patient. Thoracic trauma may significantly increase the likelihood of death when combined with polytrauma. Pneumothorax, hemothorax, a flail chest, or lung contusions are all ailments that might make it more challenging to care for a patient [2].

The prognosis of thoracic trauma depends on the thoracic aorta, cardiac chambers, esophagus, diaphragm, and inferior and superior vena cava, which could result in high morbidity and mortality rates if not managed probably [3]. Additionally, the prognosis for patients with thoracic trauma is affected by age, gender, pre-existing health conditions, and medications taken for other pre-existing conditions. The management of specific trauma varies depending on the type and severity of the injury

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[4]. A multidisciplinary team approach is essential to provide optimal care for these critically ill patients. Early recognition and appropriate management can help improve outcomes and prevent complications in patients with thoracic trauma [5].

Overall, managing patients with thoracic trauma in the ED requires a comprehensive and systematic approach to ensure the early identification of life-threatening trauma and appropriate management. However, the current evidence supporting such practices is limited or has contradictions in its efficacy. Therefore, this study aims to provide a systematic review of ED management for patients with thoracic trauma. This study would help to a clear understanding of optimal ED management, addressing controversies in pre-hospital treatment, variations in surgical interventions, pain management techniques, and subsequent mortality rates. It is likely to provide invaluable insights to enhance the care and outcomes of patients suffering from thoracic trauma in the ED.

Methods

Search strategy

A comprehensive search process was implemented to identify relevant and appropriate articles on the management of thoracic trauma patients in the ED. The various online databases utilized included PubMed, Cochrane Library, Google Scholar, MEDLINE, and Web of Science. The articles searched for review were from the years 1984 to 2021. The keywords used to extract relevant studies were "thoracic trauma," "emergency department management," and "chest wall trauma." A total of 157 relevant studies were obtained initially, which was reduced to 11 after excluding articles due to duplication and not meeting inclusion criteria. Out of 157 studies, 59 were found duplicates; thus, removed. The remaining (n = 98) records were screened by title and abstract). Records were excluded for not matching inclusion criteria were excluded (n=64). Subsequently, 34 full-text articles were reviewed for eligibility out of which 12 studies were removed due to incomplete data and 11 studies were not considered as the data request was not entertained by their author(s). Hence, the sample size of this scoping review was 11 studies.

A title and abstract screening were performed by two independent reviewers using Rayan (https://rayyan.qcri.org/). Articles considered potentially relevant to this review were subject to full-text assessment for eligibility. The reviewers then extracted data from the eligible studies to a structured table that included information on the following: First author name, publication year, country, study design, population, and sample size. At each step, a third reviewer checked for accuracy and consistency. Disagreements were solved by discussion and consensus between reviewers. A robust search strategy was conducted to ensure comprehensive findings to contribute to the understanding of the management of thoracic trauma patients in ED.

Inclusion and Exclusion Criteria

The key search terms were used to retrieve the required studies. All of the articles were screened by title and abstract to identify and exclude duplicate records, which decreased the number of articles to 98. The researchers included studies based on the human population irrespective of their age, and studies written in the English language. Also, the studies focusing on the clinical characteristics of the patients with thoracic trauma who were taken to ED management were included. The study which recruited the patients who were not taken to or had not received interventions in the ED, or were not in the English language were excluded. Studies were also omitted based on having a small sample size. After the screening and exclusion process, the final data set of 11 studies was selected by the researchers for a systematic review of the management of thoracic trauma patients in the ED. Furthermore, this study adhered to the standard guidelines of PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) to ensure the credibility and transparency of the study. The PRISMA flowchart is presented below which demonstrates the process of article selection (Figure 1).

Risk of bias (quality) assessment

Each included study was assessed for quality independently by two reviewers using a modified form of the QUADAS-2 criteria to meet the needs. Three domains of this tool were assessed: patient selection, index test, and flow and timing.

The study underwent a thorough risk of bias assessment across all three domains. Furthermore, applicability was evaluated solely for patient selection and index tests. Tailored signaling questions were included to aid in bias risk judgment. A third reviewer ensured the accuracy and consistency of the assessment.

