American Journal of Emergency Medicine 38 (2020) 2658–2660

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

# Effectiveness and safety of small-bore tube thoracostomy (≤20 Fr) for chest trauma patients: A retrospective observational study

Toshinori Maezawa *, Machi Yanai, Ji Young Huh, Koichi Ariyoshi

*Department of Emergency Medicine, Kobe City Medical Center General Hospital, Japan*

ARTICLE INFO

*Article history:*
Received 15 July 2020
Received in revised form 31 August 2020
Accepted 11 September 2020

*Keywords:*
Chest tube
Tube thoracostomy
Chest trauma
Complications

ABSTRACT

*Introduction:* Tube thoracostomy is an important treatment for traumatic hemothorax and pneumothorax. The optimal tube diameter remains unclear. To reduce invasiveness, we use small-bore chest tubes (≤20 Fr) for all trauma patients for whom tube thoracostomy is indicated in our emergency department (ED). The aim of this study was to investigate the effectiveness and safety of small-bore tube thoracostomy for traumatic hemothorax or pneumothorax.

*Method:* We conducted a retrospective observational study at a single emergency medical center. This study included adult patients (≥18 years old) who had undergone tube thoracostomy for chest trauma in the ED during the 5 years from October 2013 to September 2018. We used 20 Fr chest tubes or 8 Fr pigtail catheters. The examined outcome was tube-related complications, such as tube obstruction, retained hemothorax, and unresolved pneumothorax.

*Results:* A total of 107 tube thoracostomies were performed in 102 patients. The mean Injury Severity Score of these patients was 17.8 (±9.6), and the mean duration of the tube placement period was 3.9 days (±1.8). Eight patients developed tube-related complications (7.8%) (retained hemothorax: 4 patients (3.9%), unresolved pneumothorax: 4 patients (3.9%)). None of these cases were caused by tube obstruction. Although the drainage itself was effective, they underwent definitive invasive interventions to stop bleeding or air leak.

*Conclusion:* Our study showed that the use of small-bore (≤20 Fr) chest tubes to treat traumatic hemothorax/pneumothorax achieved the purposes of tube thoracostomy. It might be possible to safely manage chest trauma with small-bore chest tubes.



## 1. Introduction

Tube thoracostomy is an important treatment for traumatic hemothorax and pneumothorax. The optimal chest tube size; i.e., the size that results in effective drainage without causing obstruction, remains unclear. The 10th edition of Advanced Trauma Life Support (ATLS) recommends the use of smaller chest tubes (28–32 Fr), based on a study that showed that tube size (either 28–32 Fr or 36–40 Fr) did not influence the effectiveness of tube thoracostomy. [1,2] However, several studies have questioned this recommendation, and the use of much smaller bore tubes during the treatment of traumatic hemothorax/pneumothorax might be more effective and safer. If smaller-bore tubes were effective for treating traumatic hemothorax/pneumothorax, it would be preferable to use as small a chest tube as possible to reduce the invasiveness of tube thoracostomy, since various studies have shown that performing tube thoracostomy with smaller-bore tubes is associated with reduced pain. [3,4]

In a study involving traumatic hemothorax patients, Tanizaki et al. demonstrated that performing tube thoracostomy with small chest tubes (20–22 Fr) had no effect on initial output or the complications rate compared with performing it with large chest tubes (28 Fr). [5] These results support the effectiveness of performing tube thoracostomy with small-bore tubes. However, the latter study had two limitations. First, selection bias regarding the use of small- or large-bore chest tubes might have affected the study's results, since the choice of tube size was left to the surgeon in charge of each case. Secondly, trauma patients with pneumothorax alone were excluded from the analyses. In seriously injured chest trauma patients, it is not realistic to exclude pneumothorax alone, as coexistence of pneumothorax and hemothorax is not uncommon. In this sense, the latter study does not reflect the whole population of chest trauma patients. We consider that patients with pneumothorax alone should be included in studies evaluating the effectiveness and safety of small-bore tube thoracostomy in the emergency department (ED).

