*Emergency Medicine Australasia*

ORIGINAL RESEARCH

# Non-Invasive Management of Blunt Traumatic Pneumothorax—a Meta-Analysis

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**Received:** 23 April 2025 | **Revised:** 24 September 2025 | **Accepted:** 13 October 2025

## ABSTRACT

**Background and Importance:** Traumatic pneumothoraces occur in 25% of patients sustaining traumatic chest injury. Tube thoracostomy carries a risk of major complications leading to the necessity of tube thoracostomy insertion for traumatic pneumothoraces to be challenged.

**Objectives:** This meta-analysis analyses current evidence relating to the management of traumatic pneumothorax and synthesises the evidence to determine whether clinicians can safely omit tube thoracostomy in patients with traumatic pneumothorax presenting to the Emergency Department (ED).

**Design:** This meta-analysis was performed by searching electronic databases. Papers were included for analysis if they used patients sustaining blunt trauma and compared tube thoracostomy to conservative management. Comparisons were made for those undergoing tube thoracostomy and those undergoing conservative management.

**Main Results:** Fourteen studies comprising 1550 patients were included. There is a non-significant combined pneumothorax progression rate of 12% for those observed, and 7.6% for those with a tube thoracostomy ($p = 0.8447$) with an odds ratio of 1.33. There was an 11.9% rate for tube thoracostomy insertion among patients observed, and a 10.4% requirement for further tube thoracostomy placement in those already with a tube thoracostomy ($p = 0.3436$) with an odds ratio of 0.553. For patients receiving positive pressure ventilation, the rates were 18% in observed patients compared to 9% of those with a tube thoracostomy ($p = 0.2848$) with an odds ratio of 4.123.

**Conclusions:** Conservative management of traumatic pneumothorax without positive pressure ventilation is a reasonable initial safe approach in the ED. Only ~12% of these patients will eventually require a tube thoracostomy.

## 1 | Introduction

Trauma is the leading cause of death in patients under the age of 35 in the United Kingdom (UK) [1] and the third commonest cause of death worldwide [2].

Blunt chest injuries comprise 10%–15% of all traumas, with blunt trauma accounting for 90% of chest trauma in Europe and the United States of America (US) [3]. Chest injuries are the cause of death in 25% of the 150,000 annual trauma fatalities [4] and are a major contributor to 50% of them [3]. Indeed, chest injuries are the second leading cause of death in all trauma patients, preceded only by head injuries.

As a result, one key priority of the initial primary survey of trauma patients is to identify and treat life-threatening thoracic injuries.

A serious consequence of chest trauma is pneumothorax (PTX), a condition that can quickly become life-threatening and require immediate treatment. Studies have reported traumatic pneumothoraces occurring in 21%–34% of patients who sustain a traumatic chest injury [4].

However, as opposed to patients with a spontaneous PTX, no professional society guidelines exist for the care of patients with a traumatic pneumothorax (TPTX).

Percutaneous tube thoracostomy (TT) remains the most widely performed procedure for managing blunt and penetrating chest trauma [3]. However, there is evidence that fewer than 10% of blunt chest injuries and 15%–30% of penetrating chest injuries require TT [5]. Advanced trauma life support (ATLS) guidelines state that "observation … of an asymptomatic pneumothorax may be appropriate" [6]. TT is not a completely harmless procedure. Patients are subjected to the potential 25% risk of major TT-related insertional, positional, and infective complications.

The conservative management of patients with a spontaneous PTX is now widely accepted [7], and this has led to the necessity of TT insertion for a proportion of TPTXs to be challenged.

The ultimate question, and the main objective of this meta-analysis, is to determine whether clinicians can safely omit TT in patients with TPTX presenting to the Emergency Department (ED). This is a question not yet answered in the clinical literature.

## 2 | Methods

An electronic search was designed following the patient-intervention-control-outcome (PICO) question—(P) patients presenting to the ED with a TPTX due to blunt trauma; (I) conservative management by serial observation; (C) tube thoracostomy; and (O) PTX progression, PTXtension, length of stay, and TT complications (pneumonia, empyema, etc.). Articles were assessed in duplicate.

