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Percutaneous thoracostomy with thoracic lavage for traumatic hemothorax: a performance improvement initiative

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ABSTRACT

Objectives Percutaneously placed small-bore (14 Fr) catheters and pleural lavage have emerged independently as innovative approaches to hemothorax management. This report describes techniques for combining percutaneous thoracostomy with pleural lavage and presents results from a performance improvement series of patients managed with percutaneous thoracostomy with immediate lavage.

Methods This was a prospective performance improvement series of patients treated at a level 1 trauma center with percutaneous thoracostomy and immediate lavage between April 2021 and May 2023.

Results Percutaneous thoracostomy with immediate lavage was used to treat nine hemodynamically normal patients with acute hemothorax. Injuries included both blunt and penetrating mechanisms. 56% of patients presented immediately after injury, and 44% presented in a delayed fashion ranging from 2 to 26 days after injury. Median length of stay was 6 days (IQR 6, 9). Seven patients were discharged home in stable condition, one was discharged to an acute rehabilitation facility, and one was discharged to a skilled nursing facility.

Conclusions Percutaneous thoracostomy with pleural lavage is clinically feasible and effective and warrants further evaluation with a multicenter clinical trial.

Level of evidence Therapeutic/care management, level V.

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Hemothorax (HTX) and hemopneumothorax (HPTX) are common injuries that often require reintervention following management with tube thoracostomy alone.
- ⇒ Studies have demonstrated the clinical effectiveness of percutaneous thoracostomy and pleural lavage separately.
- ⇒ A simulation study demonstrated the feasibility of combining percutaneous 14Fr thoracostomy and pleural lavage for treating HTX.

WHAT THIS STUDY ADDS

- ⇒ This performance improvement initiative demonstrates the clinical feasibility of combining percutaneous 14Fr thoracostomy with pleural lavage for treating HTX and HPTX.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Percutaneous thoracostomy with pleural lavage is a reasonable option for treating hemodynamically stable patients with acute HTX and HPTX.
- ⇒ Further research is needed to determine clinical outcomes of using percutaneous thoracostomy with pleural lavage when compared to large-bore tube thoracostomy.

INTRODUCTION

Traumatic hemothorax (HTX) and hemopneumothorax (HPTX) are common injuries with multiple available treatment options. For stable patients with a moderate to large HTX, drainage with tube thoracostomy (TT) remains standard practice.[1] Unfortunately, recent studies demonstrate that up to 40% of patients with HTX have either incomplete drainage or reaccumulated blood after TT placement resulting in retained hemothorax (RH).[2] RH is associated with complications including empyema, potential need for additional procedures, and worse functional outcomes after discharge.[3 4] These suboptimal outcomes highlight the need for improved initial management.

The ideal TT size for the initial management of HTX/HPTX has recently come under scrutiny as provider-level and center-level initial tube size and management vary widely.[5] Over time, the trend has been toward the use of smaller caliber tubes. The most current Advanced Trauma Life Support handbook recommends the use of 28–32 Fr chest tubes, which is a downsize from the previous recommendation for 36–40 Fr chest tubes.[6 7] And taking this concept a step further, two recent randomized controlled trials suggest that HTX management with even smaller, percutaneously placed catheters results in drainage rates no different from open large-bore (≥28 Fr) TT, and the percutaneous approach is better tolerated by patients.[8 9] Current Eastern Association for the Surgery of Trauma guidelines conditionally recommend small-bore catheter placement for traumatic HTX only in hemodynamically stable patients using ultrasound guidance.[10] Yet, concerns remain over the ability of small-bore tubes to fully drain the semisolid component of the initial HTX.

