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Outcome of tube thoracostomy in paediatric non-traumatic pleural fluid collections

Eyo E. Ekpe, M. U. Akpan[1]

ABSTRACT

Objective: Management of pleural fluid collection not due to trauma increases workload of the paediatric thoracic surgeons, while delay or inappropriate treatment worsens the prognosis of the disease. This study aimed at assessing the outcome of therapeutic tube thoracostomy in non-traumatic paediatric pleural fluid collections and identifying factors responsible for treatment failure with tube thoracostomy. **Design:** Prospective analysis of socio-demographic characteristics, clinical features, clinical diagnosis, radiological diagnosis, and bacteriological diagnosis including bacteria cultured with sensitivity pattern, also treatment offered including tube thoracostomy with duration of tube thoracostomy and length of hospitalisation, indication for additional surgical procedure with type, and outcome of treatment of 30 paediatric patients with non-traumatic pleural fluid collection. **Results:** Thirty paediatric patients with various causes of non-traumatic pleural fluid collection in 34 pleural spaces were analysed. Their ages ranged between six months and 16 years (mean = 6.5 years) and M:F ratio of 2:1. Pleural effusion and empyema thoracis accounted for 46% and 40% with staphylococcus aureus and streptococcus pneumoniae cultured in 10% each and a high negative culture rate of 46%, which was higher with age. The parents of 40% of the patients belonged to social class 3. Success rate of tube thoracostomy was 86% in unilateral cases, 50% in bilateral cases and 81% in all cases. Alternative treatment with thoracotomy and decortications gave a success rate of 100%. **Conclusion:** Thoracotomy with decortication is superior to tube thoracostomy in paediatric non-traumatic pleural fluid collection and should be chosen as the primary treatment option when there is bilateral disease, chronicity, loculated effusion, thickened pleural membranes or trapped lung.

Keywords: Tube thoracostomy, Pleural fluid collections, Paediatric

Departments of Surgery, Cardiothoracic Surgery Unit, [1]Paediatrics, University of Uyo Teaching Hospital, Uyo, Akwa Ibom, Nigeria

Address for correspondence:
Dr. Eyo E. Ekpe,
Department of Surgery, Cardiothoracic Surgery Unit, University of Uyo Teaching Hospital, Uyo, P.M.B. 1136, Uyo, Akwa Ibom – Nigeria.
E-mail: docekpe@yahoo.com

INTRODUCTION

Tube thoracostomy may be used as prophylaxis or for therapy in both adult and paediatric thoracic surgery. The role of therapeutic tube thoracostomy in thoracic trauma is well established where it is known to constitute up to 85% of surgical interventions indicated in both blunt and penetrating types of chest injury.[1] However, in non-traumatic thoracic pathology, the role of therapeutic tube thoracostomy is not so well established. This is because of the heterogeneous nature of non-traumatic thoracic pathologies associated with pleural fluid collection and their differing natural history.

Pleural fluid collections not due to chest trauma in children remain common thoracic surgical problems in the developing countries including Nigeria.[2,3] This is largely because of the persistently ravaging poverty, ignorance and infections.[4] The thoracic surgeons practicing in Nigeria are frequently consulted to review and manage paediatric patients presenting with non-traumatic pleural fluid collection.

Pleural sepsis has remained the most common cause of non-traumatic pleural fluid collection in Nigerian children with empyema thoracis resulting from poorly treated broncho-pneumonia ranking high.[4] Pleuro-pulmonary tuberculosis in children is increasingly becoming important as a cause of pleural fluid collection especially now that multiple-drug resistant tuberculosis (MDR-TB) and extended-drug resistant tuberculosis (EDR-TB) cases are being increasingly diagnosed in Nigeria.[5] Contribution by non-infectious pathologies such as connective tissue diseases and malignancies as causes of pleural fluid collection in children is still small.

In non-traumatic pleural fluid collection caused by pleural sepsis, in addition to appropriate anti-microbial therapy, therapeutic tube thoracostomy alone or with intra-pleural fibrinolytic adjunct can result in complete drainage and lung expansion in the early stages of the disease when complete lung re-expansion could still

be achieved following the drainage of the fluid.[6,7] However, with chronicity, loculation and pleural peel development will impair a successful treatment outcome with simple pleural drainage and, therefore, thoracotomy with decortication becomes ideal option.[8]

This study aimed at finding the outcome of therapeutic tube thoracostomy in non-traumatic paediatric pleural fluid collection and identifying factors responsible for treatment failure with tube thoracostomy.