Due to considerations regarding invasiveness, in our ED we use a 20 Fr chest tube or an 8 Fr pigtail catheter for all trauma patients for whom

* Corresponding author at: 2-1-1 Minatojima-Minamimachi, Chuo-ku, Kobe-city, Hyogo 650-0047, Japan.
*E-mail address:* toshinori_maezawa@kcho.jp (T. Maezawa).

https://doi.org/10.1016/j.ajem.2020.09.028

tube thoracostomy is indicated. The aim of this study was to investigate the effectiveness and safety of performing tube thoracostomy with a small-bore chest tube for traumatic hemothorax or pneumothorax.

## 2. Method

This was a retrospective observational study conducted at a single emergency medical center located in Kobe, Japan. We obtained data from medical records and included adult patients (≥18 years old) who had undergone tube thoracostomy for chest trauma (pneumothorax, hemothorax, or pneumohemothorax) in the ED or as pre-hospital care during the 5 years from October 2013 to September 2018. Patients who were in a state of cardiopulmonary arrest on arrival at the ED were excluded. Tube thoracostomy was performed by emergency physicians and/or thoracic surgeons using the blunt dissection method. Tubes were placed via the lateral chest wall into the fourth or fifth intercostal space. We used 20 Fr chest tubes or 8 Fr pigtail catheters (Covidien Japan, Tokyo) in each case.

We collected data regarding the following factors: age, sex, vital signs on arrival (systolic blood pressure (sBP), heart rate (HR), and respiratory rate (RR)), the indications for tube thoracostomy, the number of rib fractures, mortality, the Injury Severity Score (ISS), and the Abbreviated Injury Scale (AIS) score for the chest. Information about tube-related variables, including tube type, the duration of the tube placement period, and the presence/absence of mechanical ventilation, was also collected.

The main outcome was tube-related complications, including tube obstruction, retained hemothorax, unresolved pneumothorax. Retained hemothorax was defined as a hemothorax that required an additional invasive intervention within 14 days of the initial tube placement. Unresolved pneumothorax was defined as a persistent or recurrent pneumothorax that required an additional invasive intervention after the tube thoracostomy. Additional invasive interventions included additional tube insertion, transcatheter arterial embolization (TAE) of the chest, video-assisted thoracic surgery (VATS), and surgical thoracotomy after the initial tube placement.

## 3. Results

During the 5-year study period, a total of 107 tube thoracostomies were performed in 102 patients (5 patients underwent bilateral procedures) in the ED. The basic clinical characteristics of these patients are shown in Table 1. Seventy-seven percent of the patients were male, and the patients' mean age was 59.6 (±19.1) years, and their mean ISS was 17.8 (±9.6). Sixty-nine tube thoracostomies were performed by emergency physicians, and 38 were carried out by thoracic surgeons. Ninety-eight (91.6%) tube thoracostomies were performed using 20 Fr chest tubes, and 9 (8.4%) were conducted using 8 Fr pigtail catheters. The mean duration of the tube placement period was 3.9 days (±1.8). Thirty-four patients were mechanically ventilated (33.3%).

The 107 tube thoracostomies led to 8 tube-related complications (7.8%) (Table 2). None of the patients experienced tube obstruction. Four patients developed retained hemothorax (3.9%), and 4 patients suffered an unresolved pneumothorax (3.9%). None of these cases of retained hemothorax or unresolved pneumothorax were caused by tube obstruction. All 8 of the patients underwent tube thoracostomy with 20 Fr chest tubes followed by additional invasive interventions later in their clinical course as definitive treatments for their chest injuries. The indications for procedure and the details of these additional invasive interventions are shown in Table 3. Although the drainage itself was effective, they underwent definitive invasive interventions to stop bleeding or air leak. One patient died. In the latter case, although there was no ineffective drainage or delays in the additional invasive interventions, the patient died of traumatic hemothorax.