Table 1 Patient demographics and clinical characteristics

Case	Mechanism of injury	Indication, intervention	Intervention timing	Volume irrigated/ returned (mL)	Tube days	LOS	Adverse outcomes
1	Fall	Acute HTX, right-sided 14 Fr chest tube	At admission	1000/1100	2	3	Lobar PNA 2 weeks after removal
2	Fall	Acute HPTX, left-sided 14 Fr chest tube	At admission	500/700	4	9	Contralateral PNA diagnosed HD 7
3	MVC with ejection	Acute HPTX, right-sided 14 Fr	HD 5	500/900	8	18	PTX after removal, 14 Fr replaced ×5 days
4	GSW	Recurrent HTX, left-sided 14 Fr	HD 10, 7 days after removal of initial chest tube	900/900	5	17	None
5	Pedestrian hit by car	Acute HTX, right-sided 14 Fr	At admission	1000/1500	4	5	None
6	Fall	Retained HTX, left-sided 14 Fr	At readmission, 26 days after initial injury	1000/2000	6	6	Small residual L retained HTX requiring thrombolytics
7	Fall from motorized bicycle	Acute HTX, right-sided 14 Fr	At admission	1000/1450	4	9	None
8	Fall	Acute HTX, left-sided 14 Fr	At admission	1000/1400	4	6	Small apical PTX after drain removal
9	Assault	Acute HTX, right-sided 14 Fr with CLR device	At admission	1000/1400	3	4	Small apical PTX after drain removal

GSW, gunshot wound; HD, hospital day; HPTX, hemopneumothorax; HTX, hemothorax; LOS, length of stay (hospital); MVC, motor vehicle collision; PNA, pneumonia; PTX, pneumothorax.;

Separately, pleural lavage has been proposed as an adjunct to TT, whereby warm saline is used to irrigate the pleural space after initial HTX evacuation. Observational studies have shown that TT with pleural lavage is associated with significantly lower rates of secondary intervention for RH when compared with TT alone.[8 11 12] The Western Trauma Association suggests that pleural lavage may be considered as an adjunct to thoracostomy after placement of a 14–28 Fr chest tube in hemodynamically stable patients with HTX volumes of 300–500 mL.[13]

The technique of performing a pleural lavage through a percutaneously placed, small-bore (14 Fr) catheter was evaluated in a recent simulation study, and this approach seems feasible.[14 15] However, to our knowledge, this approach has not been reported in a clinical setting. We thus conducted a prospective performance improvement evaluation of small-bore thoracostomy with pleural lavage to evaluate the risks and benefits of this approach in our level 1 trauma center.

METHODS

Ethics and regulatory approval

Our Institutional Review Board approved this as a minimal risk protocol with a waiver of consent. Standard procedural consent was obtained prior to each procedure. Patients were identified prospectively for performance improvement review. This article was completed in accordance with Standards for Quality Improvement Reporting Excellence 2.0. Funding for this project included an internal award from the Penn Presbyterian Medical Center Bach Fund for lavage tubing. The funding source had no input on our study design, implementation, interpretation, or reporting.

Study design

Adult patients presenting with a moderate to large acute HTX, acute HPTX, or RH seen on CT chest with intravenous contrast and stable hemodynamics between April 2021 and May 2023 were considered for percutaneous drainage with immediate saline lavage. Data collected for this performance improvement project included patient demographics, injury mechanism, procedural details, radiographic images, tube duration, hospital length of stay (LOS), and discharge condition. In the following paragraphs, we describe the procedural approach in general terms.

Technique

Patient preparation

Preprocedure considerations included patient selection, analgesia, and antibiotic prophylaxis. Patients should be hemodynamically stable with no indication for immediate open TT placement or need for thoracotomy. Cross-sectional CT imaging and measurement of the HTX using the Mergo formula should be used to identify patients with moderate to large HTX, HPTX, or RH.[16] After procedural consent, local anesthetic and a small dose of intravenous opioid or anxiolytic are generally sufficient to optimize patient comfort during this procedure. The use of sterile technique is paramount, and prophylactic antibiotics should be administered to reduce the risk of empyema.[17]

