

## Lateral Thoracostomy Tubes: Is Outcome Affected by Level of Intercostal Space?

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### Abstract

**Objectives:** Tube thoracostomy is a common procedure performed after chest trauma. The current practice is to insert the tube in the 3<sup>rd</sup>, 4<sup>th</sup>, or 5<sup>th</sup> intercostal space (ICS) at the anterior axillary line. In this study we compared the outcome of tubes inserted at lower spaces versus the standard (higher) location.

**Methods:** Patients receiving a chest tube after chest trauma were identified using the trauma registry at a Level 1 trauma center from July 2009 to December 2011. Each tube inserted was categorized as either "High" (3<sup>rd</sup>-5<sup>th</sup> ICS) or "Low" (6<sup>th</sup>-7<sup>th</sup> ICS) placement. Patient records were reviewed for demographics, Injury Severity Score (ISS), chest tube interval (CTI), length of hospital stay (LOHS), interventions (including thoracoscopy and thoracotomy), and mortality.

**Results:** There were no differences between both groups regarding age, ISS, interventions or mortality. However, patients receiving chest tubes in the 3<sup>rd</sup> through-5<sup>th</sup> ICS (High group) demonstrated significantly lower CTI and LOHS when controlling for age and ISS. (Multi-linear Regression, F-Value=3.14 and 9.44; p=0.027 and <0.0001, respectively)

**Conclusion:** Low thoracotomy placement tubes are as safe as High placement with no difference in outcome in terms of morbidity and mortality. However, patients with low placement reported longer CTI and a longer LOHS.

**Keywords:** Hemopneumothorax; Thoracostomy; Injury severity score

### Introduction

Tube thoracostomy is a procedure frequently performed in medical centers. Indications for tube thoracostomy include pneumothorax, hemopneumothorax, and postoperative drainage [1,2]. While the lifesaving potential of this procedure is very high, it is not without risk of complications. The most common complications following tube thoracostomy are positional (i.e. kinking, malposition) and infective, however insertional (i.e. structural trauma) complications can also occur [2]. Infections, when they occur, have a tendency to be drain site infections which are minor in nature. Clinically major infections such as an empyema have a relatively low incidence rate [3]. While lateral placement seems to be preferred by most physicians, there is no clinically significant difference between ventral and lateral placement of chest tubes [4]. Lateral chest tube placement is associated with a higher rate of interlobar positioning, however studies have shown that there is no loss of function related to placement within the pleural fissure [4,5]. While many health care practitioners believe lower chest tubes are superior for draining fluid, and resulting in reduced risk of retained hemothorax and empyema, others are concerned that inserting low tubes carry the risk of injury to diaphragm and intra-abdominal organs. The purpose of this study is to compare the complication rates of thoracostomy tube placed after chest trauma at a current standard practice, high placement (3-5<sup>th</sup> ICS), versus low (6-7<sup>th</sup> ICS) placement and to determine if a lower placement yields better outcomes.

### Materials and Methods

Between July 1, 2009 and December 31, 2011 non-incarcerated trauma patients between the ages of 18 and 80 that received a de novo chest tube for pneumothorax, hemothorax, and/or hemopneumothorax were identified using the trauma registry (TraumaOne, Version 4.10).

This study was approved by the Institutional Review Board of the Louisiana State Health Sciences Center, Shreveport, Louisiana.

Patients with bilateral chest tubes yielded two data points. Each chest tube placement was categorized as either High (chest tube placement in the 3<sup>rd</sup>, 4<sup>th</sup>, or 5<sup>th</sup> intercostal space) or Low (chest tube placement in the 6<sup>th</sup> or 7<sup>th</sup> intercostal space). Chest tube interval (CTI) was defined as the duration of the chest tube insertion. The standard practice at our facility is that patients who receive chest tubes should be evaluated daily by chest x-ray. Therefore, each tube was categorized to their relevant positions based on chest x-ray and was confirmed by computed tomography (CT) when available. A board-certified radiologist then reviewed each tube categorization for verification of the ICS location. Outcome variables measured included indication for tube placement, chest tube interval (CTI), length of hospital stay (LOHS), mortality, the need for any related intervention (replacement, adjustment of malposition, placement of second chest tube), and the need for surgical intervention (Video-assisted thoracoscopic surgery (VATS), Thoracotomy) and complications. Similarly to the study performed by Bailey, complications were classified as insertional, positional, or infective [3]. Demographic data studied included age, race, gender, injury class and mechanism, prior injuries, Injury

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Severity Score (ISS) and Abbreviated Injury Severity Score (AIS). We used ISS and AIS because these are most standardized anatomical scoring system which correlates with the severity of injury. Descriptive analyses for continuous variables are presented as mean with standard deviation and as frequencies with percentages for categorical variables. For continuous variables, independent Student's t-tests were used to compare mean differences, while the Chi-square test used to analysis. P-values of less than 0.05 were considered statistically significant. All statistical analysis were performed using Statistical Analysis Software (SAS 9.2, Cary, NC).