**Table 1**
Clinical characteristics.

| | Value (%) or mean (SD) |
|---|---|
| Age (y) | 59.6 (19.1) |
| Sex, male | 79 (77.4%) |
| Indication | |
| Pneumothorax | 43 (42.1%) |
| Hemothorax | 9 (8.8%) |
| Pneumohemothorax | 50 (49.0%) |
| Vital signs on arrival | |
| sBP (mmHg) | 135.9 (28.3) |
| HR (beats/min) | 92.7 (22.2) |
| RR (breaths/min) | 23.5 (6.9) |
| ISS | 17.8 (9.6) |
| Chest AIS | 3.6 (0.6) |
| Number of rib fractures | 4.2 (3.2) |
| Mortality | 3 (2.9%) |
| Tube-related variables | |
| Tube type | |
| 20 Fr chest tube | 98 (91.6%) |
| 8 Fr pigtail catheter | 9 (8.4%) |
| Duration of tube placement period (days) | 3.9 (1.8) |
| Mechanical ventilation | 34 (33.3%) |

SD: Standard deviation, sBP: Systolic blood pressure, HR: Heart rate, RR: Respiratory rate, ISS: Injury Severity Score, AIS: Abbreviated Injury Scale score.

## 4. Discussion

Conventionally, large-bore chest tubes have been used for tube thoracostomy for chest trauma. However, there is little evidence to support their use, and the optimal tube diameter for such procedures remains unclear. In this retrospective observational study, which involved small-bore chest tubes and was conducted at a single emergency medical center in Japan, we found that the complications rate of small-bore tube thoracostomy was 7.8%.

Inaba K et al. reported in their study that the overall complications rate was 16.7% in their 28–32 Fr chest tube group. When the analysis was limited to cases involving retained hemothorax or unresolved pneumothorax, the complications rate was 13.0%. [2] In 2018, the ATLS changed their guidelines regarding the recommended chest tube size based on the latter study, but our study suggests that chest tubes with much smaller bore sizes can be used for tube thoracostomy without increasing the complications rate. [1] Other studies in which smaller chest tubes were used support this finding. Tanizaki S et al. found that among patients with retained hemothorax the complications rate was 2.9% when 20–22 Fr chest tubes were used. [5] In addition, the mean duration of the tube placement period (3.8 days) in our study was also shorter than the tube placement periods reported in previous studies (6–7 days). [2,5] Although direct comparisons with these studies cannot be made because the patients' backgrounds were not comparable, these results suggest that performing tube thoracostomy with a 20 Fr tube does not cause higher complications rates and is not inferior in terms of safety compared with the procedures employed in previous studies.

The main purposes of tube thoracostomy in patients with traumatic hemothorax are to drain blood to maintain the intrathoracic cavity, to allow the drainage volume to be monitored, and to aid decisions regarding the necessity and most appropriate timing of additional invasive interventions. Generally, in cases of traumatic hemothorax the immediate

**Table 2**
Tube-related complications.

| | Value (%) |
|---|---|
| Total | 8 (7.8%) |
| Retained hemothorax | 4 (3.9%) |
| Unresolved pneumothorax | 4 (3.9%) |
| Tube obstruction | 0 (0%) |

**Table 3**
Details of additional invasive interventions for retained hemothorax or unresolved pneumothorax.

| Case | | | ISS | Condition | Additional invasive intervention | Time from arrival to intervention | Outcomes at discharge |
|---|---|---|---|---|---|---|---|
| Retained hemothorax | | | | | | | |
| 1 | 54 | M | 22 | Hemorrhagic shock | TAE | 3 h | Alive |
| 2 | 59 | M | 29 | Hemorrhagic shock | TAE | 6 h | Dead |
| | | | | | Surgical thoracotomy | 11 h | |
| 3 | 64 | M | 16 | Exacerbation of hemothorax | VATS + rib ORIF | 6 days | Alive |
| 4 | 69 | M | 20 | Exacerbation of hemothorax | VATS | 2 days | Alive |
| Unresolved pneumothorax | | | | | | | |
| 1 | 16 | M | 25 | Persistent air leakage | VATS | 4 days | Alive |
| 2 | 50 | F | 9 | Persistent air leakage | VATS | 8 days | Alive |
| 3 | 61 | M | 9 | Persistent air leakage | VATS | 2 days | Alive |
| 4 | 89 | M | 9 | Persistent air leakage | VATS | 4 days | Alive |

ISS: Injury Severity Score, TAE: Transcatheter arterial embolization, VATS: Video-assisted thoracic surgery.
ORIF: Open reduction internal fixation.

drainage of ≥1500 mL of blood indicates a need for urgent surgical thoracotomy. Shock and persistent substantial bleeding (200 mL/h for 2 to 4 h) are additional indications. [1] An in vitro study demonstrated that small-bore tubes (19 Fr) can drain blood volumes of up to 11.6 L/h [6]; therefore, small-bore tubes; i.e., ≥19 Fr, are theoretically considered to be safe for the management of chest trauma patients.