Small-bore catheter placement

We recommend the Seldinger technique for the placement of the catheter rather than a trocar technique. The patient should be positioned in the supine position and seated at a 45° angle with their arm ipsilateral to the HTX raised above their head. An insertion site is then selected superior to a rib within the triangle of safety, the space bounded laterally by the latissimus dorsi, medially by the pectoralis major, superiorly by the base of the axilla, and inferiorly by the 5th intercostal space. Once the site is marked and cleaned, the chest is anesthetized using a rib block with injection lateral to the site of insertion at the level of insertion as well as one rib above and one rib below. The catheter (Wayne Pneumothorax Catheter, Cook Medical, Bloomington, IN; note this catheter does not have an HTX drainage indication; so, this use is considered off-label by the Food and Drug Administration) is then placed using sterile technique with the needle angled posteriorly into the HTX and advanced just until blood returns.[18]

Potential complications of percutaneous catheter insertion using the Seldinger technique include puncture of intercostal vessels, organ perforation, hospital-acquired infection, and tube obstruction.[19] Ultrasound guidance is widely recommended and may reduce the rate of complications while optimizing placement of the tube within the collection, but it is not a substitute for provider training, education, and knowledge of surface anatomy.[10 20] We recommend the use of ultrasound guidance when available.

Pleural lavage

One approach to performing pleural lavage using commonly available medical supplies has been described in the literature.[14] Prior to connecting the catheter to suction, a large syringe is used as a funnel to introduce warmed saline via gravity into the pleural cavity through the 14 Fr catheter Pleur-evac (Teleflex Inc, Morrisville, NC) adapter that has a flared end. Alternatively, a three-way stopcock can be placed between the Pleur-evac adapter and the 14 Fr catheter, and a 1 L warm saline bag can be connected to the stopcock using standard intravenous tubing. The desired total lavage volume can be achieved by toggling between infusion and drainage with the stopcock.

The volume of saline used will depend on the size of the patient, the HTX, and the resistance in the line. We suggest stopping the lavage infusion once flow backs into the syringe or after 500 mL of warm saline has been introduced. The syringe barrel is then removed from the Pleur-evac adapter, and a sterile Yankauer suction device tip is introduced into the flared adapter opening to allow for evacuation at −80 to −120 mm Hg suction into a suction canister. We generally infuse two aliquots of 500 mL saline and evacuate as much volume as possible between infusions. After the final evacuation via the small-bore tube, we then place the catheter to −20 cmH_2O suction.[8]

Pleural lavage using specialized devices

Specialized devices, such as the CLR Irrigator (CLR Medical, Calverton, MD), can allow for more ergonomic lavage as well as the ability to rapidly cycle between irrigation and suction. To use the CLR Irrigator, an adaptable nozzle is connected to the chest tube and the two lines to a suction canister and a lavage bag, respectively. Using a single hand, flow may be aligned to suction or lavage by depressing the corresponding buttons. When used to rapidly cycle between irrigation and lavage, the CLR Irrigator may agitate and more effectively dilute the traumatic HTX, theoretically inhibiting coagulation. Cycling irrigation may also help to clear mild obstructions formed during suction. Once lavage is complete, the CLR Irrigator is removed, and the chest tube is placed to −20 cmH_2O suction.

Follow-up

A portable chest plain film (chest X-ray, CXR) should be obtained to confirm proper positioning as soon as possible after the placement of the catheter and daily thereafter. If the patient remains symptomatic or an opacity remains on CXR 48–72 hours after the procedure, then CT is recommended to assess for potential RH. Chest tube removal may be considered when drainage is <200 mL/24 h and pneumothorax (PTX) is absent with no significant air leak.

RESULTS

Patient management and outcomes

From April 2021 to May 2023, we performed percutaneous small-bore TT with acute pleural lavage in nine cases with varying demographics, mechanisms of injury, intervention timings, and intervention locations (table 1). Plain film CXRs immediately prior to and after the thoracostomies for cases 1–8 are shown (figure 1), and more detailed imaging for case 9 is also provided (figure 2).

