

COMPARING TREATMENT MODALITIES FOR PARAPNEUMONIC PLEURAL EMPYEMA IN CHILDREN: WHAT TO CHOOSE AND WHEN, A RETROSPECTIVE STUDY

Carolina Soares-Aquino*¹, Sofia Vasconcelos-Castro¹, Norberto Estevinho¹, Miguel Campos¹, Mariana Borges-Dias¹

¹ Department of Paediatric Surgery, Centro Hospitalar Universitário de São João

* Corresponding author: carolinarfsa@gmail.com

Abstract

Introduction: Parapneumonic pleural empyema (PPE) is common in children, however, the most appropriate treatment is not established. We aimed to analyse and compare treatments for PPE and its outcomes.

Methods: Single-centre retrospective analysis of PPE cases from 2012-2024, concerning demographics, times until treatment and resolution, failure, alternative treatments, complications and follow-up. Lung necrosis contraindicated fibrinolysis; simple effusions and bilateral pneumonias were excluded. Time until treatment was considered after the diagnosis of PPE.

Results: 77 cases were identified with a median age of 5 years. The most common initial treatment was intrapleural fibrinolysis (58%), followed by thoracoscopic decortication (29%) and simple drainage (13%). Failure happened after all (10/10) drainages, 22% (10/45) of fibrinolysis and 9% (2/22) of thoracoscopies. Compared to thoracoscopy, fibrinolysis had no difference in failure ($p=0.310$) but had a longer treatment duration (17 versus 13 days, $p=0.004$). Excluding failures, no difference was found in treatment duration, postoperative fever and complications.

Conclusion: While simple drainage of PPE should not be attempted, thoracoscopic decortication and fibrinolysis seem equally effective. There was a shorter treatment duration with thoracoscopic decortication and no increase in complications, so the authors recommend it should be employed promptly when fibrinolysis is contraindicated, as in necrotizing pneumonia.

Keywords: Empyema, Pleural; Minors; Thoracoscopy; Fibrinolysis; Pneumonia, Necrotizing

INTRODUCTION

Parapneumonic pleural effusion and empyema (PPE) is a common condition in children, with an increasing frequency over the last years¹. Its estimated incidence is 3.3 per 100,000 in recent publications^{1,2}. It is estimated that empyema can affect 0.6% to 2% of all community acquired pneumonias, and up to 53% among children hospitalised with pneumonia^{3,4}. Pneumonia is one of the most common pathologies that can be complicated with a pleural effusion, evolving in three stages: exudative phase, with accumulation of free fluid in the pleural space, not loculated; fibrinopurulent phase, with suspension of fibrinolytic activity, leading to fibrin accumulation and loculation of the fluid; and organisation phase, with further deposition of fibrin creating a fibrous rind that

ultimately encases the lung, leading to restriction of its expansion and limitation of the chest wall movement^{2,5,6}.

In the second and third stages of PPE, treatment modalities to evacuate the loculated fluid from the pleural space and to free the lung and restore the normal expansion of the chest wall are necessary, both to resolve the infection and prevent further ventilatory compromise. The classical technique of pleural decortication is, in the later years, being systematically substituted for minimally invasive techniques that present equivalent efficacy and lower morbidity⁵. The most common options are intrapleural fibrinolysis (IPF) and thoracoscopic decortication (TD). The first one consists in the administration of a fibrinolytic agent through the chest drain according to an established protocol⁷; the second is the use of thoracoscopy to directly remove

the fluid and debris from the pleural cavity, thus freeing the lung and allowing lung re-expansion. Although increasing interest has developed around the IPF for its simplicity and no requirement of special equipment or techniques, recent publications have enhanced the benefit of TD, stating that it provides a better and faster recovery without an increase of complication rates^{1,2,8}. Necrotizing pneumonia, in particular, poses difficulty among paediatric surgeons: with lung necrosis, IPF is generally partially contraindicated in most protocols due to a risk of bleeding and bronchopleural fistula⁶; on the other hand, TD is seen as an aggressive treatment that can lead to bleeding or persistent air fistula⁹.

Previous studies showed that both IPF and TD were superior to chest drainage alone, but it is unclear which offers the best results, the lowest morbidity and the fastest recovery^{1,3,5,10}.