Databases including MEDLINE, EMBASE, CINAHL, the Cochrane Library, the Best BETs (Best Evidence Topic), National Research Register, and the Database of Abstracts of Reviews of Effects (DARE) were searched, and hand searches of references from relevant papers were completed. Data was extracted from the relevant papers and pooled for analysis.

Subsequent to the search, further refinement was accomplished by applying inclusion and exclusion criteria relating to key component areas (see Table 1).

The PRISMA flow chart is detailed in Figure 1. A total of 14 articles relevant to the PICO question were identified. These comprised 3 randomised controlled trials (Enderson et al. [8], Brasel et al. [9], Ouellet et al. [10]), 4 prospective cohort studies (Holmes et al. [11], Misthos et al. [12], Wolfman et al. [13], Knottenbelt et al. [14]), and 7 retrospective cohort studies (Ball et al. [15], Collins et al. [16], Wilson et al. [17], Lee et al. [18], Barrios et al. [19], Hill et al. [20], Baldwin et al. [21]).

## 3 | Results

### 3.1 | Pneumothorax Progression

There is a significant range of PTX progression reported within the papers (range 0%–38%). A potential explanation for this variety is that different studies use varying methods of defining PTX progression, and many do not mention whether the patient became symptomatic.

This yields a combined rate of 12% for those observed, and 7.6% for those with a TT. Using a paired t-test, this reveals a $p$ value of 0.8447, implying that the differing rates are not clinically significant. These data were compared against each other to calculate odds ratios, the results of which are demonstrated in Figure 2.

### 3.2 | Need for TT Insertion

Pooling of this data revealed an 11.9% rate among those patients observed, and a surprising 10.4% requirement for further TT placement in those already with a TT. This was for many reasons, including malfunction, dislodgement, and PTX progression. Analysis with a paired t-test reveals a $p$ value of 0.3436, which is not statistically significant. The results are shown in Figure 3.

This analysis can be broken down further into those patients receiving PPV and those not.

For those patients receiving PPV, the rates change to 18% in observed patients compared to 9% of those with a TT ($p$ value 0.2848). This contrasts with the 5.9% rate in observed patients without PPV compared with a rate of 10.3% of those with a TT ($p$ value 0.3151).

These results are shown in Figures 4 and 5.

### 3.3 | Pneumonia or Empyema Development

Unfortunately, only a few of the papers report on complications of this nature. Pooling the data reveals a rate of 2.4% for those

**TABLE 1** | Inclusion and exclusion criteria for refinement of literature search.

| Question component | Inclusion criteria | Exclusion criteria |
|---|---|---|
| Population | Patients with a traumatic pneumothorax due to blunt trauma | Spontaneous pneumothorax, penetrating trauma |
| Interventions | TT insertion vs. conservative management | Lack of comparison |
| Outcomes | Pneumothorax progression, tension pneumothorax, TT complications | Poor or lacking assessment |
| Study design | Randomised controlled trials (RCTs), cohort studies | Case series, individual case reports, editorials, review articles |

