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Systematic Review

Management of traumatic hemothorax: thresholds for chest tube insertion and outcomes; systematic review

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Abstract

Background: Traumatic hemothorax is common after blunt and penetrating chest trauma. With routine CT imaging, small and occult hemothoraces are detected more frequently, creating doubt about when to observe or insert a chest tube and how those choices affect outcomes. We aimed to synthesize original articles on radiologic and clinical thresholds associated with chest tube insertion for traumatic hemothorax and outcomes related to drainage strategy and escalation. Study eligibility: Original clinical studies (randomized or observational) of traumatic hemothorax and hemopneumothorax that reported drainage decisions, thresholds, or outcomes. **Methods:** our study followed PRISMA guided screening, data extraction, and qualitative synthesis, meta-analysis performed where two or more studies reported comparable outcomes. Primary meta-analysis outcome were needed for VATS after initial drainage in small bore vs large bore drainage strategies. **Results:** Ten original studies were included, CT based hemothorax depth was associated with drainage decisions, in one cohort >3 cm thickness was drained, while 2 cm was a decision inflection point. In the ventilated trauma patients with occult hemothorax and hemopneumothorax, greater CT thickness correlated with tube placement. Delayed hemothorax is uncommon but clinically relevant, readmission for delayed hemothorax after rib fracture observed in 0.26% in a large database study. In meta-analysis, small-bore drainage showed no clear difference in VATS compared with larger bore tubes (RR 0.87, 95% CI 0.47 - 1.60). **Conclusion:** CT depth is the most reproducible radiologic threshold informing tube insertion decisions, while delayed hemothorax is uncommon but require drainage and operative escalation when it occurs. Small bore drainage strategies did not show a higher VATS requirement in pooled analysis, though articles remains limited and context dependent.

Keywords: Traumatic Hemothorax; Occult Hemothorax; Chest Tube; Tube Thoracostomy; Ct Thickness; Delayed Hemothorax

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Introduction

Traumatic hemothorax results from bleeding into the pleural space after blunt or penetrating thoracic injury and is managed with tube thoracostomy to evacuate blood, re expand the lung, and prevent retained hemothorax and infection (Zeiler et al. 2020; Rösch et al. 2024). Modern trauma evaluation includes frequent CT imaging, which identifies hemothoraces that are not visible on initial chest radiograph and are often small volume. This creates a recurring dilemma, which patients can be observed, and what radiologic thresholds trigger tube insertion (Rösch et al. 2024).

Clinical decisions must balance risk that inadequate drainage lead to retained hemothorax, prolonged symptoms, empyema, or escalation to VATS (Hu et al. 2021). Second, chest tube placement is associated with pain and procedural complications, malposition, organ injury, infection, and tube failure, and these risks affect threshold decisions, mainly for borderline hemothoraces (Kwiatt et al. 2014).

Guideline level recommendations for blunt thoracic trauma show individualized drainage decisions based on physiologic stability, imaging findings, and the broader injury pattern, but they also acknowledge important evidence gaps, especially in defining small hemothorax and standardizing thresholds for tube insertion (Coccolini et al. 2025). Recent evidence syntheses also indicate that smaller caliber drains were effective in selected, stable trauma patients, yet trial evidence were limited and heterogeneous (Granieri et al. 2025).

The purpose of this systematic review is to evaluate PMC full text clinical studies addressing management of traumatic hemothorax, focusing on thresholds especially CT based measurements associated with tube thoracostomy and key

outcomes including escalation to VATS and complication profiles.

Methods

This manuscript follows PRISMA guidelines for transparent reporting of systematic reviews screening, eligibility, inclusion, and synthesis, adapted here to an evidence base restricted to original full text studies to ensure validation.

Eligibility criteria: we include original clinical studies, randomized controlled trials, prospective and retrospective cohorts, and database studies, available as full text in electronic databases (PubMed, Scopus, and WOS). Adult or pediatric trauma populations with traumatic hemothorax and hemopneumothorax, reported at least one of the following: A threshold linked to chest tube insertion, outcomes of drainage strategy, or outcomes of delayed hemothorax and subsequent interventions. We exclude case reports without extractable management-outcome data, non-traumatic hemothorax, and non-full text articles.

Information sources and search strategy

We searched electronic databases (PubMed, Scopus, and WOS) for full text articles. Search terms include; traumatic hemothorax, occult hemothorax, delayed hemothorax, retained hemothorax, chest tube, tube thoracostomy, pigtail catheter and VATS with trauma related filters when available.