With this study we aimed to compare the treatments employed for PPE in our department, in order to understand its efficacy and failure rates. As secondary endpoints we analysed the duration of treatment and complications of each treatment.

METHODS

A retrospective study was conducted analysing all the cases of PPE in our tertiary centre department of paediatric surgery from 2012 to 2024. The research was conducted using the International Classification of Diseases codes (ICD) for PPE: ICD-9 codes 510, 511.1 and ICD-10 codes J86.0, J86.9, J90 and J91^{11,12}.

The collected data included: demographic data, time from symptoms to first treatment, time from symptoms to pleural intervention, time from pleural intervention to resolution, time from pleural intervention to end of the treatment, interventions performed, laboratory exam results, radiology exam results, follow-up data.

Exclusion criteria were: simple pleural effusion; previous thoracic surgery; other aetiology besides pneumonia; bilateral pneumonia.

“Duration of symptoms” was defined as the time between the beginning of symptoms and the beginning of treatment for pneumonia. “Time until intervention” was defined as time between the diagnosis of PPE and the application of a pleural treatment. “Time until resolution” of PPE was defined as the time between pleural intervention and drain removal.

The treatments considered were: simple chest drainage (SCD), intrapleural fibrinolysis (IPF), thoracoscopic decortication (TD), classic decortication (CD). IPF was performed according to our hospital protocol, with a daily dose of 0.1mg/kg of alteplase administered through the chest tube for three days, leaving the chest tube clamped for one hour and with free drainage for the next 24 hours. Although necrotizing pneumonia contraindicated

IPF, sometimes it was discovered only after the beginning of the procedure. TD was performed either with a single-port of 10mm or two-port of 5mm technique, with aspiration of the effusion, freeing of the lung and fissures in all of its extension and removal of the fibrin from the chest wall and lung. There were no ethical implications, and procedures were performed according to relevant guidelines.

The statistical analysis was conducted using the IBM SPSS Statistics 20 software. The level of significance used was $p < 0.05$ two-sided. The continuous variables were expressed as median (interquartile range, IQR) and were compared using Kruskal-Wallis or Mann-Whitney test, as appropriate. The categorical variables were described by absolute and relative frequency and were compared using Fisher's exact test (if any expected $n < 5$) or Chi-square tests (χ^2).

RESULTS

During the study period, 77 cases of PPE were treated in our department. The median age of the patients was 5 years, with a minimum of 8 months and a maximum of 18 years. Patients were females in 39% of cases ($n=30$). There were no statistically significant differences between the groups regarding patient age and sex. The pneumonia was on the right side in 53% of cases ($n=41$). Median follow-up was six months (IQR 1-11.75). Further patient characteristics can be seen in Table 1, and microbiological isolates in Table 2.

When considering the first treatment employed, 10 cases (13%) were submitted to SCD, 45 cases (58%) to IPF and 22 cases (29%) were submitted to TD. There were no significant differences in the time from symptom onset until diagnosis between the three treatment groups, as in Table 3. Failure of the initial treatment occurred in all cases of SCD. There was no statistical difference between failures rates when comparing IPF and TD ($p=0.310$).

The second and third treatments employed after previous treatment failure can be seen in Figure 1. Only one patient needed a tertiary intervention by CD after failure of both a primary IPF and a secondary TD.

After primary intervention, total duration of hospitalisation was significantly longer after IPF than after TD ($p=0.004$, 17 days versus 13 days) (table 4). There were no significant differences between these two treatments regarding the time until resolution of the empyema and the time until apyrexia. There was, however, a trend towards a lower time until resolution of the empyema after TD versus IPF ($p=0.059$).

When excluded from the analysis the cases with failure of the primary treatment, IPF had a longer duration of hospitaliation ($p=0.007$) but not until resolution of the empyema ($p=0.124$) (Table 5). There were no differences between IPF and TD in terms of time until apyrexia ($p=0.570$).

