Original Article

HEALTH SCIENCES
MEDICINE

DOI: 10.32322/jhsm.1348080
J Health Sci Med. 2023;6(6):1356-1359

Retrospective assessment of pediatric patients with tube thoracostomy inserted in a tertiary pediatric intensive care unit

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Cite this article as: Durak C, Şahin C. Retrospective assessment of pediatric patients with tube thoracostomy inserted in a tertiary pediatric intensive care unit. *J Health Sci Med.* 2023;6(6):1356-1359.

Received: 22.08.2023 ◆ **Accepted**: 16.10.2023 ◆ **Published**: 29.10.2023

ABSTRACT

Aims: The aim of this study was to examine the indications for tube thoracostomy (TT) procedures in pediatric intensive care units and to analyze the role of chest X-rays in the subsequent monitoring and management of patients.

Methods: A retrospective evaluation of 31 pediatric patients aged 1 month to 18 years who had been admitted between January 2023 to July 2023 at Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital, were performed. Children who underwent TT were included. Demographic data, clinical variables, and outcome data were analyzed

Results: The median age was 50 (4-214) months, and the gender distribution of the patients was almost equal. The median duration of a PICU stay was 10 (4-100) days. Pneumothorax (PTX) was diagnosed in 45,1%, pleural effusion in 38,7%, and hemothorax in 16,1% of patients. Six (19,4%) patients experienced complications related to chest tubes. Invasive mechanical ventilation (IMV) was required in 19 patients (61,3%), and the median duration of IMV was 9 (3-93) days. A total of 23 patients (74,2%) required non-invasive mechanical ventilation (NIMV) support during their stay in PICU. There was no statistically significant difference between indications of TT and length of stay, NIMV and IMV requirement, duration of TT, complications, and mortality.

Conclusion: TT is a life-saving interventional procedure in emergencies. The absence of proper execution of this technique may result in considerable morbidity and fatality. Hence, all clinicians must possess a comprehensive understanding of the tube thoracostomy operation.

Keywords: Pediatrics, pleural effusion, pneumothorax, trauma, thoracostomy

INTRODUCTION

Pediatric intensive care units (PICUs) are designated facilities that are dedicated to the management and treatment of challenging clinical scenarios. These facilities offer treatments to critically ill children who suffer from multiple organ system involvement, requiring careful coordination of their treatment. One of the therapeutic options involves the placement of a tube thoracostomy in the pleural space. Tube thoracostomy (TT) is indicated in various pathological conditions, including pneumothorax, hemothorax, empyema, pleural effusion, and chylothorax.[1] Furthermore, the necessity for TT may arise in children undergoing treatments such as anesthesia and chemotherapy, as well as following lung and heart surgeries, due to drainage requirements.[2]

Chest X-rays (CXR) play a crucial role in the management of TT. The American College of Radiology (ACR) has put up a recommendation advocating for the daily use of radiographs in critically ill patients.[3] Nevertheless, the management and utilization of TT vary significantly heterogeneity across different healthcare organizations.[4]

The objective of this study was to examine the indications for tube thoracostomy procedures in pediatric intensive care units and to analyze the role of chest X-rays in the subsequent monitoring and management of patients.

METHODS

The study was carried out with the permission of Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital Scientific Researches Ethics Committee (Date: 17.02.2023, Decision No: 2023/07). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki, and all study-related anonymized data are available upon reasonable request. We obtained informed consent from all parents before hospitalization and during all procedures.

A retrospective evaluation of 31 pediatric patients who underwent tube thoracostomy was performed (between 0 and 18 years of age) at Sancaktepe Şehit Prof Dr İlhan Varank

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Training and Research Hospital PICU from January 2023 to July 2023. Healthcare provision for children aged from 1 month to 18 years is provided in our PICU, which is equipped with 12 beds, 12 ventilators, 5 Prismaflex™ hemofiltration machines (Baxter, USA), and 9 isolation rooms. A total of 525 patients were hospitalized and followed up during the study period. The study excluded patients who were admitted to the PICU more than 24 hours following the insertion of a thoracostomy tube or died prior to TT removal. Tube thoracotomies were placed by the pediatric surgeon. To maintain consistency, only the last TT removal event was reviewed. Therefore, TT removals in a given patient were not reviewed for removal details while another TT remained intact. In the study, patients who underwent the simultaneous removal of two TTs were included as a single count.