## Results

The trauma registry inquiry yielded 161 patients that met the criteria listed above. A total of 17 patients were excluded due to death within 48 hours of admission. All deaths were related to severity of injury and there were no complications associated with thoracostomy tube recorded prior to death. Another 10 patients were not included due to incomplete medical records and one additional patient was excluded for tampering with his chest tube. A total of 133 patients were analyzed, 29 of which received bilateral chest tube placement. A total of 162 chest tube placements were observed as eligible for this study. While some patients may have been given antibiotics during their hospitalization for treatment of other ailments, no patients were recorded as having been given prophylactic antibiotics. The patients' medical records were reviewed to determine age, race, sex, mechanism of injury, indication for tube placement, CTI, LOHS, ISS, AIS, complications, as well as post-placement interventions (i.e. surgical interventions, placement of second chest tube, and replacement after removal). Surgical interventions (i.e. VATs, thoracotomy) were also compared separately from other interventions.

The mechanism of injury in the majority of the patients in the study was related to motor vehicle crashes. Of the 162 observations, 112 were categorized as High and 50 were classified as Low. Average CTI for the High versus Low placement groups was  $8.34 \pm 5.33$  days and  $10.68 \pm 7.39$  days, respectively. The average LOHS for the High placement group was  $15.36 \pm 12.82$  days, versus  $25.16 \pm 21.37$  days for the Low placement group. Among those patients receiving a high placement tubes, 28 (25.0%) received some type of intervention and 8 received surgical intervention. Comparatively, 13 interventions and 6 surgical interventions were performed on patients with low placed tubes. Patients with chest tubes in the 3<sup>rd</sup>, 4<sup>th</sup>, or 5<sup>th</sup> intercostal space had significantly lower chest tube durations, controlling for age and ISS (Multi-linear Regression, F-Value=3.14, p=0.027). These patients also demonstrated a significantly shorter LOHS, controlling for age and ISS (Multi-linear Regression, F-Value=9.44, p<0.0001) There were no differences between the placement groups in regards to age, ISS, need for further intervention, need for surgical intervention or mortality (Tables 1 and 2).

## Discussion

While studies have shown that there is no significant difference in outcomes of lateral versus ventral tube placement, [4,5] no studies have assessed outcomes, in particular complications rates, based on the

Variable	T-Value	P-Value
ISS	-0.54	0.5929
Age	-1.86	0.0650
Duration of Insertion	-2.01	0.0483
Length of Stay	-3.01	0.0037

Table 1: T-test results comparing high and low chest tube placement.

Variable	Chi-Square	P-Value
All Interventions*	0.0183	0.8924
Surgical Interventions**	1.0329	0.3095
Mortality	0.1356	0.7127

\*All Interventions include: Replacement of Chest Tube, Addition of Second Chest Tube, and Surgical Interventions\*\*

\*\*Surgical Interventions Include: VATS, Thoracotomy

Table 2: Table of Chi-Square results comparing frequencies in high and low chest tube placement groups.

intercostal level of tube placement. The current recommendation is to achieve a position in what was described as the "safe triangle" which encompasses the 3<sup>rd</sup> through 5<sup>th</sup> intercostal spaces [6]. Such placement is thought to decrease various complications associated with lateral tube placement including pulmonic perforation [7] cardiac perforation [8-10] neurovascular injury [11-13] intra-abdominal placement and diaphragmatic injury [14-18]. The latter two complications are of particular concern with lower tube placement due to the proximity of the diaphragm and abdominal cavity to the lower intercostal spaces. It is of note, however, that no diaphragmatic injuries or intra-abdominal placements were observed in our study among those patients who had lower tubes. According to the British Thoracic Society (BTS) guidelines, the "safe triangle" is the area contained posteriorly by the latissimus muscle, laterally by the pectoralis major muscle, inferiorly by an imaginary line drawn from the horizontal level of the nipple, and an apex slightly below the axilla which correlates to high placement.