Results

Table 1 outlines the review of findings from the selected studies. The summary of each study is presented highlighting the study design, study setting, sample size, presentation and management of thoracic trauma patients, outcomes, and conclusion. These studies explored surgical interventions, pain management techniques, protocols of resuscitation, settings, and the efficacy of management in ED.

A retrospective study was conducted by Coats et al. [7] to assess the pre-hospital management of patients with severe thoracic injury. They examined 1,048 patients from 1991 to 1992, who were presented with severe injuries to the chest. Those patients were broadly managed with needle decomposition and thoracic drainage. The specific treatment given to those patients was intensive pre-hospital resuscitation along with airway management while providing volume and oxygen supplemental replacement. The treatment resulted in significant improvement in the patient's pulse, blood pressure, and oxygen. The findings also demonstrated that needle chest decomposition independently is not enough for the treatment in ED.

Table 1. *Outline of the articles reviewed.*

S. No.	Authors	Year	Study Setting	Study design	Sample Size	Presentation	Management	Outcome	Conclusion
1	Mattox and Allen [6]	1984	USA	Review article	-	Thoracic trauma	Minor procedures employed by emergency physicians	This study showed up to 50% of deaths occurred due to chest injuries, however, the link between them could be direct or indirect. Notably, 85% of patients may be treated by emergency physicians after employing minor procedures.	This research concluded that the majority of patients with chest injuries can be managed by the physicians in the emergency department by utilizing minor procedures.
2	Coats et al. [7]	1995	UK	Retrospective cross-sectional	1048 patients	Severe injuries, causing thoracic trauma. The thoracic drainage procedure was performed between 1 January 1991 and 31 June 1992.	Thoracic drainage & needle decompression	Thoracic drainage was used as part of intensive prehospital resuscitation of patients with a severe chest injury, being combined with airway management, supplemental oxygen, and volume replacement. This treatment leads to significant improvement in physiology.	This study highlights the importance of using standard ATLS protocols for pre-hospital treatment of patients with severe chest injury, which results in significant improvements in oxygen saturation, blood pressure, and pulse. Whereas, needle chest decompression alone is not an adequate treatment in the emergency department.
3	Greenberg and Rosen [8]	1999	Boston	Evidence-based approach	-	Blunt thoracic trauma	Diagnosis via computed tomography scan	This research revealed that the current state of CT scan technology cannot be used independently for imaging the aorta in the patient.	This study concluded that there is a need to further search for noninvasive and quick methods for identifying the diagnosis of traumatic aorta injury. Also, the disparity surrounding the requirement to make the diagnosis in patients with blunt chest trauma needs to be clarified.
4	Hunt et al. [9]	2005	UK	Review article	-	Thoracic trauma	Emergency department	This review outlined the prevalence of thoracic trauma of 20%-25% among all traumatic injuries, suggesting it to be one of the common causes of death in all age groups.	The review concluded that the need for emergency thoracotomy during initial resuscitation is observed in small but significant cases. The suggested procedures during emergency thoracotomy are control of massive air embolism, direct control of intrathoracic hemorrhage, open cardiac massage, evacuation of pericardial tamponade, and cross-clamping of the descending aorta.
5	Menditto et al. [10]	2012	Italy	Pre-post observational study	110 pre – 130 post	**isolated blunt thoracic trauma** at high risk of pulmonary complications	Emergency Department Observation Unit (EDOU) with routine care.	The pre-and post-EDOU showed that the frequency of hospitalization reduced to 24% from 49% along with a decline in the duration of hospitalization.	The research revealed that EDOU is more efficacious with little impact on cost as compared to routine care.
6	Roodenburg and Roodenburg [11]	2014	-	Review article	-	Thoracic trauma	Resuscitation process with tube thoracostomy (or finger thoracostomy): an intercostal catheter (ICC) is placed in the mid-axillary line at the fourth or fifth intercostal space.	This study showed the need for immediate resuscitation along with further management for patients with thoracic trauma.	This article summarized the injuries of thoracic trauma including massive haemothorax, tension pneumothorax, airway injury, open pneumothorax, flail chest, and lung contusion.