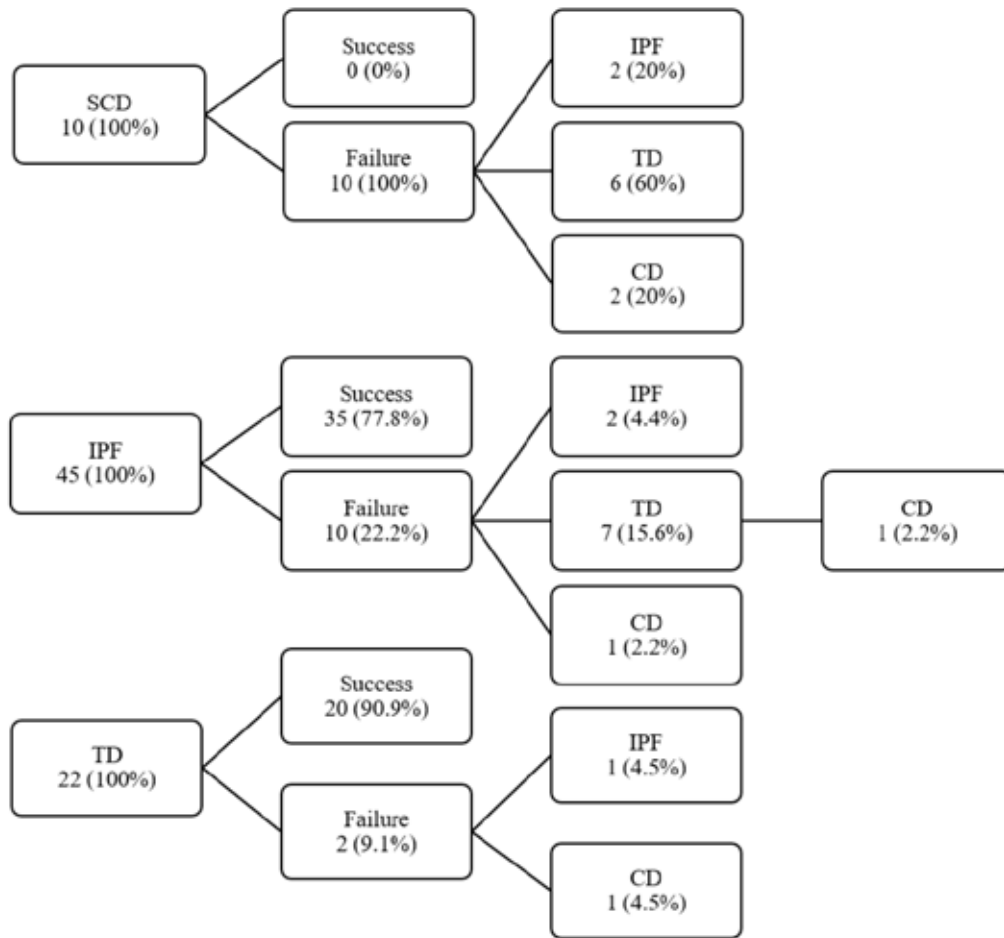


Figure 1 Secondary treatments employed after failure. Data displayed as absolute count (percentage).

There were no differences in terms of complications in any of the groups. Complications can be seen on Table 6.

DISCUSSION

The optimal treatment for PPE is a clinical difficulty most paediatric surgeons encounter regularly, and its apparently growing incidence has made this question even more pertinent nowadays¹.

Several authors have been addressing this question, without a definitive answer. The present study couldn't, also, indicate what is the best option for treatment, as both intrapleural fibrinolysis and thoracoscopic decortication had no statistical difference in terms of efficacy and failure rates. This is according to the published literature, where fibrinolysis was considered comparable to thoracoscopic decortication¹³. What we found from analysing our data, however, is a

proportion of patients in which only chest drainage was employed due to a contraindication in the employment of fibrinolysis. In all these patients a secondary procedure was necessary, leading to higher times until resolution. This reinforces previous reports on the literature that show that both fibrinolysis and thoracoscopy showed better results than drainage alone³. It has also been described that a delay in adequate treatment is associated with worse outcomes, with better recovery and shorter hospitalisation and intensive care unit stay in the groups where an early intervention is performed^{2,14}. In these studies, an early approach is defined as the one that takes place in the first five days after diagnosis^{2,14}.

According to our protocol, lung necrosis generally contraindicates intrapleural fibrinolysis, especially if the necrosis is peripheral in the lung, due to a higher risk of haemorrhage and bronchopleural fistula. Nevertheless, recent data showed that fibrinolysis might be used in

Table 1 Patients' demographics and clinical characteristics. IQR, interquartile range. No, absolute number.