MATERIALS AND METHODS

A prospective study involving all paediatric patients referred to the cardiothoracic surgery unit with diagnosis of pleural fluid collection not associated with trauma between November 2006 and November 2011. Each patient's proforma form sought information on socio-demographic characteristics, clinical features, clinical diagnosis, radiological diagnosis; bacteriological diagnosis including bacteria cultured with sensitivity pattern, also treatment offered including tube thoracostomy with duration of tube thoracostomy and length of hospitalisation, indication for additional surgical procedure with type and outcome of treatment.

Table 1: Demographic characteristics of the patients

	Gender of patients		N (%)	X^2	*P*-value
	Male	Female			
Age (years)					
< 1	4	0	4 (13.3)		
1-5	3	5	8 (26.7)		
6-12	9	2	11 (36.7)	6.48	0.09
> 12	4	3	7 (23.3)		
Social class					
1	0	0	0 (0)		
2	0	0	0 (0)		
3	9	3	12 (40.0)	0.87	0.64
4	6	3	9 (30.0)		
5	5	4	9 (30.0)		

Table 2: Diagnosis/indication for thoracostomy

Indication for thoracostomy	N (%)
Empyema secondary to lung abscess	1 (3.3)
Empyema secondary to pneumonia	9 (30.0)
Pleural effusion secondary to pneumonia	10 (33.3)
Pleural effusion secondary to rheumatoid arthritis	1 (3.3)
Pleural effusion secondary to mediastinal lymphoma	1 (3.3)
Pleural effusion secondary to amoebic liver abscess	1 (3.3)
Pleural/pericardial effusion secondary to pneumonia	1 (3.3)
Empyema secondary to tuberculosis	2 (6.7)
Hydro-pneumothorax secondary to tuberculosis	3 (10.0)
Empyema secondary to bronchiectasis	1 (3.3)
Total	30 (100)

All specimens for bacteriologic study were obtained before administration of antibiotic in our facility.

Data obtained was analysed using SPSS version 11.6.

RESULTS

During the study period, there were 30 children with various causes of non-traumatic pleural fluid collection in 34 pleural spaces (being bilateral in four patients), with age range between six months and 16 years (mean = 6.5 years) and M:F ratio of 2:1. More than one-third of patients (36.7%) belonged to school age, teenagers were 23.3%, pre-school children were 26.7% while infants accounted for only 13.3% [Table 1]. Table 1 further shows that 40% of the patients were children of parents in social class 3, while parents of remaining children were equally distributed into social classes 4 and 5 as 30% each. There was no child with pleural fluid collection whose parents were in social class 1 or 2.

Analysis of the causes of pleural fluid collection/indications for tube thoracostomy in the 30 patients shows pleural effusion to be responsible for about 46.7%, out of which pneumonia accounted for 78.6%, while amoebic liver abscess, rheumatoid arthritis and mediastinal lymphoma accounted for the pleural effusion in one (7.7%) patient each [Table 2]. Empyema thoracis accounted for about 43.3% of pleural fluid collection in this study. Of this, pneumonia was again responsible for about 69.2%, while tuberculosis was responsible for 15.4%, and bronchiectasis and lung abscess occurred in one case (7.7%) each. The remaining 10% of patients needed tube thoracostomy because of hydro-pneumothorax caused by pulmonary tuberculosis.

Table 3 shows that six bacteria were isolated from the pleural aspirates of 16 (53.3%) patients. The bacteria were streptococcus pneumoniae, staphylococcus aureus, coliforms, haemophillus, proteus mirabilis, and pseudomonas, either occurring singly or mixed growth.

Table 3: Distribution of patients according to organisms isolated

Organisms Isolated	N (%)
Coliforms	2 (6.7)
Haemophilus	2 (6.7)
No organism isolated	14 (46.7)
Proteus mirabilis	2 (6.7)
Pseudomonas	2 (6.7)
Staph aureus	3 (10.0)
Coliforms/Strept pneumonia	1 (3.3)
Strept pneumonia	3 (10.0)
Strept pneumonia/Staph aureus	1 (3.3)
Total	30 (100.0)

There was a high negative culture rate of 46.7%. Further analysis shows that negative culture increases as the age of the patients with negative culture in six out of the seven teenagers in the study ($P = 0.45$), and no negative culture in all the four infants in the study [Table 4].