Following TT removal, a post-removal CXR was obtained. The timing was variable; therefore, CXR following removal between 2 h and up to 12 h following TT removal was considered as a post-removal CXR.

A detailed form was used to collect data on the patient's age, gender, comorbid disease, reasons for admission, length of stay in PICU, requirement for invasive mechanical ventilation (IMV) and noninvasive ventilation (NIV), TT indications and duration, complications, and mortality. For the calculation of the Pediatric Risk of Mortality III (PRISM III) Score, data from 16 variables regarding temperature, systolic blood pressure, heart rate, partial pressure of arterial oxygen (PaO_2), partial pressure of arterial carbon dioxide ($PaCO_2$), GCS, pupillary reaction, prothrombin time (PT) and activated partial thromboplastin time (APTT), serum creatinine, serum urea nitrogen, serum potassium, blood glucose, and serum bicarbonate levels, white blood cell and platelet counts were recorded within 24 hours of PICU admission.

Statistical Analysis

SPSS statistical software 20.0 for Windows (Armonk, New York: IBM Corp.) was used for statistical analyses. Numbers, frequencies [%], ratios, medians, and standard deviation values were used in the descriptive statistics of the data. The distribution of variables was checked by using the Kolmogorov-Smirnov test. The $\chi 2$ test was used to compare categorical variables, and the Fischer test was used when chi-square conditions could not be met.

RESULTS

A total of 31 pediatric patients who required tube thoracostomy were included in our study. The median age was 50 (4-214) months, and the gender distribution of the patients was almost equal. The median duration of a PICU stay was 10 (4-100) days. The median PRISM score was 6 (0-29). Eight patients (25.8%) had co-morbid diseases, while respiratory tract diseases were the most common (12.9%). Respiratory diseases (64.5%) such as pneumonia and asthma attacks were among the most common causes of admission to the PICU in patients undergoing TT, followed by trauma (22.6%) (Table 1).

Table 1. Clinical characteristics of patients admitted to pediatric intensive care

Gender, n (%)	
Male	16 (51.6)
Female	15 (48.4)
Age (month), median (min-max)	50 (4-214)
PRISM III score), median (min-max)	6 (0-29)
Comorbid diseases, n (%)	
Respiratory diseases	4 (12.9)
Neurological diseases	2 (6.5)
Hematology-oncological diseases	1 (3.2)
Metabolic diseases	1 (3.2)
Etiologies of admission, n (%)	
Respiratory diseases	20 (64.5)
Trauma	7 (22.6)
Neurological diseases	2 (6.5)
Others	2 (6.5)
Length of stay, median (min-max)	10 (4-100)
Requirement of IMV, n (%)	19 (61.3)
IMV duration, median (min-max)	9 (3-93)
Requirement of NIMV, n (%)	23 (74.2)
NIMV duration, median (min-max)	4 (1-11)
NIMV modality, n (%)	
HFNC	16 (69.5)
NIMV-oronasal	5 (21.7)
NIMV-nasal	2 (8.7)
NIMV, n (%)	
Inisial	13 (56.5)
Postextubation	10 (43.5)
Mortality, n (%)	6 (19.4)

HFNC: High-flow nasal cannula, IMV: Invasive mechanical ventilation, NIMV: Noninvasive mechanical ventilation, PRISM III: Pediatric Risk of Mortality III,

Analysis of the patients' TT indications reveals that pneumothorax (PTX) accounts for roughly 45.1% of them, followed by pleural effusion (38.7%), and hemothorax (16.1%). Six (19.4%) patients experienced complications related to chest tubes (Table 2). Effective oscillation could not be achieved due to malposition in 2 patients. The thoracic tube was removed unplanned in 2 patients. In 2 patients, recurrent pneumothorax was observed after tube removal. CXR was performed in 17 patients after tube removal. Recurrent PTX was identified in one of these patients while conducting a post-removal chest X-ray, despite the absence of accompanying symptoms. In the CXR of the second patient, recurrent PTX was seen, which was taken after the occurrence of desaturation during the follow-up period. The other 13 patients who did not undergo CXR were asymptomatic.