In the present study, 4 patients suffered retained hemothorax that required additional invasive interventions, such as TAE, surgical thoracotomy, or VATS, during their clinical courses. Only one patient died of traumatic hemothorax; however, we consider that the purpose of tube thoracostomy had been achieved even in this case. In the latter case, tube thoracostomy was performed appropriately after the patient's visit, and the patient was admitted to the ICU. In the ICU, tube drainage was continued without any problems, and the amount of drained blood was less than the surgical indication for traumatic hemothorax. However, TAE and surgical thoracotomy were carried out because metabolic acidosis and coagulopathy persisted, and they were suspected to have occurred secondary to persistent bleeding in the chest cavity. Even with these interventions, the hemothorax was not resolved because of coagulopathy, and the patient died 45 h after his arrival.

In cases of traumatic pneumothorax, although there are no established surgical indications, continuous air leakage for >5 days is generally accepted to be an indication for VATS. [7] In our study, depending on the judgment of the thoracic surgeon, VATS was generally performed as a definitive treatment a few days after a chest injury occurred. A patient who had self-extracted a chest tube due to alcohol withdrawal-induced delirium underwent VATS on the second day, but the drainage itself went well. No patients with unresolved pneumothorax suffered respiratory failure secondary to drainage dysfunction before VATS, and all of them survived to hospital discharge. In addition, none of the patients experienced exacerbated pneumothorax due to ventilator management during general anesthesia or for respiratory failure. Even when the main purpose of tube thoracostomy is to treat pneumothorax, small-bore chest tubes are considered safe to use.

## 5. Conclusion

Our study showed that small-bore (≤20 Fr) chest tubes to treat traumatic hemothorax/pneumothorax achieve the purposes of tube thoracostomy. It might be possible to safely manage chest trauma patients with small-bore chest tubes. However, our study was a descriptive study and there is a need to compare the differences between small- and large-bore tube thoracostomy. Further investigation is necessary for clarification of these topics.

## Declaration of Competing Interest

None.

## References

[1] Committee on Trauma. Advanced Trauma Life Support® Student Course Manual. 10th ed.. Chicago: American College of Surgeons; 2018.
[2] Inaba K, Lustenberger T, Recinos G, Georgiou C, Velmahos GC, Brown C, et al. Does size matter? A prospective analysis of 28–32 versus 36–40 French chest tube size in trauma. J Trauma Acute Care Surg. 2012;72(2):422–7.
[3] Rahman NM, Maskell NA, Davies CWH, Hedley EL, Nunn AJ, Gleeson FV, et al. The relationship between chest tube size and clinical outcome in pleural infection. Chest. 2010;137(3):536–43.
[4] Rahman NM, Pepperell J, Rehal S, Saba T, Tang A, Ali N, et al. Effect of opioids vs NSAIDs and larger vs smaller chest tube size on pain control and pleurodesis efficacy among patients with malignant pleural effusion: the TIME1 randomized clinical trial. JAMA. 2015;314(24):2641–53.
[5] Tanizaki S, Maeda S, Sera M, Nagai H, Hayashi M, Azuma H, et al. Small tube thoracostomy (20–22 Fr) in emergent management of chest trauma. Injury. 2017;48(9):1884–7.
[6] Niinami H, Tabata M, Takeuchi Y, Umezu M. Experimental assessment of the drainage capacity of small silastic chest drains. Asian Cardiovasc Thoracic Ann. 2006;14(3):223–6.
[7] Bruns BR, Diaz JJ. Early and persistent hemothorax and pneumothorax. Curr Trauma Rep. 2015;1(4):251–6.