Residual hemothorax after chest tube placement correlates with increased risk of empyema following traumatic injury

Riyad Karmy-Jones MD1, Michele Holevar MD2, Ryan J Sullivan MD2, Ani Fleisig MD1, Gregory J Jurkovich MD1

BACKGROUND: Empyema complicates tube thoracostomy following trauma in up to 10% of cases. Studies of potential risk factors of empyema have included use of antibiotics, site of injury and technique of chest tube placement. Residual fluid has also been cited as a risk factor for empyema, although the imaging technique to identify this varies.

OBJECTIVE: To determine whether residual hemothorax detected by chest x-ray (CXR) after one or more initial chest tubes predicts an increased risk of empyema.

METHODS: A study of patients admitted to two level I trauma centers between January 7, 2004, and December 31, 2004, was conducted. All patients who received a chest tube in the emergency department, did not undergo thoracotomy within 24 h, and survived more than two days were followed. Empyema was defined as a pleural effusion with positive cultures, and a ratio of pleural fluid lactate dehydrogenase to serum lactate dehydrogenase greater than 0.6 in the setting of elevated leukocyte count and fever. Factors analyzed included the presence of retained hemothorax on CXR after the most recent tube placement in the emergency room, age, mechanism of injury and injury severity score.

RESULTS: A total of 102 patients met the criteria. Nine patients (9%) developed empyema: seven of 21 patients (33%) with residual hemothorax developed empyema versus two of 81 patients (2%) without residual hemothorax developed empyema (P=0.001). Injury severity score was significantly higher in those who developed empyema (31.4±26) versus those who did not (22.6±13; P=0.03).

CONCLUSIONS: The presence of residual hemothorax detected by CXR after tube thoracostomy should prompt further efforts, including thoracoscopy, to drain it. With increasing injury severity, there may be increased benefit in terms of reducing empyema with this approach.

Key Words: Empyema; Residual hemothorax; Tube thoracostomy

Tube thoracostomy plays a fundamental role in the management of chest trauma. Primarily, in the acute setting, this procedure is used to drain pneumothorax and treat massive hemothorax. It is often considered a relatively minor procedure, but can be associated with significant complications, including misplacement, laceration of organs, pain and infection (eg, empyema). In the trauma setting, empyema can be roughly divided into two groups: those occurring as a complication of seeding hemothorax, with a preponderance of Gram-positive organisms; and those that occur in a delayed fashion in patients with multiple potential sources of contamination, including pneumonia (1,2). Overall, empyema has been documented as a complication of tube thoracostomy in as many as 18% of patients in some series (3). Many reviews (1,3-6) have attempted to focus on the benefits of administering prophylactic antibiotics and the duration of
Right-sided hemothorax 49 (64) 2 (20) 3 (20)  
Residual hemothorax 11 (14) 2 (20) 8 (53)

Procedure depending on the presence of other injuries or indications. A dose of antibiotics (cefazolin), and subsequent doses were given as per the treating surgeon's preferences, antibiotic coverage varied. Of the four cases in which Haemophilus influenzae was cultured, one was penicillin-resistant.

Empyema was defined as a pleural effusion with positive cultures, and a ratio of pleural fluid lactate dehydrogenase to serum lactate dehydrogenase greater than 0.6 in the setting of elevated leukocyte count and fever. Management of these patients and indications were directed by the admitting surgeon according to his or her practice.

Permission to perform the study was obtained from the institutional review boards at Harborview Medical Center and Mount Sinai Hospital. Results are expressed as mean ± SD. Univariate analyses were performed using the χ² test for categorical data. The independent paired t test was used for continuous variables. All variables significant at a level of P≤0.1 were entered into a logistic regression model to determine predictors of empyema. Statistical significance was taken to be P≤0.05. ORs and CIs were used to predict the risk of empyema. All statistical analyses were performed with SPSS 14 for Windows (SPSS Inc, USA).

RESULTS
A total of 102 patients met the criteria for inclusion in the study (Table 1). Seventy-six patients (75%) were male. A mean (±SD) age of 40.1±17.3 years, ISS 23.7±11.9, abbreviated injury score 3.4±1.3 and systolic blood pressure on admission 107.5±38.1 mmHg were obtained. Chest tubes were placed within 45±30 min of arrival. Blood loss through chest tubes in the first 24 h averaged 817±823 mL. Eight patients had more than two chest tubes placed. Ultimately, nine patients died: six due to closed head injury or anoxic brain injury, and three due to complications related to multiple organ failure. However, all patient deaths occurred after seven days following admission. Overall, nine patients (9%) developed empyema seven to 24 days following admission: five cases had undergone thoracotomy; and two cases, image-directed drainage. Lytic therapy was not used. In five patients, the predominant organism was Staphylococcus aureus; in two patients, Streptococcus species; and in two patients, a mixture of Pseudomonas species and Haemophilus influenzae.

Of note, during this time period, 12 patients underwent thoracotomy or thorascopy within 24 h of admission purely because of retained hemothorax, and none developed empyema. These patients all had isolated penetrating chest injury.

Using univariate analysis, six factors were found to be associated with risk of empyema at the P≤0.1 level. These were incorporated into a simple regression analysis, and two factors (ISS and presence of residual fluid) were found to be significant (Table 2). The presence of residual fluid was associated with a 1.25-fold (95% CI 1.17 to 1.35) increased risk of empyema. Of note, empyema developed in four of 33 patients (12%) who were covered with antibiotics (predominantly cefazolin) directed at Gram-positive bacteria throughout the time the tube thoracostomy was in place, compared with five of 69 patients (7%) in whom the duration of antibiotic coverage was less than 48 h (P=0.4). It should be stressed that, depending on the treating surgeon's preferences, antibiotic coverage varied. Of the four cases in which S. aureus was the predominant bacterial culture, one was methicillin-resistant. Of the two cases in which Streptococcus species were cultured, one was penicillin-resistant.