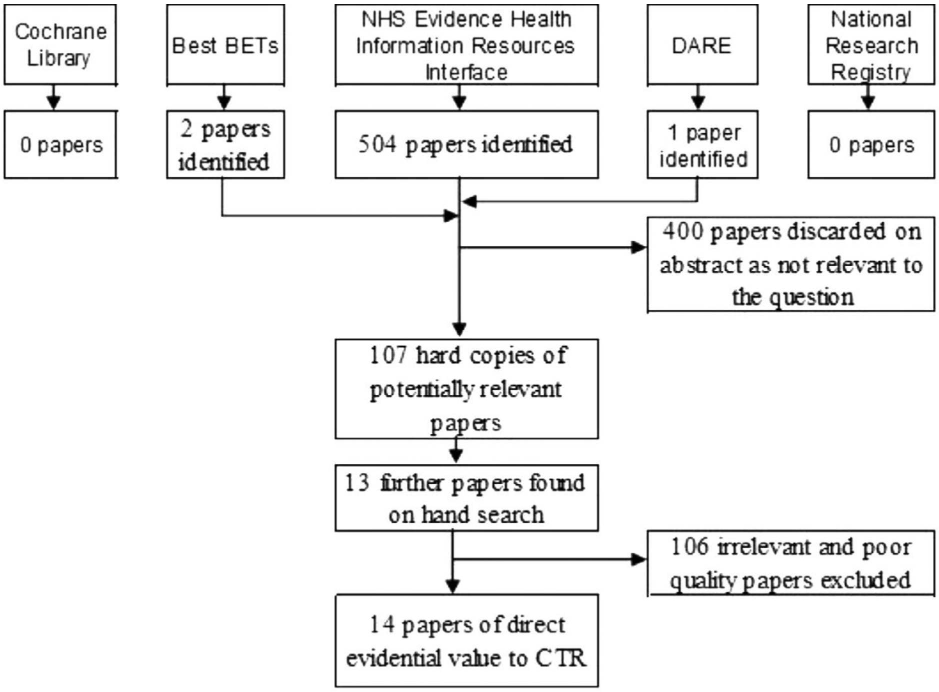


**FIGURE 1** | PRISMA flowchart to show identification of literature.

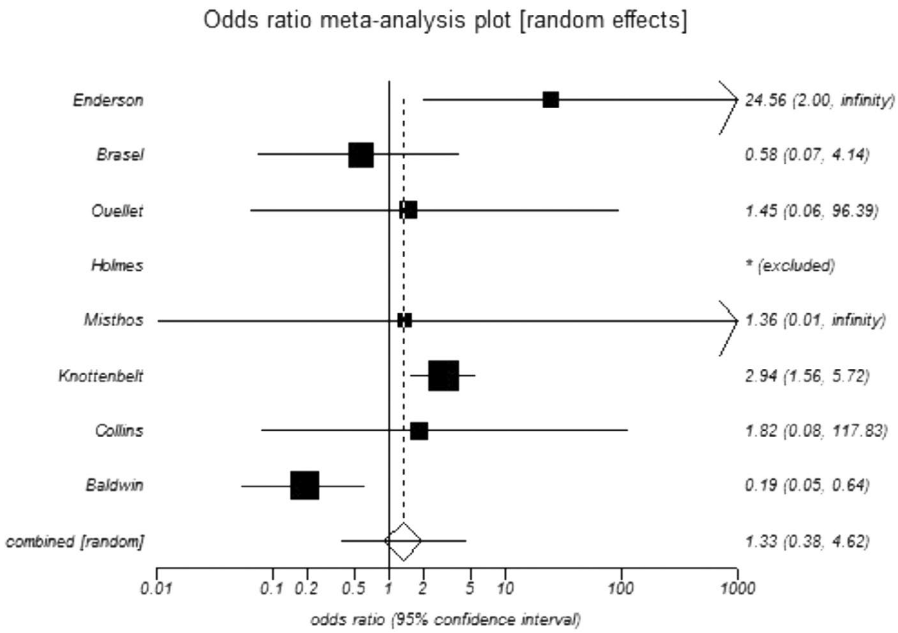


**FIGURE 2** | Forest plot—rate of PTX progression.

observed compared with a rate of 7.3% for those with a TT. Analysis with a paired t-test reveals statistical significance in this result, with a *p* value of 0.0393.

### 3.4 | Respiratory Distress

Any mention within the papers of respiratory distress or tension pneumothorax was included in this dataset. Pooling the data reveals a rate of 5.5% for the observed patients and 3.1% for those with a TT. This data has a *p* value of only 0.2801, indicating that the difference is not statistically significant.