Among these nine cases, mechanisms of injury included four falls, one motor vehicle collision with ejection, one gunshot wound, one pedestrian hit by a car, one fall from a motorized bicycle, and one assault with a blunt weapon. The timing of patient presentation varied widely, ranging from immediately to as late as 26 days after injury. Pleural lavage was performed

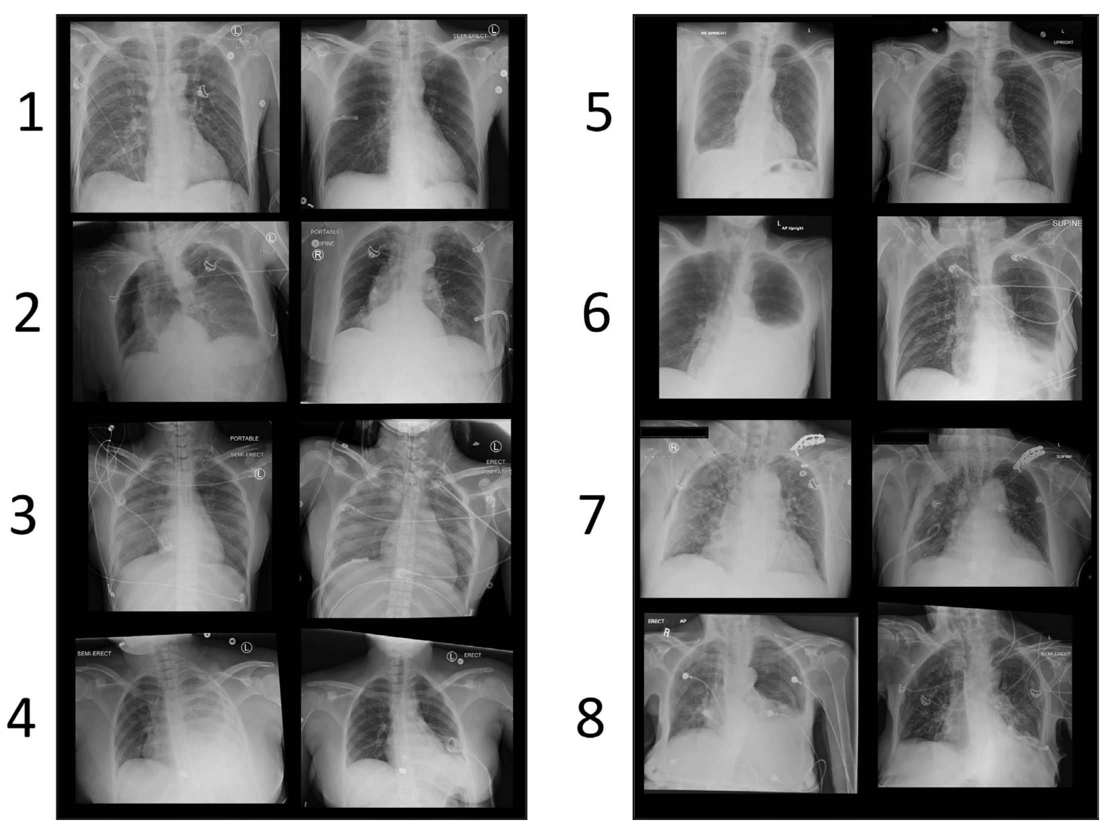

Figure 1 Chest X-rays before and after each reported thoracostomy excluding the detailed example.