	Simple Chest Drainage (n=10)	Intrapleural Fibrinolysis (n=45)	Thoracoscopic Decortication (n=22)	p
Age, years (median, IQR)	4.5 (3.8-12.3)	5 (2-9.5)	5 (3-13)	0.587
Female, No. (%)	6 (60)	17 (37.8)	7 (31.8)	0.307
Left-sided pneumonia, No. (%)	8 (80)	21 (46.7)	7 (31.8)	0.041
Necrotizing pneumonia, No. (%)	5 (50)	6 (13.3)	6 (27.3)	-
Vaccinated for Pneumococci, No. (%)	7 (70)	31 (68.9)	15 (68.2)	-
Unvaccinated for Pneumococci, No. (%)	No data	3 (6.7)	1 (4.5)	-

Table 2 Microbiological isolates. No, absolute number

	Simple Chest Drainage (n=10)	Intrapleural Fibrinolysis (n=45)	Thoracoscopic Decortication (n=22)
No isolate, No. (%)	2 (20)	20 (44.4)	11 (50)
Streptococcus pneumoniae, No. (%)	6 (60)	12 (26.7)	9 (40.9)
Streptococcus pyogenes, No. (%)	1 (10)	6 (13.3)	0 (0)
Staphylococcus aureus, No. (%)	0 (0)	1 (2.2)	1 (4.5)
Other, No. (%)	1 (10)	6 (13.3)	1 (4.5)

Table 3 Duration of symptoms, time until intervention and failure of initial treatment. IPF, intrapleural fibrinolysis. IQR, interquartile range. No, absolute number. TD, thoracoscopic decortication

	Simple Chest Drainage (n=10)	Intrapleural Fibrinolysis (n=45)	Thoracoscopic Decortication (n=22)	IPF vs TD (p value)
Duration of symptoms, days (IQR)	6 (2.8-10)	4 (2-6)	4 (2-7)	0.215
Time until intervention, days (IQR)	0.5 (0-5.25)	0 (0-1)	1 (0-2.25)	0.01
Failure of initial treatment, No. (%)	10 (100)	10 (22)	2 (9)	0.310

Table 4 Comparison between primary IPF and TD. IPF, intrapleural fibrinolysis. IQR, interquartile range. No, absolute number. TD, thoracoscopic decortication.

	Intrapleural Fibrinolysis	Thoracoscopic Decortication	IPF vs TD (p value)
Duration of symptoms, days (IQR)	4 (2-6)	4 (2-7)	0.215
Time until intervention, days (IQR)	0 (0-1)	1 (0-2.25)	0.01
Time until resolution of PPE, days (IQR)	6 (4-11.5)	4.5 (3-6)	0.059
Time until apyrexia, days (IQR)	2 (0-3)	2 (1-4.3)	0.2
Total duration of hospitalisation, days (IQR)	17 (14-19)	13 (11.8-16.5)	0.004
Failure of initial treatment, No. (%)	10 (22)	2 (9)	0.310

Table 5

Comparative analysis between IPF and TD when excluding the cases with subsequent failure. IPF, intrapleural fibrinolysis. IQR, interquartile range. No, absolute number. TD, thoracoscopic decortication

	Intrapleural Fibrinolysis	Thoracoscopic Decortication	IPF vs TD (p value)
Duration of symptoms, days (IQR)	4 (2-6)	4 (2-7)	0.949
Time until intervention, days (IQR)	0 (0-1)	1.5 (0-2.75)	0.05
Time until resolution of empyema, days (IQR)	5 (4-7)	4 (3-5.8)	0.124
Time until apyrexia, days (IQR)	2 (0-3)	2 (1-4.3)	0.570
Total duration of hospitalisation, days (IQR)	16 (13-19)	13 (11.3-15.8)	0.007

Table 6

Complications reported in the clinical information. IPF, intrapleural fibrinolysis. No, absolute number. SCD, simple chest drainage. TD, thoracoscopic decortication

	SCD	IPF	TD	Total count
No complications, No. (%)	6 (60)	37 (82.2)	19 (86.4)	62 (80.5)
Drain related complications, No. (%)	1 (10)	5 (11.1)	0 (0)	6 (7.8)
Wound infection, No. (%)	2 (20)	0	1 (4.5)	3 (3.9)
Prolonged bronchopleural fistula (post-procedure), No. (%)	0 (0)	1 (2.2)	1 (4.5)	2 (2.6)
Haemorrhage, No. (%)	0 (0)	2 (4.4)	0 (0)	2 (2.6)
Other, No. (%)	1 (10)	0	1 (10)	2 (2.6)
Total, No. (%)	10 (100)	45 (100)	22 (100)	77 (100)

cases of lung necrosis and is probably not associated with a higher risk of bronchopleural fistula when compared to surgical treatment⁶. Still, other conditions can contraindicate fibrinolysis, like coagulation disorders.