Study selection

Titles and abstracts were screened for traumatic hemothorax management content and PMC availability, full texts were assessed against eligibility criteria. Included studies were those with

extractable predictor information or outcome data.

Data extraction

From each study we extracted design, setting, population, hemothorax definition, threshold, predictor, drainage strategy, and outcomes, need for tube, complications, retained hemothorax, VATS/thoracotomy, mortality. When a detail was not reported in accessible sections during drafting, it was recorded as NR rather than inferred.

Risk of bias

Randomized trials were appraised conceptually using RoB 2 domains (randomization, deviations, missing data, measurement, reporting). Observational studies were appraised conceptually using selection, comparability, and outcome domains (Newcastle-Ottawa style).

Synthesis and meta-analysis

A qualitative synthesis summarized thresholds and outcomes. A random-effects meta-analysis (risk ratio, RR) was performed for VATS requirement after initial drainage comparing smaller-bore vs larger-bore drainage strategies when reported in at least two studies.

Results

Study selection and characteristics

Ten original PMC studies were included, in ventilated occult hemothorax and hemopneumothorax cohorts, CT measurement cohorts, delayed hemothorax studies, and interventional comparisons of drainage approaches including a randomized trial of pigtail catheter versus chest tube.

Thresholds associated with chest tube insertion

Studies that evaluated thresholds, CT hemothorax thickness emerged as the most reproducible decision variable. In a CT measurement cohort of traumatic hemothorax all cases with thickness >3 cm received chest tube insertion, while 2.05 cm represented a decision inflection point for tube placement (Malekpour et al. 2018). In ventilated trauma patients with occult hemothorax, patients managed without chest tubes had a lower median CT hemothorax thickness (9 mm) compared with those receiving chest tubes (13 mm), this support thickness as a marker associated with clinician decision making (Mahmood et al. 2015).

A model development study in traumatic occult hemothorax identified multiple predictors of delayed hemothorax, including hemothorax depth on imaging in its variables, showing that small initial collections can progress in selected patients (Seok et al. 2024).

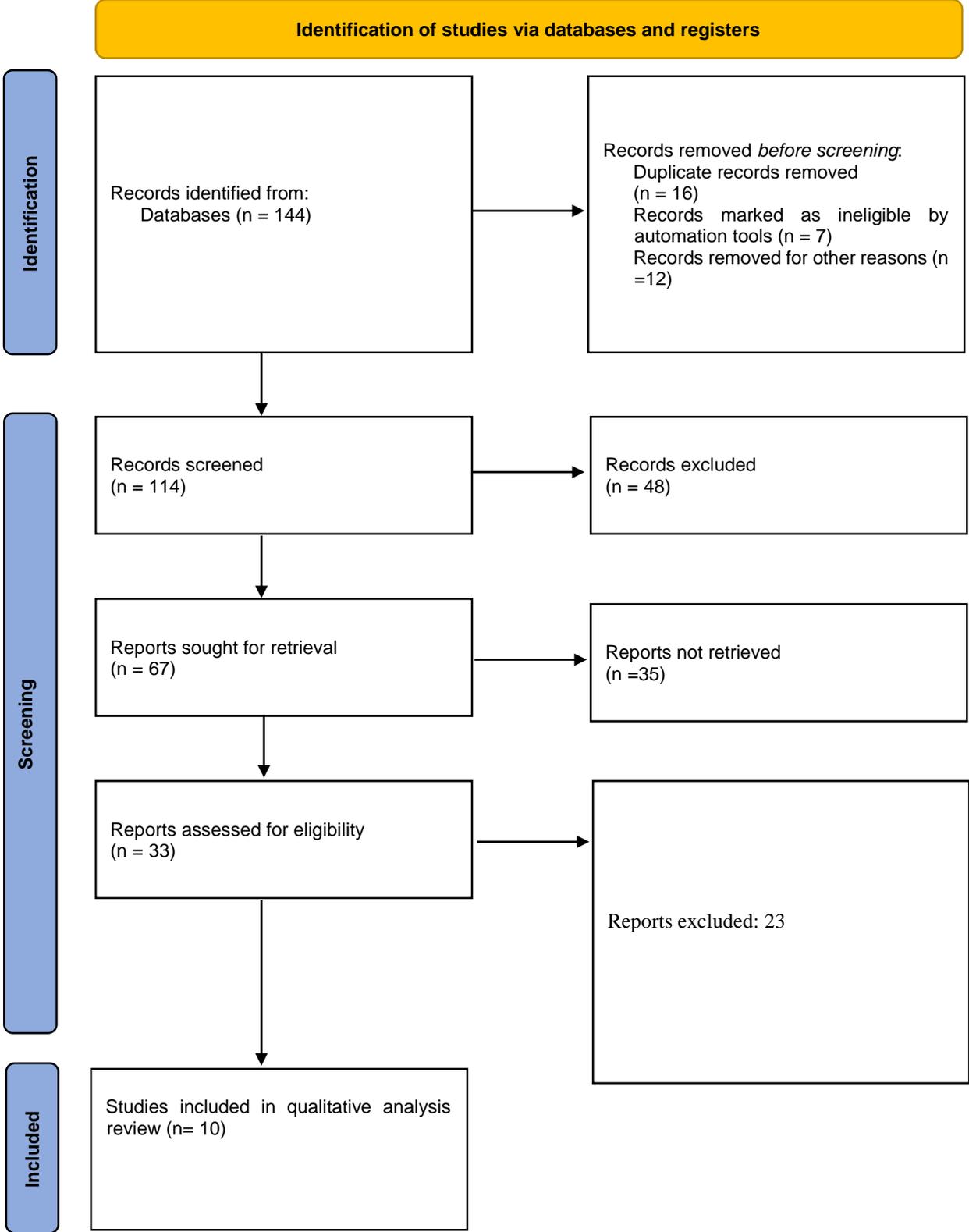
Delayed hemothorax frequency and interventions