The ideal position for the patient during chest tube insertion is one in which the patient is tilted slightly to opposite side to that which the tube is to be placed, while the ipsilateral arm is abducted toward the patient's head [6-8]. After the patient is positioned and an appropriately sized drain is chosen, the chest wall is prepped, adequate local anesthetic used and a 2 to 3 cm incision made careful blunt dissection is utilized and the tube introduced. The tube is then secured to the patient with suture. Once the tube is placed and secured, it can be attached to a closed water seal system or directly to suction based on physician discretion [8]. Aseptic technique with full barrier precautions should be emphasized during the procedure. A chest x-ray is preformed following the procedure to screen for malposition or other complications associated with the insertion. While the CT scan has proven an accurate tool to assess the position of thoracostomy tubes, radiographs are more cost effective and have been shown to be sufficient in thoracostomy tube evaluation [9,10].

Development of an empyema is a highly concerning complication that can occur with any insertional approach. The occurrence of empyema seems to be more highly associated with hemothorax than pneumothorax [19,20] and rates are reported to vary between 4% and 10% [21-23]. Empyema is a particularly prevalent risk in the presence of retained hemothorax as the nutrients provided by the remaining blood products are ideal for bacterial growth. In comparison to previously-reported incidence rates, our data yielded an empyema rate of 4.46% with higher tube placement and 6% with lower placement. Recent studies are inconclusive as to the benefits of prophylactic antibiotic use in patients with thoracostomy tubes [24]. No prophylactic antibiotics were used in our patients. Some physicians believe that, with the assistance of gravity, lower placed tubes would be more efficient at resolving hemothoraces and thus prevent empyema formation. However, our data showed no statistical difference in the rates of empyema formation when comparing higher and lower intercostal tube placement.

Moreover, when comparing the need for all or surgical intervention, there was no statistical difference between the two groups. There was also

no difference in ISS, age, and mortality demonstrated between levels of placement. Interestingly, our data showed that patients receiving lower chest tubes had both a longer CTI and longer LOHS. The discrepancy between the two groups is postulated to be a surrogate marker for another underlying factor. Age was the first factor considered since our t-test data revealed a p-value approaching statistical significance with older patients receiving lower tube placement. However, after controlling for both age and ISS our data yielded the same results. Body habitus (i.e. obesity) has been shown to be an independent risk for increased LOHS and could possibly be associated with lower level of insertion as the body habitus associated with obesity may also be associated with a relatively lower nipple line used in determining the base of the 'safe triangle'. Furthermore, our data approached clinical significance regarding older patients who were more likely to receive a lower tube placement. Although age was controlled for in our multilinear regression analysis, the trend toward statistical significance when examining older patients may further validate the theory that changes in body habitus (either due to age, obesity, or both) may be associated with a lower tube placement. Another confounding factor could be physician preference.

Our study was limited by lack of sufficient data needed to adequately explore the body habitus of the patient receiving a thoracostomy tube or the identity of the inserting physician. However, our study was sufficiently powered at the  $\alpha=0.05$  level with power at 80%.

## Conclusion

Our investigation illustrated that a majority (2:1) of tubes are placed in the 3<sup>rd</sup> through 5<sup>th</sup> intercostal spaces, which coincided with current recommendations to approach insertion through the "safe triangle". However, there is no significant difference in mortality, surgical intervention, or total interventions when higher (ICs 3<sup>rd</sup> through 5<sup>th</sup>) and lower (ICs 6<sup>th</sup> through 7<sup>th</sup>) placement is compared. Patients who received lower tube placement demonstrated both an extended duration of insertion and LOHS. This, however, is considered to be a surrogate marker for an unexamined factor. As such, it is a reasonable assumption that lower intercostal space chest tube placement when compared to higher intercostal space placement is equally efficacious and, when performed by a well-trained physician, offers no increase in adverse outcomes or clinical interventions required. A prospective controlled study is needed to confirm our findings.

## Conflicts of Interest

All of the authors on this manuscript are without any known conflicts of interest that could bias the information obtained from this study. Additionally, no study sponsors were utilized in any aspect of this work, including, but not limited to, data collection, analysis of data, writing of manuscript, or submission for publication.

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