Invasive mechanical ventilation (IMV) was required in 19 patients (61.3%), and the median duration of IMV was 9 (3-93) days. A total of 23 patients (74.2%) required non-invasive mechanical ventilation (NIMV) support during their stay in PICU. NIMV support was required after extubation in 43.5% of the patients. High-flow nasal oxygen therapy was

given in 69.5% of the patients as NIMV support, followed by NIMV-oronasal in 21.7% and NIMV-nasal in 8.7%. The median duration of NIMV was 4 (1-11) days. Of 9 patients with PTX who required NIMV support, 6 underwent HFNC and 3 underwent nasal NIMV. No increase in air leakage was observed during NIMV administration in these patients.

Table 2. Clinical characteristics of chest tubes placed in pediatric intensive care

TT indication, n (%)	
Pneumothorax	14 (45.2)
Pleural effusion	12 (38.7)
Hemothorax	5 (16.1)
Location TT , n (%)	
Right	24 (77.4)
Left	4 (12.9)
Both sides	3 (9.7)
TT duration, days, median (min-max)	5 (2-36)
Complications, n (%)	6 (19.4)
Chest X-Ray after TT removal	
Yes	17 (54.8)
No	14 (45.2)

TT: Tube thoracostomy

In univariate analyzes for indications of TT, no statistically significant difference was found in terms of PICU length of stay, NIMV and IMV requirement, duration of TT, complications, and mortality (Table 3).

DISCUSSION

Therapeutic tube thoracostomy is indicated in both pediatric and adult populations, presenting a range of clinical manifestations. The majority of the studies on the management of thoracostomy tubes and catheters have been done in adults. There is a limited number of research that has been conducted in the pediatric population. The effectiveness of therapeutic TT in pediatric patients appears to be superior to that observed in adult populations. Due to differences in anatomical and metabolic characteristics, earlier detection of respiratory failure in children causes symptoms to appear earlier compared to adults. Earlier diagnosis and treatment correlate with better outcomes.[5]

According to pediatric studies, there is a higher prevalence of thoracic trauma and the requirement for TT placement in the male gender within the childhood age group.[6,7] In our study, we found almost equal distribution between the genders. This difference in distribution was attributed to the diagnosis of the patients. Since patients other than trauma are admitted in our PICU, gender distribution may be different compared to TT studies in which only trauma patients are included.

The placement of a thoracostomy tube is a frequently performed medical intervention aimed at evacuating air (pneumothorax), fluid (effusion), pus (empyema), or blood (hemothorax) from the pleural cavity, as well as administering drugs into this region for therapeutic purposes such as pleurodesis or fibrinolysis.[8] In our study, TT was mostly used for PTX drainage, followed by pleural effusion. This can be explained by patients with high auto-positive end-expiratory pressure (PEEP) such as asthma, bronchiolitis, and subsequent trauma exposure. In addition, we found the rate of hemothorax to be 16.1%, consistent with the literature.[9,10]