### 3.5 | Mortality

Unfortunately, the reporting of mortality rates was sparse through the papers. Pooling the data reveals a mortality rate of 4.3% for those observed compared with 11% of those with TT.

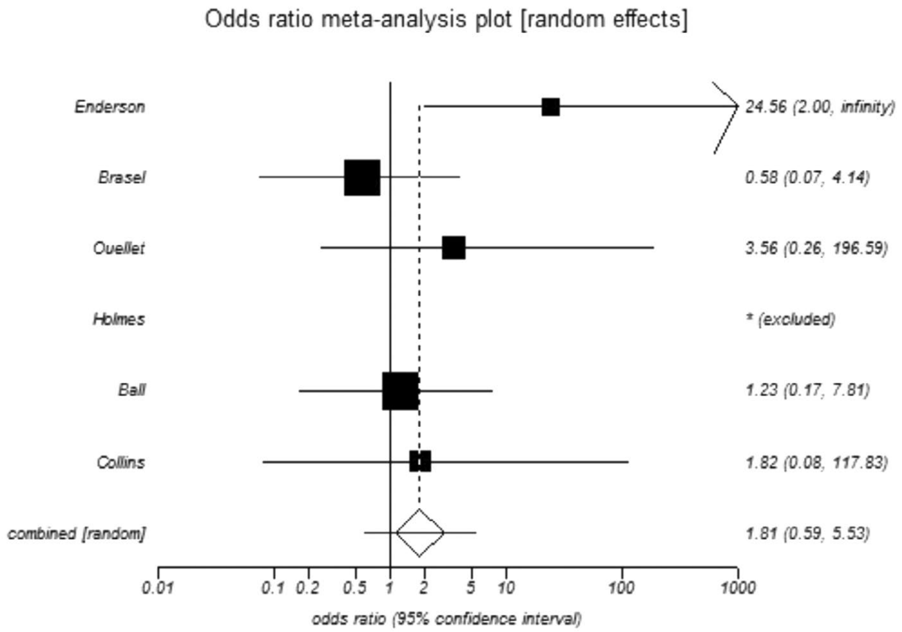


**FIGURE 3** | Forest plot representing the rate of TT insertion.

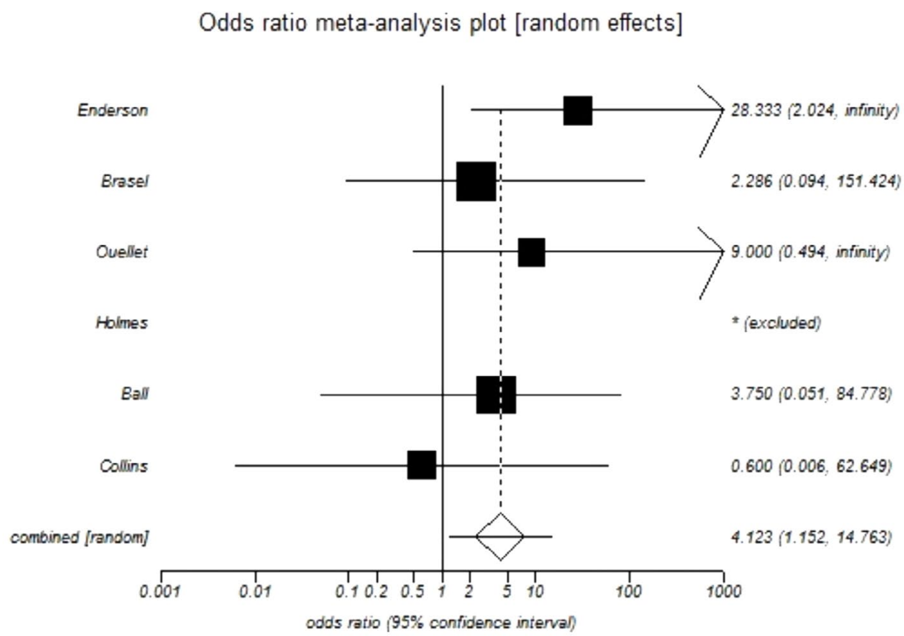


**FIGURE 4** | Forest plot—rate of TT for patient with PPV.

Analysis of these statistics reveals a $p$ value of 0.0907, implying a not statistically significant difference.