Continued

S. No.	Authors	Year	Study Setting	Study design	Sample Size	Presentation	Management	Outcome	Conclusion
7	Hamilton et al. [12]	2017	USA	Retrospective study	233 patients	Rib fracture	Clinical procedure guidelines.	This research revealed that the most common cause reported for chest injury is fall (59.6%), and the median for the rib fractures and FVC was 2 and 2,500 ml respectively.	This study showed that the criteria for discharging patients include FVC of 1,500 ml rib fracture patients. More research is required to reduce the return rate to ED using CPG.
8	Schellenberg and Inaba [13]	2018	USA	Review article	-	Thoracic trauma	Invasive bedside procedures.	Many thoracic injuries can be managed nonoperatively. Invasive bedside procedures, such as chest tube placement, are critical skills for all emergency medicine physicians who treat trauma patients.	This study emphasized the importance of familiarity with imaging options for further assessment of thoracic trauma along with the need for the physician to be equipped with the skills for quickly placing chest tubes, decompressing tension pneumothoraces, and performing RT. Quick management of life-threatening injuries would make the ED physician adequately manage the patients.
9	Aseni et al. [14]	2020	Italy	A narrative review	7,236 patients	Thoracic trauma	EDRT	The findings of this review showed that 7.8% of 7,236 patients survived after receiving EDRT, along with indicating the signs to note to perform EDRT. Those conditions included cardiopulmonary arrest, Penetrating trauma with the presence of vital signs at the trauma center.	This study emphasized the reservation of EDRT specifically for acute resuscitation of dying patients with thoracic trauma. This review also pointed out the necessary cautions to be ensured before performing the surgical procedures including assessing its benefits, costs, and risks of futility.
10	Celik et al. [15]	2021	Turkey	Prospective observational study	145 patients	ED with thoracic pain after blunt chest trauma in the last 24 hours.	ED	The prospective observation showed that the diagnostic accuracy of ultrasonography (US) is 80% with the sensitivity and specificity for any rib fracture detection of 91.2% and 72.7% respectively, which increases to 81.3% if each rib is evaluated independently.	A negative US of the location of the highest bruising and neighboring ribs in a patient with BCT and lateralizing pain at ED decreases the possibility of a rib fracture significantly.
11	Muhamed et al. [16]	2023	USA	Retrospective cross-sectional	81	Blunt thoracic trauma	Emergency department observation unit	This study demonstrates the potential use of EDOUs to treat patients with mild to moderate blunt thoracic injuries. The availability of trauma surgeons for consultation along with ED provider experience may be rate-limiting steps in utilizing observation units to care for trauma patients. Additional research with more participants is needed to determine the impact of implementing such a practice at other institutions	The research highlights the need to consider EDOUs to treat patients with mild to moderate blunt thoracic injuries, which could be carried out in other settings, for instance, trauma centers where trauma surgeons and emergency physicians are available.

Critical decisions encountered in the management of patients with thoracic injury were evaluated by Schellenberg and Inaba [13]. In their review article, they emphasized the importance of rapid clinical examination to screen traumatic injury to the chest for every trauma patient. The screening procedures in the ED must include pain radiographs, ultrasound, and CT scans, along with emergency medicine physicians to be familiar with the pitfalls and indications of each. Also, equally crucial for emergency medicine physicians is to be well-equipped with the critical skills to perform resuscitative thoracotomy and chest tube placement. Schellenberg and Inaba [13] noted that many thoracic injuries can be treated non-operatively.

The efficacy of emergency department observation units (EDOUs) in managing traumatic injury patients was assessed in the study carried out by Muhamed et al. [16]. It was a retrospective analysis comparing pre- and post-EDOUs groups while controlling patients' gender, age, and injury severity scores (ISSs). A protocol for the management of blunt chest injuries was developed by the trauma and acute care surgery team along with the ED team. The utilization of the designed protocol resulted in a statistically shorter span of hospital stay while stratifying the risk by ISS. However, the protocols did not guarantee 100% results, as relapses for both groups were reported.

Hunt et al. [9] presented a review on emergency thoracotomy presented to trauma victims with thoracic injury. They noted that pre-hospital resuscitation, which is part of emergency thoracotomy, is required in a small but significant number of cases. While a significant number of cases are managed by other means. Given that, the initial resuscitation process involves direct control of intrathoracic hemorrhage, open cardiac massage, evacuation of pericardial tamponade, control of massive air embolism, and cross-clamping of the descending aorta. The survival rate following emergency thoracotomy is approximately 9%-12%, whereas, for blunt trauma, the survival rate is 1%-2%.