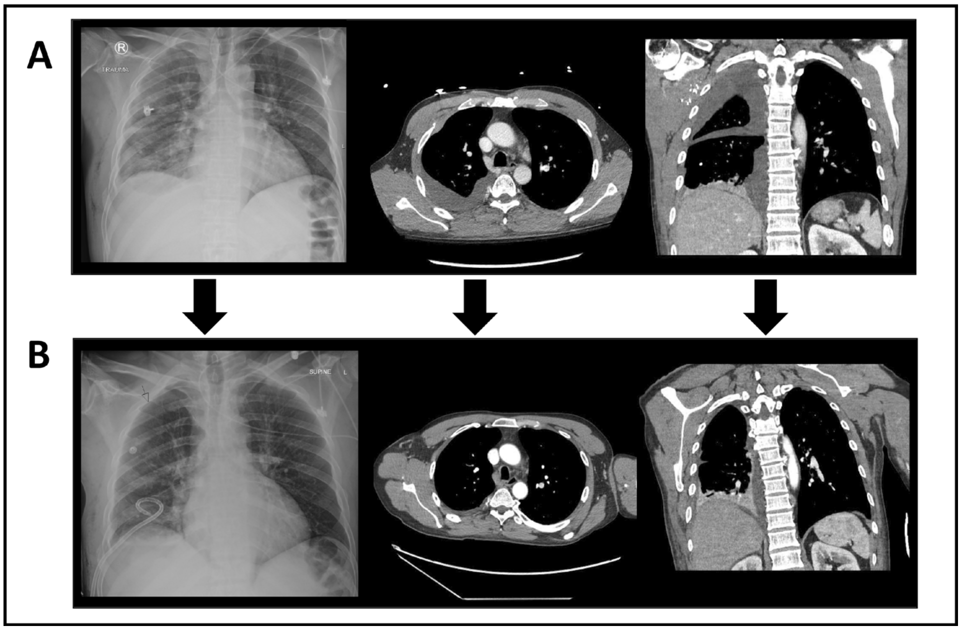

Figure 2 Interval improvement in hemothorax immediately after percutaneous thoracostomy with lavage (case 9). (A) Pre-CT chest X-ray (CXR) and CT chest at admission. (B) CXR demonstrating catheter placement and CT chest after catheter removal.

in eight of the nine patients using commonly available medical supplies without the use of a three-way stopcock as described above. The CLR Irrigator was used in case 9. The index percutaneous TT remained in place for a median length of 4 days (range 2–8; IQR 4, 5). Median hospital LOS was 6 days (range 3–18; IQR 5, 9). Seven patients were discharged home in stable condition, one patient was discharged to acute rehabilitation, and one patient was discharged to a skilled nursing facility.

Detailed example: case 9

Patient 9 is an otherwise healthy, adult patient who presented after an assault with a blunt weapon 2 days prior. On arrival, they were hemodynamically stable with a negative Focused Assessment with Sonography in Trauma (FAST) examination, and they were found to have bilateral chest wall tenderness on examination. A CT scan of their chest revealed fractures of their 3rd–8th ribs as well as a small right pleural effusion (figure 2). The patient was offered but refused surgical repair of the fib fractures.

A right-sided 14 Fr catheter was placed and connected to a CLR Irrigator. 400 mL of bloody fluid was evacuated before the pleural space was irrigated with 1000 mL of warm normal saline. Proper placement was confirmed by X-ray, and the chest tube was placed to suction.