Acute respiratory failure can be induced by clinical circumstances such as respiratory tract infections and severe thoracic injuries, which result in alveolar collapse and destruction.[11] Hence, for decades, the utilization of invasive mechanical ventilation accompanied by PEEP has been advocated as the sole viable method of providing respiratory support to enhance gas exchange. IMV has been performed in up to 50% of patients with chest injuries.[12] While tracheal intubation and mechanical ventilation are essential medical interventions that can save lives, they are not without potential drawbacks. These interventions have been associated with complications such as barotrauma, ventilator-associated infections, and other issues related to sedation and immobility.[13] Non-invasive mechanical ventilation (NIMV) has the potential to enhance gas exchange and potentially mitigate the need for intubation and mechanical ventilation in certain pediatric patients.[14] In cases with PTX, especially positive pressure ventilation can increase air leakage and eventually lead to hypertensive pneumothorax. However, Chiumello et al.[12] showed no significant relationship between the use of NIMV and the incidence of pneumothorax. Given that continuous positive airway pressure (CPAP) presents a reduced physiological risk of barotrauma while maintaining comparable efficacy to non-invasive mechanical ventilation (NIMV), it is recommended as the primary therapeutic approach for those suffering from severe chest trauma. In our study, no increase in air leakage was observed in patientes requiring NIMV support during the TT insertion period.

Table 3. Comparison of chest tube indications

	Pneumothorax	Pleural effusion	Hemothorax	p
Length of stay, median (min-max)	12.5 (7-100)	9 (4-17)	16 (4-64)	0.181
Requirement of IMV, n (%)	10 (52.6%)	5 (26.3%)	4 (21.1%)	0.193
IMV duration, median (min-max)	12.5 (4-93)	6 (5-7)	15 (3-32)	0.069
Requirement of NIMV, n (%)	9 (39.1%)	11 (47.8%)	3 (13%)	0.308
NIMV duration, median (min-max)	5 (1-11)	3 (1-10)	3 (1-10)	0.406
TT duration, median (min-max)	5 (2-25)	5 (3-15)	6 (3-36)	0.777
Complications, n (%)	4 (66.7%)	0 (0.0%)	2 (33.3%)	0.082
Mortality, n (%)	5 (83.3%)	1 (16.7%)	0 (0.0%)	0.071

IMV: Invasive mechanical ventilation, NIMV: Noninvasive mechanical ventilation, TT: Tube thoracostomy

The tube thoracostomy placement carries inherent risks. Numerous issues may arise throughout the application process or during the subsequent follow-up period. Although estimates of the rate of injury in children are often greater than those for adults, with some publications citing rates as high as 30%, the risks of complications are thought to be the same for both children and adults.[15-17] The most common complication of tube thoracostomy is malposition of the tube, as in our study.[18]

Since TTs are often used for the drainage of pleural fluid or the evacuation of air leaks, a new air leak or fluid can accumulate in the pleural cavity upon removal of TT. These potential side effects of chest tube removal can cause respiratory distress and require immediate attention. Generally, a post-removal CXR was obtained after TT removal to rule out any complications. However, considering the number of complications found in post-removal CXR in studies, the place of routine CXR has become controversial to reduce radiation exposure and be cost-effective, especially in pediatric patients.[4,19] In our study, recurrent PTX was seen in 2 patients, routine CXR was not performed in only 1 of them. PTX was detected in the CXR taken due to respiratory distress in the patient. Due to the insufficient number of patients, there was no statistical significance in our study in terms of routine CXR. However, multicenter and large studies are needed to establish post-removal guidelines instead of routine CXR, especially considering radiation exposure in pediatric patients.

Study Limitations

The most important limitation of our study is the small number of patients. With medical advances and the development of less invasive treatment strategies, there have been fewer TT insertions and subsequent removals in patient subgroups, making our overall numbers for analysis small.

CONCLUSION

TT is a life-saving interventional procedure in emergencies. This method, which must be implemented universally across all age groups, might arise as a result of either traumatic or non-traumatic causes. The absence of proper execution of this technique may result in considerable morbidity and fatality. Hence, all clinicians must possess a comprehensive understanding of the tube thoracostomy operation.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Sancaktepe Şehit Prof Dr İlhan Varank Training and Research Hospital Scientific Researches Ethics Committee (Date: 17.02.2023, Decision No: 2023/07).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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