Table 5 depicts the various treatment modalities offered to the patients directed at drainage of the pleural fluid collection. Closed tube thoracostomy drainage (CTTD) was done in 26 (86.3%) patients (bilateral in 13.3%), CTTD combined with window pericardiostomy in one patient that had associated pericardial effusion, and open thoracotomy with decortication in two patients combined with bronchotomy for removal of foreign body in one patient who had chronic lung abscess and empyema thoracis caused by aspiration of non-organic foreign body. Analysis of treatment with outcome [Table 6] shows that for unilateral non-traumatic pleural fluid collection in children, therapeutic tube thoracostomy resulted in complete drainage and lung expansion in up to 86% of cases as against 100% following thoracotomy with decortication in the two patients that were offered this treatment modality. Also, mean length of hospitalisation and duration of tube thoracostomy were longer in the tube thoracostomy patients than in the thoracotomy with decortication patients (22.4 vs. 14.1 days and 9.2 vs. 5.6 days, respectively). However, tube thoracostomy resulted in complete drainage and lung expansion in two (50%) out of the four patients that had bilateral diseases, and cannot be directly compared with thoracotomy with decortication since there were no patients that were treated with bilateral thoracotomy with decortication. The only thoracostomy – related complication was failed drainage in one patient that had loculated empyema thoracis.

Factors identified in this study to be predictive of failure of medical treatment with tube thoracostomy include bilateral disease, chronicity, thickened pleural membranes and trapped lung.

Table 4: Distribution of organisms isolated by the age of the patients

	Organism isolated	No organism isolated	Total
Age (years)			
< 1	4	0	4 (13.3)
1-5	5	3	8 (26.7)
6-12	6	5	11 (36.7)
> 12	1	6	7 (23.3)
Total	16	14	30 (100)

$X^2 = 8.06$ $P = 0.045$ percentages in parenthesis

Table 5: Distribution of patients according to treatment received

Treatment received	N (%)
Bilateral CTTD	4 (13.3)
CTTD	22 (73.0)
CTTD, bronchotomy, thoracic decort	1 (3.3)
CTTD, pericardiotomy	1 (3.3)
Failed CTTD	1 (3.3)
Thoracotomy + decort	1 (3.3)
Total	30 (100)

DISCUSSION

There are various indications for therapeutic tube thoracostomy in children just as in adults. The efficacy of the medical treatment with therapeutic tube thoracostomy in non-traumatic indications in children seems to be better than in adults.[9] This is because presentation of diseases associated with pleural fluid collections is earlier in children than in adults since the symptoms of pressure effect of pleural fluid collection manifest earlier in children who because of smaller anatomy tolerate such symptoms poorer than adults. Earlier presentation and treatment correlate positively with successful outcome of treatment.[9] The present study reveals a male preponderance (M:F = 2:1) as shown by other studies,[4,7,8] with a median age in the school age where 36.7% of the patients belongs [Table1]. Analysis of the socio-economic data of the parents reveals that ignorance and poverty are positively related to the occurrence of pleural effusion in association with pulmonary diseases as 40%, 30% and 30% of the parents

Table 6: Treatment received and outcome

Treatment received	Residual fluid	Complete drainage/partial lung expansion	Outcome LAMA	Removed on request	Complete drainage/complete lung expansion	Total
Bilateral CTTD	2	1	0	0	1	4
CTTD	1	3	1	1	16	22
CTTD, bronchotomy, thoracic decort	0	0	0	0	1	1
CTTD, pericardiotomy	0	0	0	0	1	1
Failed CTTD	0	0	1	0	0	1
Thoracotomy + decort	0	0	0	0	1	1
Total	3	4	2	1	20	30

$X^2 = 40.45$ $P = 0.026$

belong to social classes 3, 4 and 5, respectively. Since pleural fluid collection is usually a late complication of pulmonary infections, it is commonly in the children of poor and illiterate parents that pulmonary infections would be neglected till complications develop. Previous studies have alluded to the importance of ignorance, poverty and medical charlatan in mismanagement of childhood pneumonia with consequent empyema thoracis.[4]

The predominance of parapneumonic pleural effusion as the indication for therapeutic tube thoracostomy among children with pleural effusion in this study is supported by other literatures[9] and is strongly indicative of the fact if paediatric pneumonia is presented to hospital on time for treatment, the need for tube thoracostomy for non-traumatic indications could be reduced by about 40%. Infective causes or parapneumonic pleural effusion accounted for 63% of the indications for tube thoracostomy in the reported series by Nwafor *et al*.[10] The rarity of non-infective causes of pleural effusion in this study is indicative of the fact that those non-infective pathologies associated with pleural effusion like advanced malignancy and connective tissue disorders are still rare in paediatric patient population.[9]