A narrative review presented by Aseni et al. [14] outlined accepted indications, surgical procedures adopted, technical details, and outcome of emergency department resuscitative thoracotomy (EDRT), by accessing literature from multiple databases available from 1975 to 2020. They found that the survival rate after receiving EDRT was 7.8% for 7,236 patients. The important indications to note for performing EDRT were reported, which included witnessed cardiopulmonary arrest with the presence of vital signs and penetrating trauma. They concluded that EDRT should be performed for acute resuscitation of selected dying trauma patients while assessing the costs, risks of futility, and benefits of the surgical procedures.

The efficacy of CT scans and plain chest radiography in diagnosing chest walls and selected pulmonary injuries was examined in an evidence-based approach conducted by Greenberg and Rosen [8]. They noted that the patterns of practice in the intervention procedures have been observed to be based on local practice and the opinions of the experts. This research revealed that the current state of CT scan technology cannot be used independently for imaging the aorta in the patient, indicating to further search for noninvasive and quick methods to identify the diagnosis of traumatic aorta injury. Also, the disparity surrounding the requirement to make the diagnosis in patients with blunt chest trauma (BCT) needs to be clarified.

The study by Roodenburg and Roodenburg [11] also outlined the summary of injuries in thoracic trauma, clinical approaches, and investigation. The injuries that are part of thoracic trauma include open pneumothorax, pericardial tamponade, cardiac injuries, diaphragmatic injury, oesophageal rupture, tension pneumothorax, massive haemothorax, pericardial tamponade, fail chest, cardiac injuries, and lung contusion. On the management part, much emphasis has been found on immediate resuscitation along with some other management.

Mattox and Allen [6] observed, while reviewing articles on treatment for chest injuries in ED, that 50% of deaths are caused by chest injuries. However, the link between them could be direct or indirect. Notably, 85% of patients may be treated by emergency physicians after employing minor procedures.

Another retrospective study on 233 patients conducted by Hamilton et al. [12] evaluated the compliance and efficacy of emergency medical physicians in following the clinical practice guidelines (CPGs) for ED management of victims with rib fractures. A CPG is a tool designed for triage of patients with rib fractures which is based on forced vital capacity (FVC). They found that the chances of returning to ED decline with high FVC and increasing age while using CPGs. The findings validated that CPG for rib fracture and an FVC of 1,500 ml are safe indicators for discharging the patients.

The management of the EDOU of blunt thoracic trauma was assessed by Menditto et al. [10] in a retrospective pre-post observational study conducted on 240 patients, by considering length of hospital stay, tube thoracostomy, cost-effectiveness, frequency of hospital admission and re-admission, as well as rate of mortality. The findings showed a significant decline in the rate of hospitalizations as well as hospital re-admissions and duration of hospital stay after receiving management in EDOU, indicating the proven efficacy of the treatment given to traumatic victims in EDOU. However, no significant changes were observed in cost-effectiveness in the before- and after-EDOU period.

Çelik et al. [15] assessed the diagnostic accuracy of ultrasonography (US) for the diagnosis of rib fractures in patients presenting to ED with BCT in a prospective observational study on 145 patients. The efficacy of the US was assessed by comparing it with the results of a CT scan. The results demonstrated that the diagnostic accuracy of US is 80% to identify any rib fracture. However, the diagnostic accuracy of the US increases to 81.3% when each rib is considered separately.

These findings highlight the protocols of resuscitation and other interventions, patient outcomes, and satisfaction as a result of receiving management in the ED. These studies also showed the pain management techniques, assessment tools, and surgical interventions