Pleural drainage and VATS were common interventions in readmitted patients, and delayed hemothorax readmission occurred in 0.26% of patients with rib fractures in a large US readmission database study (Ouwerkerk et al. 2023). Delayed traumatic hemothorax may be diagnosed after discharge, according to a focused older adult case series with many cases requiring tube thoracostomy and some require operative management (Choi et al. 2021).

Meta-analysis

Regarding VATS requirement with smaller-bore vs larger-bore drainage, two studies reported VATS as an escalation outcome in a way that allow pooling a randomized trial (Bauman et al. 2021) and a

Fig 1: PRISMA consort chart



retrospective cohort in delayed hemothorax (Orlando et al. 2020). Random effects pooled estimate, RR 0.87 (95% CI 0.47–1.60) for VATS with smaller bore drainage compared with larger bore tubes, with low observed heterogeneity in the two included studies.

Discussion

Our systematic review identified CT based hemothorax depth as the repeatedly measurable factor linked to tube insertion decisions. In one CT measurement cohort, clinicians drained all hemothoraces with thickness >3 cm and showed a decision inflection of 2 cm (Malekpour et al. 2018), while in ventilated occult hemothorax, median thickness differed between drained and observed groups (Mahmood et al. 2015). These findings align with broader review level descriptions that show CT role in defining hemothorax burden and guiding management when the chest radiograph underestimates pleural blood (Rösch et al. 2024; Zeiler et al. 2020).

A second important contribution of the included studies is the framing of delayed hemothorax as uncommon overall but high impact in selected populations. The national database study indicate that delayed hemothorax readmission is rare (0.26%), and when it occurs, a majority undergo drainage and a minority undergo VATS (Ouwerkerk et al. 2023). The older adult case series underscores that delayed diagnosis occurs after discharge and requires tube thoracostomy, with a proportion requiring operative management (Choi et al. 2021). These data support a risk-stratified approach very small hemothoraces observed in stable patients, but clinicians should maintain vigilance for progression in higher risk phenotypes, consistent

with guideline perspectives showing individualized care (Coccolini et al. 2025).

Chest tube complications and patient discomfort are well recognized, and these burdens shift the acceptable threshold upward for otherwise stable small hemothoraces (Kwiatt et al. 2014). In this context, studies comparing tube caliber is clinically relevant, a randomized trial found similar failure and VATS rates for 14 Fr pigtail catheters versus chest tubes, with better patient reported experience in the pigtail group (Bauman et al. 2021). A retrospective cohort in delayed hemothorax reported comparable VATS rates in small-bore versus large-bore tubes (Orlando et al. 2020). Our pooled analysis of these two studies found no clear difference in VATS requirement (RR 0.87, 95% CI 0.47 - 1.60), indicate that smaller bore approaches do not increase escalation to VATS in selected settings. This interpretation is consistent with a recent meta-analysis of randomized trials concluding that small-caliber drains appear not inferior to large-bore tubes for selected, hemodynamically stable trauma patients with uncomplicated thoracic injuries, while also show remaining uncertainty and the need for larger trials (Granieri et al. 2025).