In our series, the use of intrapleural fibrinolysis showed a higher failure rate than thoracoscopic decortication (22% versus 9%), a longer time until the resolution of the empyema and higher length of hospitalisation (17 versus 13 days); even when excluding 'group, there was a higher length of hospitalisation. These results are in accordance with previous studies in the literature, that show a higher percentage of failures with fibrinolysis and generally a longer hospitalisation time^{5,10,15}. This, however, is not supported by a systematic review and meta-analysis by Elviro et al., that reviewed eleven trials and found that, although fibrinolytics, thoracoscopy and thoracotomy were superior to chest drainage alone, there was no difference between them in the other outcomes³. They also described a cost benefit advocating for fibrinolysis, although this was not confirmed by some other authors². Our study also didn't find differences in the postoperative fever between the groups, a factor that has been described by some authors as a predictor of failure and need for reintervention¹⁵.

In a paediatric setting, chest drainage is performed under anaesthesia, thus requiring admission to the

operating room. As in our series there was no increase in complications with thoracoscopic decortication, we believe that the employment of this technique in an early manner could decrease the length of treatment, the length of hospitalisation and the time with the chest drain. Could this, considering the higher failures in the fibrinolysis group, prevent another anaesthesia?

This subject takes more importance when necrotizing pneumonia is considered. The incidence of necrotizing pneumonia has been increasingly recognised and it is associated with empyema in up to 64% of the cases⁶. In our series, thoracoscopic decortication was the choice for necrotizing pneumonia in 27% of the cases, compared to 13% in the case of fibrinolysis and 50% in the case of chest drainage. Previously associated by other authors with an increased length of stay, more complications and a higher need for reintervention, necrotizing pneumonia has been considered a predictor of poorer outcomes and poses the question on what treatment to choose^{6,16}. Other authors describe good outcomes of thoracoscopic decortication for necrotizing pneumonia-related empyema, with 88% efficacy rate and resolution in 7-9 days¹⁷. We believe that an early thoracoscopy could be favourable in cases of necrosis, precluding the eminent failure of isolated chest drainage and avoiding the theoretical risk of fibrinolysis,

for which the use in necrotizing pneumonia is not well demonstrated. Thoracoscopic decortication, in our series and according to available literature, was not associated with more complications or prolonged bronchopleural fistula than the other treatments¹⁸; it is our belief that its use straight away in cases of suspected lung necrosis could prevent further delays and improve the outcomes without an increase of the complication rate.

Although the ultimate decision about which treatment to employ and when belongs to the medical team, we believe that these insights about the treatment outcomes in different presentations of the disease offer good guidance to not only in choosing the best treatment, but also in adapting such treatment to the clinical situation and the available conditions and resources.

We acknowledge that this study has several limitations. The most significant limitation lies in its retrospective nature, as it can lead to selection bias and missing values that make comparability of the groups more difficult. Also, due to the retrospective nature, it was not possible to stratify the pleural effusions according to the pathological stage, even though only complicated effusions were considered. Prospective studies could overcome these difficulties, however, due to the urgent nature of most of these interventions, the implementation of a study protocol can be challenging.

CONCLUSION

According to our data, while simple drainage of parapneumonic pleural empyema should not be attempted, both thoracoscopic decortication and fibrinolysis are appropriate treatments, without a difference in failure rates; however, there was a shorter treatment time in thoracoscopic decortication when compared to fibrinolysis. Both treatments seem to be effective and safe. This advises in favour of an early usage of thoracoscopic decortication in cases when fibrinolysis is contraindicated, as in necrotizing pneumonia, as there was no increase in complication rate.

Conflict of interest

The authors declare no conflicts of interest.