## 4 | Discussion

### 4.1 | General Weaknesses of Studies

Collectively, the 14 studies provide a vast amount of data (a total of 1550 patients) on the treatment of TPTX.

However, when analyzing the studies individually, there are a multitude of imperfections in the methodology of the studies which may lead to bias. The majority of the studies were small—only 3 papers had over 100 patients enrolled. This small sample size may predispose to a type II error.

Only 5 studies mentioned consecutive recruitment of patients, meaning the other 9 may have had selection bias of cases for inclusion. This is not to mention the fact that most studies let individual physicians determine the treatment modality of the patients—again marked selection bias.

Furthermore, due to the nature of the outcomes (TT vs. observation), it was impractical, if not impossible, to blind either the treating physicians or the assessors to the

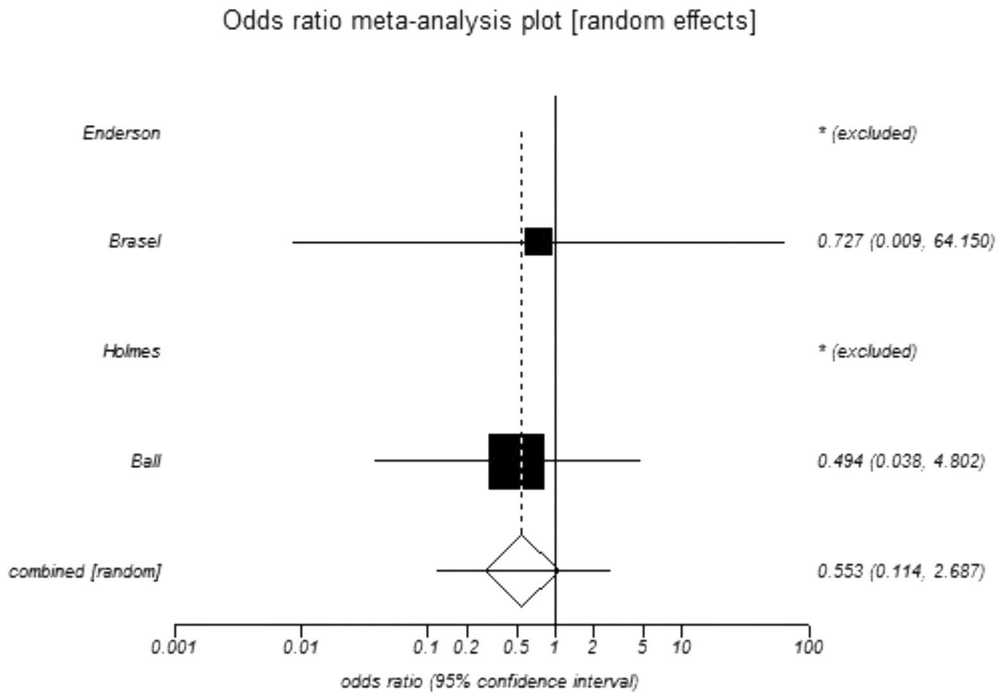


**FIGURE 5** | Forest plot—rate of TT for patient without PPV.

treatment arm. This clearly introduces the potential for observation bias.

There were only 3 RCTs relevant to the topic [8–10]. Unfortunately, two of these studies, although roughly equal in size, arrived at completely opposite conclusions. The third study by Ouellet [10] simply concludes that a more definitive trial is feasible. As a result, the findings of the cohort studies also need to be analysed [11–21].

### 4.2 | Occult vs. Overt

The detection of a PTX via CT has revealed that the incidence of occult pneumothorax (OPTX) is greater than was experienced or recognized previously. As many as 72% of all pneumothoraces are now thought to be occult [22]. The management of these occult pneumothoraces has generated much debate.