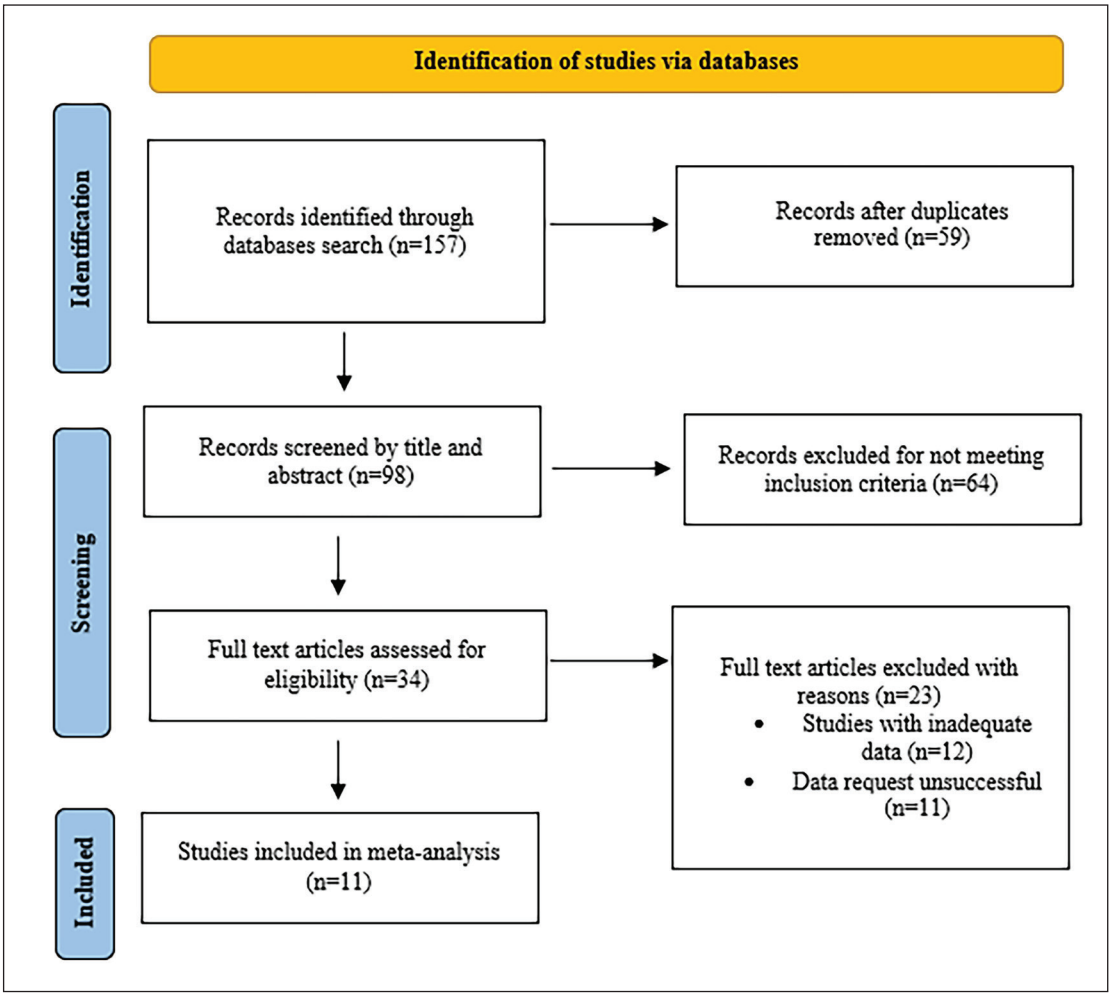

Figure 1. *Search strategy (PRISMA flow diagram) for identification of studies via databases.*

that have been deployed for the treatment of traumatic patients with thoracic injuries, along with providing a nuanced understanding of the efficiency of the tools and interventions contributing to the progress of handling of chest related injuries to ensure high survival rates.

Discussion

The selected studies revealed valuable insights into the various aspects of thoracic trauma care, including surgical interventions, pain management techniques, resuscitation protocols, and patient outcomes. The fact mentioned by Roodenburg and Roodenburg [11] is that chest injuries accounted for 20%-25% of deaths as a result of trauma. This indicated the immediate attention for rigorous evaluation of the interventions being given to the patients with thoracic injury, diagnostic tools used for assessment along with considering their efficiency, and credibility of the emergency medicine physicians to manage the patients in the ED to decrease the mortality rate. The present study has examined the dynamics of management presented in ED by reviewing the studies conducted concerning the injuries of thoracic trauma, surgical interventions, pain management techniques, and assessment tools.

Trauma to the thorax includes many injuries that require thorough consideration while giving pre-hospital management, for instance, open pneumothorax, pericardial tamponade, cardiac injuries, diaphragmatic injury, oesophageal rupture, tension pneumothorax, massive haemothorax, pericardial tamponade, fail chest, cardiac injuries, and lung contusion [11].