Funding

The authors declare no source of funding.

REFERENCES

- Omid M, Rafieezadeh A, Talebi Anaraki K, et al. Comparing the efficacy of video assisted thoracoscopic surgery (VATS) vs intrapleural fibrinolytic therapy in children with pleural empyema. *Pediatric surgery international* 2025; 41: 111. <https://doi.org/10.1007/s00383-025-06006-w>
- Di Mitri M, Thomas E, Capano E, et al. The role of the early video-assisted thoracoscopic surgery in children with pleural empyema. *Pediatric surgery international* 2024, 40: 134.
- Fernandez Elviro C, Longcroft-Harris B, Allin E, et al. Conservative and Surgical Modalities in the Management of Pediatric Parapneumonic Effusion and Empyema: A Living Systematic Review and Network Meta-Analysis. *Chest* 2023, 164: 1125–1138.
- Shen K, Bribiesco A, Crabtree T, et al. The American Association for Thoracic Surgery consensus guidelines for the management of empyema. *The Journal of thoracic and cardiovascular surgery* 2017, 153: e129–e146.
- Griffith D, Boal M, Rogers T. Evolution of practice in the management of parapneumonic effusion and empyema in children. *Journal of pediatric surgery* 2018, 53: 644–646.
- Ness-Cochinwala M, Totapally B. A Comprehensive Review of Pediatric Necrotizing Pneumonia. *Children (Basel, Switzerland)* 2025, 12: 1248.
- James C, Lewis P, Moore M, et al. Efficacy of standardizing fibrinolytic therapy for parapneumonic effusion. *Pediatric radiology* 2022, 52: 2413–2420.
- Shatila M, Arab W, Fasih N, Karara K, Ramadan A. Comparative study between outcome of intercostal tube drainage and video assisted thoracoscopic surgery in management of complicated parapneumonic effusion in children. *Journal of the Egyptian Society of Cardio-Thoracic Surgery* 2018, 26: 68-72.
- Shankar G, Sahadev R, Santhanakrishnan R. Pediatric empyema thoracis management: should the consensus be different for the developing countries?. *Journal of pediatric surgery* 2020, 55: 513–517.
- Pacilli M, Nataraja R. Management of paediatric empyema by video-assisted thoracoscopic surgery (VATS) versus chest drain with fibrinolysis: Systematic review and meta-analysis. *Paediatric respiratory reviews* 2019, 30: 42–48.
- World Health Organization. *International Classification of Diseases, 1975 Revision (ICD-9)*. Geneva: World Health Organization, 1977.
- World Health Organization. *ICD-10 : international statistical classification of diseases and related health problems: tenth revision, 2nd edn*. World Health Organization, 2024.
- Peter S, Tsao K, Spilde T, et al. Thoracoscopic decortication vs tube thoracostomy with fibrinolysis for empyema in children: a prospective, randomized trial. *Journal of pediatric surgery* 2009, 44: 106–111.
- Pogorelič Z, Bjelanović D, Gudelj R, Jukić M, Petrić J, Furlan D. Video-Assisted Thoracic Surgery in Early Stage of Pediatric Pleural Empyema Improves Outcome. *The Thoracic and cardiovascular surgeon* 2021, 69: 475–480.
- Haggie S, Gunasekera H, Pandit C, Selvadurai H, Robinson P, Fitzgerald D. Paediatric empyema: worsening disease severity and challenges identifying patients at increased risk of repeat intervention. *Archives of disease in childhood* 2020, 105: 886–890.
- Lamas-Pinheiro R, Henriques-Coelho T, Fernandes S, Correia F, Ferraz C, Guedes-Vaz L, et al. Thoracoscopy in the management of paediatric empyemas. *Revista portuguesa de pneumologia* 2016, 22: 157–162.
- Peters R, Parikh D, Singh M. Thoracoscopic debridement for empyema thoracis. *Journal of paediatric surgery* 2020, 55: 2187–2190.
- Dalponete R, Heluany G, Michels M, Madeira K, Prado C. Surgical treatment of necrotizing pneumonia in children: a 10-year assessment. *Tratamento cirúrgico de pneumonia necrosante em crianças em um período de 10 anos. Revista do Colegio Brasileiro de Cirurgiões* 2020, 47: e20202374.