The two patients who developed empyema and who did not have residual fluid initially were both blunt trauma patients who had sustained a significant pulmonary contusion
require intubation on admission, had prolonged ventilator courses and had developed ventilator-associated pneumonia. Their empymas presented on hospital days 21 and 24, respectively. The bacteriology in both cases was a mixture of Pseudomonas species and H influenzae, and it was assumed that these represented seeding of the hemothorax as a complication of ventilator-associated pneumonia rather than contamination at the time of tube placement. Stab wounds had a relatively higher incidence of undergoing laparotomy within 24 h, and of diaphragmatic injury (Table 1). In addition, three of the stab wound patients were found at laparotomy to have gastric perforation, two of whom developed empyema (despite irrigation through the diaphragmatic defect). This may explain why the univariate analysis identified both stab wounds and diaphragmatic injury as risk factors for the development of empyema.

DISCUSSION
Tube thoracostomy is a common and vital tool in the immediate management of thoracic trauma; however, it is not without complications. Other than technical complications, empyema represents a major burden, which (assuming an approximately 5% incidence and requiring thoracoscopic drainage) can represent as much as $118,000 per 100 patients who receive a chest tube (1). However, some series have documented the incidence of empyema as high as 18% (3).

Empyema following trauma is characterized by a preponderance of Gram-positive organisms and early localizations, presumably due to hemothorax being present (2). Empyema in this setting occurs relatively early in the hospitalization, as opposed to trauma patients who develop empyema as a complication of ventilator-associated pneumonia (11). A number of risk factors have been identified, but there are conflicting data in the literature (1,2,5,11-18). The routine use and duration of antibiotics that provide Gram-positive coverage has been vociferously debated (1-4,6,12,13). Reviewing the available literature in 2000, the Eastern Association for the Surgery of Trauma noted that 24 h coverage appeared to be equivalent to longer periods, but there are conflicting data in the literature (1,2,4,5,12,17,18). Retained hemothorax after tube thoracostomy is still visible on plain radiograph after the patient leaves the emergency room (7). Historically, there has been concern that any retained hemothorax can lead to complications of fibrothorax, thus prompting aggressive drainage. However, in the vast majority of cases clinically relevant fibrothorax is really a consequence of infection complicating the hemothorax. Furthermore, much of the experience prompting aggressive drainage for fear of fibrothorax was based on plain radiographic detection of hemothorax rather than the more sensitive CT imaging, and presumably reflected a larger volume of blood.

Injury severity score
With residual hemothorax 31.4±26 0.09 0.03
Without residual hemothorax 22.6±13

Systolic blood pressure on admission to the ER, mmHg
With residual hemothorax 102.7±40 0.1 0.08
Without residual hemothorax 121±30

Stab wound, n (%)
With residual hemothorax 5 (33) 0.006 0.16
Without residual hemothorax 4 (5)

Left-sided hemothorax, n (%)
With residual hemothorax 7 (15) 0.05 0.25
Without residual hemothorax 2 (4)

Diaphragmatic injury, n (%)
With residual hemothorax 4 (36) 0.005 0.1
Without residual hemothorax 5 (5)

Residual fluid after one or more chest tubes, n (%)
With residual hemothorax 7 (33) 0.001 0.001
Without residual hemothorax 2 (2)

Data are presented as mean ± SD unless otherwise indicated. ER Emergency room

If a residual hemothorax is identified, video thoracoscopic drainage, particularly if performed within two to three days, has been shown to result in lower complications and length of stay compared with placing more tubes, and appears to be more cost-effective than lytic therapy (19). In patients who cannot tolerate single lung ventilation for video thoracoscopic drainage, simple pleuroscopic approaches using 'rigid' thoracoscopy can still be performed (20).

Our results were consistent with the notion that placing a tube thoracostomy and not draining the effusion, such that fluid is still visible on plain radiograph after the patient leaves the acute management area, is associated with a marked increase in the risk of empyema, particularly in more severely injured patients. A CT scan can help confirm the residual fluid if there is difficulty distinguishing between pulmonary contusion and pleural fluid, but is not mandated. Consideration should be given to early thoracoscopic drainage and washout before localizations make the procedure more difficult, ideally within 24 h to 48 h after admission. Alternatively, close follow-up with CT or ultrasound may help direct earlier intervention. Patients with stab wounds that result in both gastric perforation and diaphragmatic injury may benefit from thoracoscopic to ensure complete pleural washout.

The data in the present study represent a concurrent study with small numbers. In addition, the different radiographic techniques may have resulted in hemothoraces not being detected. We did not design the study to evaluate whether retained hemothoraces detected by CT but not by plain CXR were associated with a different risk of empyema. Although our study supports the notion that once a chest tube is placed (and residual hemothorax is noted on plain CXR) patients are at an increased risk of empyema, it cannot be considered definitive. However, it does stress the importance of following these patients closely. A more large-scale prospective, multicentre
study is needed to definitively determine whether routine CXR might serve to identify patients at increased risk of developing empyema after tube thoracostomy.

Presented at the 37th Annual Meeting of the Western Trauma Association, Steamboat Springs, Colorado, USA, March 1, 2007.

REFERENCES