Although current evidence indicates that observation of a small OPTX without TT in trauma patients not receiving mechanical ventilation is likely safe [9, 12], actual clinical practice remains varied [22]. Ball [15] reports that although 65% of injured patients received a TT in cases of overt PTX, only 31% underwent TT insertion when their PTX was occult [22]. In spite of data confirming overt and occult PTXs as similar in size and distribution [15], this variance in practice reflects the difficulty clinicians have in determining the appropriate therapy for OPTX.

The overall rate of TT insertion seems to vary depending on the patient cohort. Rates of 25% in patients with 'minor' chest trauma [12], 40% in a small emergency medicine study, 59% in a large retrospective review of injured patients, and 82% in patients with concurrent occult haemothoraces [3] have been published.

However, do we really need to drain these at all? Collins [16] performed an observational study and concluded that you could potentially observe those with OPTX. Supporting this argument, Sirmali [23], and Shorr [24] both report that within the first 48 h of admission, only 5%–6% of patients developed a delayed PTX. All of these were found to be handled in an outpatient setting without a TT. Presumably, these pneumothoraces were originally present as an OPTX, just not identified as no CT was performed. So, if these can all be handled conservatively, should we really worry about any OPTX whatsoever? In trying to address this question, Wolfman [13] described a classification system for OPTX. However, in the prospective evaluation of this system, the decision to place a TT was not dependent solely on clinical signs and symptoms. All patients with anterolateral PTX received a TT on diagnosis, and all patients with an anterior PTX who received PPV had a TT placed. Therefore, the results cannot support the validation of this system due to the inherent selection bias.

Finally, there is evidence that the size and intrathoracic distribution of overt and occult PTX appear to be similar [22]. This clouds the rationale for the higher rates of TT insertion noted among patients with overt PTX compared with those with OPTX [20, 22].

### 4.3 | Positive Pressure Ventilation

Overall, there does appear to be a growing recognition and acceptance that PTX can be safely treated without TT in non-ventilated patients [9, 10]. However, there is a tendency towards decompression of PTX in patients who are ventilated, due to the likelihood that PPV of such patients will cause tension PTX [3, 8]. Converse to this opinion, it has been shown that OPTX in spontaneously breathing, stable patients can be treated expectantly with serial examination and CXR [12, 16] even if moderately sized [3, 13]. There have been small studies that show that the observation of OPTX in those with PPV is a viable option [9]. Ball reports that only 12% of patients underwent TT insertion, irrespective of mechanical ventilation [15]. This group reported no complications. Wilson [17] likewise reported no instances of PTX progression or tension PTX.

On inspection of the patients receiving mechanical ventilation as a separate entity, more patients with overt PTX (95%) receive chest tube therapy than those with OPTX (76%) [22]. There seems to be no real evidence to support this reasoning. The most recent RCT, by Ouellet [10], found that there were no clinically concerning differences in morbidity or mortality between the treatment groups. Barrios [19] reports a success rate of 86% for observation overall, and 80% for those on PPV. Although these and other retrospective studies indicate that TT may not be required [13], only 3 small prospective randomised controlled trials comprising a total of 67 ventilated patients with OPTX are available. Enderson [8] reported that 38% of 21 patients managed without initial TT progressed in the size of their PTX, became symptomatic, and required insertion of a TT. 14% developed a tension PTX. The rate increased to 53% of the 15 patients on PPV. They recommend that all patients with OPTX on PPV should have a TT placed. However, there was a high proportion of patients undergoing operative anaesthesia; they did not qualify those OPTX, and the sample size of those randomised to receive TT was small. Conversely, Brasel [9] in a similar study of 18 patients on PPV with OPTX (50% managed with a TT) found no difference in the overall complication rate, and only 10% progressed and needed TT. They concluded that patients with an OPTX who require ventilation can be managed safely without TT insertion. Ouellet [10] also analysed 22 patients with OPTX on PPV and found 31% required TT. However, none of these were for PTX progression. Combining the data from these three RCTs yields a rate of 38% for those observed patients receiving PPV who require TT (vs. 13% of those with a TT). However, the rate across all the papers is 18% (vs. 9% of those with a TT). Neither of these differences was statistically significant.