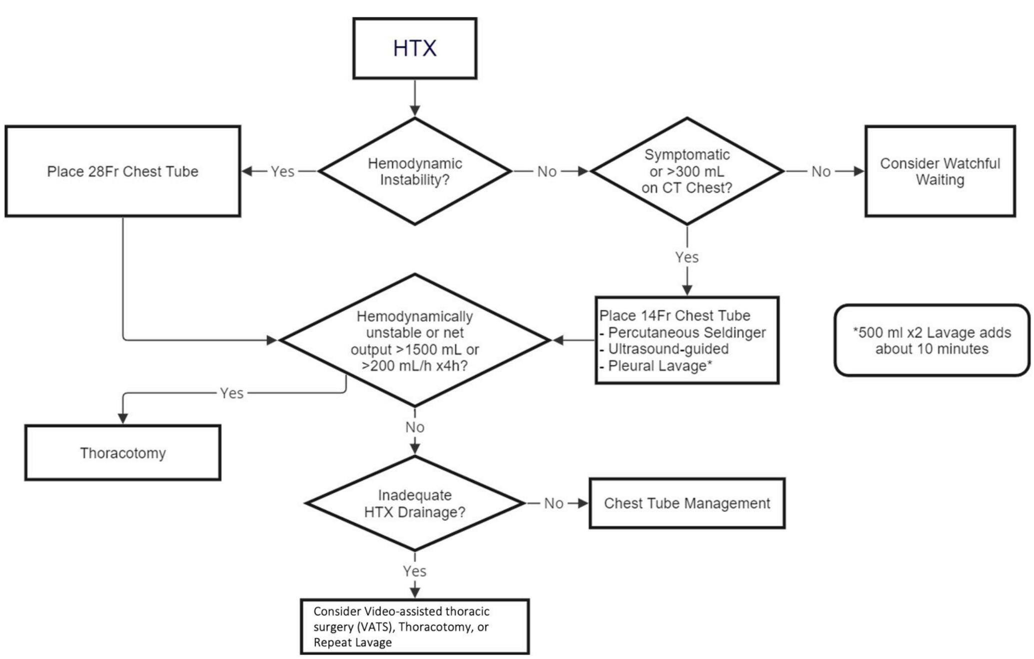

Figure 3 Hemothorax (HTX) management decision algorithm.

The patient's pain was managed with multimodal analgesia, and their clinical status steadily improved during the following day. The chest tube was placed to water seal on postprocedural day 2 and removed on postprocedural day 3. CXR the following day revealed a stable right apical PTX and probable small pleural effusion, which was confirmed with interval improvement on repeat CT. They were deemed suitable for discharge to home later that day.

DISCUSSION

This brief report represents the first series of percutaneous HTX/HPTX drainage with lavage to our knowledge. Our performance improvement experience demonstrates that percutaneous thoracostomy with lavage is clinically feasible and effective and can be considered as an option for the acute management of HTX/HPTX in stable patients. Kugler *et al* suggest that saline lavage assists drainage via blood dilution and breakage of the clot,[8] and Kulvatunyou *et al* demonstrated that pain was significantly less when using 14 Fr catheters compared with 28 Fr TT.[11] The technique demonstrated in this report capitalizes on the benefits of both techniques with acceptable clinical outcomes.

Adverse events observed in this study include a PTX after percutaneous TT removal requiring the placement of a second TT, a small residual HTX requiring thrombolytics, two clinically insignificant PTXs, and two cases of pneumonia, one 2 weeks after removal of the TT and the other in the contralateral lung. Due to the small sample size and heterogeneity of patients in this study, conclusions on the effectiveness of this intervention are limited. Still, HTX management failure requiring secondary intervention after TT without thoracic lavage is greater than 20%.[5] Given that only two of the nine patients reported in this study required a secondary intervention with TT replacement or thrombolytics, it is reasonable to pursue larger prospective studies to determine the clinical effectiveness of percutaneous TT with thoracic lavage.

Of course, this technique is not appropriate in all settings. The decision to employ percutaneous thoracostomy for HTX/HPTX hinges on the hemodynamic status of the patient as well as the procedural skill and available equipment. In a busy trauma center or multiple-patient scenario, time may be a significant factor. In our experience, 1 L warm saline lavage through a 14 Fr catheter with HTX evacuation takes approximately 10 minutes. The total added procedural time varies somewhat from patient to patient based on the volume infused and the combined volume of lavage fluid and HTX evacuated. We present figure 3 as a potential algorithm for initial HTX/HPTX management. In our center, we now use percutaneous drainage with acute pleural lavage as the management approach of choice for stable patients with moderate to large HTX/HPTX and no indications for immediate thoracic exploration.

CONCLUSION

Pleural lavage is a feasible adjunct to small-bore thoracostomy, although further clinical studies are warranted to determine the effect on outcomes compared with large-bore TT. Given the wide array of management options for acute HTX, providers would likely benefit from the development of risk stratification and clinical decision-making tools. A multicenter clinical trial is warranted to compare large-bore and small-bore 14 Fr tubes with and without pleural lavage.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the University of Pennsylvania Institutional Review Board (FWA00004028, expires April 5, 2026). Participants gave informed consent to participate in the study before taking part.

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