A pragmatic interpretation is that CT thickness near 2 cm represents a gray zone, while >3 cm supports drainage in many settings (Malekpour et al. 2018), and very small thickness (1 cm range) is more commonly observed, especially when the patient is stable and without respiratory compromise (Mahmood et al. 2015). These are associations and practice patterns from included cohorts; the decision still depends on physiology, ventilatory needs, associated pneumothorax, and institutional pathways (Rösch et al. 2024; Coccolini et al. 2025).

Table 1. Included original studies

Study	Design and setting	Population	Key exposure and threshold	Key outcomes reported
Mahmood et al. 2015	Observational cohort	Trauma patients requiring assisted ventilation with occult hemothorax and hemopneumothorax	CT hemothorax thickness associated with tube placement	Tube vs no-tube groups; CT thickness differences and outcomes
Malekpour et al. 2018	Retrospective cohort	Traumatic hemothorax on CT	CT thickness: >3 cm uniformly drained; 2.05 cm inflection	Drainage decisions by CT measures
Seok et al. 2024	Retrospective model development	Traumatic occult hemothorax	Predictors for delayed hemothorax	Delayed hemothorax incidence and prediction model
Choi et al. 2021	Case series + review	Older adults with delayed traumatic hemothorax	Delayed presentation after blunt trauma	Tube placement and operative escalation frequencies
Ouwerkerk et al. 2023	National database study	Rib fracture admissions	Readmission with delayed hemothorax	Readmission rate; drainage and VATS rates
Orlando et al. 2020	Retrospective cohort	Delayed hemothorax requiring drainage	Small bore vs large bore tube comparison	Complications, pneumonia, VATS and thoracotomy
Bauman et al. 2021	Randomized clinical trial	Traumatic hemothorax/hemopneumothorax	14 Fr pigtail catheter vs chest tube	Failure, VATS rates, patient-reported experience
Huang et al. 2018	Retrospective cohort	Blunt head + chest trauma with retained hemothorax	Early vs delayed management	Hospital outcomes and complications

Study	Design and setting	Population	Key exposure and threshold	Key outcomes reported
Chou et al. 2015	Retrospective cohort	Blunt chest trauma with retained hemothorax	VATS based management strategy	VATS outcomes
Goodman et al. 2025	Comparative cohort	Pediatric traumatic hemothorax	Pigtail catheter vs chest tube	Comparative outcomes

Table 2. Extracted thresholds and outcome signals

Domain	summary
CT thickness threshold	>3 cm, uniformly drained in one cohort; 2.05 cm: decision inflection for tube placement (Malekpour et al. 2018).
Occult hemothorax in ventilated patients	Tube group had higher median CT thickness (13 mm) vs no-tube group (9 mm); 56 total patients (Mahmood et al. 2015).
Risk of delayed hemothorax	Prediction model in occult hemothorax included hemothorax depth among variables; 688 patients, 64 delayed hemothoraces (Seok et al. 2024).
Delayed hemothorax burden after rib fracture	0.26% readmission rate; drainage in 62.2% and VATS in 10.1% of readmitted cases (Ouwkerk et al. 2023).
Drain size strategy	Small-bore vs large-bore: similar VATS rates (21.7% vs 24.3%) and reported complication patterns (Orlando et al. 2020).
Pigtail vs chest tube	RCT enrolled 43: failure 10% pigtail vs 17% chest tube; VATS 5% vs 9% (Bauman et al. 2021).
Retained hemothorax management	Early vs delayed management strategies reported outcome differences in cohorts (Huang et al. 2018; Chou et al. 2015)

Conclusion

CT measured hemothorax depth is the most reproducible factor associated with chest tube insertion decisions, with practice signals suggest an inflection of 2 cm and universal drainage when thickness exceeds 3 cm in one cohort. Delayed hemothorax after rib fracture is uncommon but often requires pleural drainage and sometimes VATS when it occurs. Meta-analysis of two studies showed no clear difference in VATS requirement between smaller-bore and larger-bore drainage strategies.

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Abbreviations

CT: computed tomography

CI: confidence interval

HTX: hemothorax

LB: large-bore

NR: not reported

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RR: risk ratio

SB: small-bore

VATS: video-assisted thoracoscopic surgery

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