Empyema thoracis classified separately from pleural effusion in this study accounted for 43.3% of pleural fluid collection and again caused by pneumonia in 69.2%. Some studies on paediatric empyema horacis have analysed the cause while others have only focussed on outcome of the various treatment modalities.[4,6-8] In the study by Anyanwu *et al.,* up to 39.4% of the pleural aspirates was culture-negative.[3] Other studies have made no demarcation between sterile pleural effusion and empyema thoracis when all pleural fluid collections are classified as pleural effusion.[10] The magnitude of primary pulmonary tuberculosis as the cause of pleural fluid collection is unexpectedly small in this study (16.7%). This is likely to be as a result of our case definition criteria, which included positive sputum Acid Fast Bacilli X3, positive tuberculin skin test (≥ 10 mm) and suggestive appearances on chest radiograph. Less stringent case definition criteria of (1) Mycobacteria tuberculosis detection from a clinical specimen, or (2) a clinical evidence of current disease and any of the following: *(a)* a history of contact with an adult case of tuberculosis; *(b)* positive tuberculin skin test (≥ 5 mm); *(c)* suggestive appearances on chest radiograph; and *(d)* favourable response to specific anti-tuberculous therapy have been used in another study.[11] The other causes of empyema thoracis were lung abscess caused by neglected foreign body in the left lower bronchus and bronchiectasis in one patient each. Three cases of broncho-pleural fistula resulting in hydropneumothorax caused by primary pulmonary tuberculosis constituted about 10% of the indications for therapeutic tube thoracostomy in this study. The presenting symptoms in this study conform with those of other similar studies and included cough, difficulty in breathing, chest pain and fever.[4,7,11] The diagnostic investigations utilized in this study included chest radiography, sputum and pleural aspirate microscopy, culture and sensitivity; Ziehl Nelsen smear of sputum and pleural aspirate, biochemical analysis of pleural fluid; pleural aspirate cytology; and Mantoux test similar to other studies.[11] Biochemical analysis showed that in all cases (100%), the pleural effusion fulfilled criteria for exudative pleural effusion with high levels of proteins (> 30 g/L) and lactate dehydrogenase (> 200 U/L). Bacteria isolated were identical to those of previous studies.[3,4] There was a high negative culture rate of 46.7%, which is attributed to pre-presentation antibiotic therapy either prescribed by a doctor or obtained from pharmacy or patent medicine shop without prescription. This has also been found in previous study.[3,4,12] This study reveals a statistically significant tendency of negative culture of pleural aspirates with increase in age of patient. Table 4 shows that all four infants' pleural aspirates cultured bacteria (100%) while only one of the seven teenagers' pleural aspirates yielded positive bacterial growth (14%) ($x^2 = 8.06$, $P = 0.045$). The likely explanation for this observation is that pre-presentation antibiotic therapy is most unlikely in infants, while the tendency to undergo un-prescribed on un-supervised medication is very high in the older paediatric age groups. Previous work by the authors has shown the tendency of broncho-pneumonia in children to progress to thoracic empyema is high with irrational pre-presentation antibiotic use.[4]

When tube thoracostomy is instituted early in paediatric pleural fluid collections with therapeutic intents, it can give success rates varying from 84-92%.[6,7,9] In some studies, clearance of fibrin from the pleural membranes during thoracostomy drainage is enhanced by intra-pleural fibrinolytic therapy with tissue plasminogen activator, streptokinase or urokinase.[6,9,12] This study demonstrates a success rate with therapeutic tube thoracostomy of 86% when analysis excludes patients with bilateral fluid collections [Table 6]. However, when analysis includes bilateral pleural fluid collections, the success rate is reduced to 81%. Success rate is adjudged by complete drainage of fluid collection and lung expansion. The success

rate of therapeutic tube thoracostomy in bilateral cases is 50%, which implies that certain other factors may be responsible for failure of tube thoracostomy, which could be predicted at diagnosis and alternative modalities of treatment offered primarily. Thoracotomy and decortication done primarily on two patients with chronic empyema thoracis in this study was well tolerated and gave uniformly excellent outcome in terms of completeness of drainage and lung expansion. This major thoracic operation has been proven superior to tube thoracostomy in both adult and paediatric empyema thoracis, and can be utilized as the primary treatment.[2,3,8] Procedure-related complication rate was only about 3%. This is low when compared to other studies,[1,10] and could be attributable to the fact all cases of paediatric tube thoracostomies in the study centre are either undertaken by thoracic surgeon or supervised as such when done by resident doctors.

This study has identified five factors as being responsible for failure of therapeutic tube thoracostomy in the treatment of pleural fluid collection in children to include bilateral disease, chronicity, loculated effusion, thickened pleural membranes and trapped lung.

CONCLUSION

Thoracotomy with decortication is superior to tube thoracostomy in paediatric non-traumatic pleural fluid collection and should be chosen as the primary treatment option when there is bilateral disease, chronicity, loculated effusion, thickened pleural membranes or trapped lung.

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