Schellenberg and Inaba [13] pointed out the screening procedures in the ED before initiating the management of patients injured with thoracic trauma. According to the study, the diagnostic tools must include pain radiographs, US, and CT scans. The diagnostic accuracy of the US has been tested by comparing it with the results of a CT scan. US was found with 80% and 81.3% diagnostic accuracy when it is used to identify any rib fracture and to consider each rib independently [15]. The efficiency of a CT scan has been questioned as it cannot be used separately for imaging the aorta in the patient [8]. Given that, it is vital for emergency medicine physicians to be familiar with the pitfalls and indications of diagnostic tools to adequately interpret their readings and subsequently adopt interventions for traumatic patients. Nevertheless, a further search for swift and noninvasive methods is warranted to avoid negligence in diagnosing the aorta injury caused by trauma [8].

Other than the diagnostic tools, the effectiveness of the procedures introduced in the management along with the efficacy of the emergency medicine physicians has to be ensured by keeping it on the same horizon of importance, as it has been noted by Greenberg and Rosen [8] that the most of interventions procedures are based on the local practice and opinions of the experts. Schellenberg and Inaba [13] threw light on the healthcare providers to possess critical skills to execute resuscitative thoracotomy and chest tube placement. Given that, 85% of patients may be treated by emergency physicians after employing minor procedures, while many thoracic injuries can be treated with procedures other than surgical operations [7]. Moreover, along with some other management, immediate resuscitation as a part of emergency thoracotomy is equally emphasized [11]. Initial resuscitation has been found as a significant means for the management of thoracotomy in ED [9,14]. The survival rate following emergency thoracotomy is approximately 9%-12%, whereas, for blunt trauma, the survival rate is 1%-2 % [9].

However, there are crucial signs that need to be considered, like cardiopulmonary arrest with the presence of vital signs and penetrating trauma, before applying resuscitation. Aseni et al. [14] also pointed out a few other things to assess before opting for thoracotomy including risks of futility and benefits of the surgical procedures. Notably, the cost-effectiveness of the EDOU in the before- and after-EDOU period has been noted to be insignificant [10].

While there are other significant methods for the treatment of patients with thoracic trauma utilized in other studies is a designed protocol developed by the trauma and acute care surgery team along with the ED team [16]. The designed tool has been tested for its validity, which resulted in a decline in the duration of hospitalization when the risk for ISS is segregated. Nonetheless, few cases of revisits to hospitals were reported after following the developed protocols by the experts. Further interventions as a part of ED management have been assessed, such as needle decomposition and thoracic drainage, intensive pre-hospital resuscitation along airway management, while providing volume and oxygen supplemental replacement, which proved to be significant techniques in causing improvement in patient's pulse, blood pressure, and oxygen [7]. However, needle chest decomposition independently is not enough for the treatment in ED [7]. Another effective method was the utilization of a CPG, a tool for patients with rib fractures based on FVC. It decreases the likelihood of returning to ED with high FVC and older age [12].

However, there are certain limitations of this systematic review study. This systematic review considers the information presented in review articles, which introduces the possibility of bias, as these reviews rely on the authors' choices and interpretations. It's important to note that review articles might contain duplicated data, a factor that requires careful consideration during the selection process to avoid incorporating redundant findings.

Conclusion

In conclusion, the comparisons among the findings demonstrate the significance of effective management strategies administered in the ED for patients suffering from thoracic trauma. The effectiveness of the management administered to patients with thoracic trauma in the ED is evident through its role in reducing hospitalization rates, hospital re-admissions, the duration of hospital stays, and overall mortality rates. However, diagnostic tools are still surrounded by controversies and contradictory results, which need intensive investigation to guarantee the validation of the diagnosis.

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List of Abbreviations

BCT	Blunt chest trauma
CPGs	Clinical practice guidelines
CT	Computed tomography
ED	Emergency department
EDOU	Emergency department observation unit
EDRT	Emergency department resuscitative thoracotomy
FVC	Forced vital capacity
ISS	Injury severity scores
QUADAS-2	Quality assessment of diagnostic accuracy studies
US	Ultrasonography

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