### 4.4 | Age of Patients

The papers comprise patients with a mean age of 39. Unfortunately, none of the papers detail their results enough to allow an analysis of whether age could be a contributing factor.

### 4.5 | Concurrent Illness/Chronic Disease

Again, unfortunately, none of the papers report their details enough to allow an analysis of whether those patients with chronic disease (such as chronic obstructive pulmonary disease [COPD]) should be managed differently from those patients with healthy lungs.

### 4.6 | Size of PTX

Only 8 of the papers make any mention of size. Unfortunately, these systems are too diverse to allow comparison between them. Furthermore, because the size of the PTX directed the treatment, there is no useful comparison between groups as to whether observation is more likely to fail in larger PTX than in smaller ones.

### 4.7 | Complications

The concept of overtreatment is particularly important with TT as it is associated with a potential 44% rate of major complications [22]. This risk of complications can be objectively compared with recent studies describing patients who were closely observed and for whom TT was initially avoided [12]. Some papers report a 0% major complication rate for observed patients [22], and only a minority of patients requiring placement of a subsequent TT after progression of a PTX during observation (9%–11%) [12, 22]. In comparison, the failure rate of TT requiring repeat TT is around 15%–20% [25]. This is not an inconsequential figure, and is double the reported progression rate of observed PTXs. However, we must again be aware of selection bias in the fact that if only the smaller PTXs were observed, then those are potentially those at lower risk of recurrence.

From the pooled data, however, we can see a statistically significant reduction in the number of patients developing pneumonia if observation is employed, without a significant rise in those patients developing respiratory distress without a TT.

### 4.8 | Summation of Results

Many experts feel that immediate decompression is necessary for any TPTX. Indeed, TT insertion is the definitive procedure for treating PTXs [15]. ATLS guidelines propose TT placement in all patients with TPTX regardless of whether the PTX is overt or occult [6], because a PTX secondary to trauma can convert to a tension PTX [26]. However, they do continue to concede that "observation and aspiration of an asymptomatic [simple] pneumothorax may be appropriate".

There is clearly a large element of selection bias involved in the majority of the studies, with individual treating physicians deciding best management practices. TT was often selected for anterolateral PTX, and all mechanically ventilated patients. With these limitations, however, roughly 90% of patients with a small or anterior PTX did not require a TT when managed conservatively [13, 15].

## 5 | Conclusions

Upon arrival at the hospital, patients with thoracic trauma should be divided into two simple categories: stable and unstable. Unstable patients are defined as having an immediately life-threatening event including haemorrhage, hypotension, laboured respirations, and altered mental status. These patients require immediate resuscitation and treatment.

Current evidence suggests that conservative management of stable, asymptomatic patients with both occult and overt TPTX who do not require ventilation is a reasonable initial safe approach in the Emergency Department.

The evidence suggests that only approximately 12% of these patients will eventually require a TT. The other 88% will not be exposed to the potential 25% risk [25, 27] of major complications associated with TT.

However, if the patient is requiring PPV or is symptomatic, then they should continue to undergo the placement of a TT, as there is insufficient evidence yet for not doing so with safety.

Size, symptoms, and presence of underlying lung disease will also guide therapeutic intervention. Currently, there is not enough data to identify which subset of patients with a PTX who require the institution of PPV can safely avoid TT. This likely explains the variation in rates of TT insertion, as well as in opinion, among clinicians. Until more conclusive evidence appears, it is probably prudent to place a TT in these patients.

What is really needed is a large randomised controlled trial for both overt and occult TPTX to assess the safety of conservative management as opposed to TT for patients presenting to the Emergency Department.

**Conflicts of Interest**

The author declares no conflicts of interest.

**Data Availability Statement**

Research data are not shared.

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