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Thoracoscopic debridement for empyema thoracis☆,☆☆

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ABSTRACT

Background/Purpose: The success rate of early thoracoscopic debridement (TD) for childhood empyema was reviewed in light of the increasing reported incidence of empyema associated with pulmonary necrosis (PN).
Methods: Data were collected from 106 patients who underwent thoracoscopic intervention from 2010 to 2016. Twenty additional patients with severe PN/Bronchopleural Fistula (BPF) were not suitable for TD requiring thoracotomy and Serratus anterior digitation flap.
Results: 106 patients with a median age of 4 years (IQR 2–6 years) were considered for TD as primary intervention of which 3 needed conversion to thoracotomy. TD alone was successful in 93/106 however, 10 patients required subsequent minithoracotomy for PN/BPF (managed with Serratus anterior digitation flap). Counting conversions as failure, the overall success rate of TD was 88%. No statistical difference was demonstrable in success rate compared to our previous series (93% (106/114) vs 88% (93/106)).
Conclusions: Primary TD in pediatric empyema is associated with an excellent outcome achieving adequate drainage and full expansion of the lung. The majority of failures in our series were attributable to PN/BPF, requiring thoracotomy and Serratus anterior digitation flap. This is likely a consequence of the increasing incidence of necrotizing pneumonia.
Level of evidence: Level IV.

Opinion remains divided concerning the preferred initial management approach for childhood empyema. The two main treatment options are intercostal drain (ICD) with instilled fibrinolysis or thoracoscopic debridement (TD).

A Cochrane intervention review comparing the two approaches found an overall reduction in mean length of stay (LOS) for the TD group but there was insufficient evidence to estimate the effect on children [1]. There have been five published randomized controlled trials (RCT) to date comparing TD with ICD and fibrinolysis in children which were all included in the Cochrane review. Two of the studies showed a statistically significant reduced LOS (up to 7 days shorter) for the TD group [2,3] whereas the other three found no difference [4–6]. Two of the studies found that there was a significantly lower failure rate in the TD group [2,5]. The remaining three found no difference in the respective failure rates [3,4,6]. A recently published systematic review and meta-analysis of these five RCTs and four further comparative studies found a statistically significantly shorter LOS in the TD group compared with the ICD and fibrinolysis group with a similar incidence of postoperative complications [7]. The TD group had a 10% reintervention group compared with 24% in the ICD and fibrinolysis group.

A US national database study looking at trends over the period 2008–2014 found empyema cases decreasing by a third [8]. Over the period, there was a trend to increasing use of ICD as the initial intervention with a corresponding decrease in TD. They found no difference over the period with respect to overall length of stay or subsequent drainage procedures. They did find, however, that 30% of children with initial chest tube placement required a second drainage procedure (compared with only 12% with initial TD). They assume that these cases reflect treatment failure after the initial procedure. By design, the study is nonrandomized and they state that they were unable to determine patient characteristics such as disease severity. We have previously reported our series of the use of TD as the primary management for empyema with a high success rate of 93% [9].

Since a number of these RCTs have completed recruitment, there have been changes in the incidence of empyema in children, the causative organisms and the severity of accompanying pneumonia with respect to pulmonary necrosis (PN) and bronchopleural fistula (BPF). Some of these changes have been assigned to introduction and evolution of the pneumococcal conjugate vaccines (PCV). The 7-valent vaccine (PCV7) was introduced into the UK immunization schedule in 2006 and was subsequently replaced by the 13-valent vaccine (PCV13) in 2010 [10]. The effect of the introduction of PCV7 appeared to be an increase in the incidence of childhood empyema [11] and also

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its severity owing to serotype replacement with, for example, serotypes 3 and 19A which appear to be associated with more severe disease and BPF. Several countries, however, have now introduced a PCV of higher valency and some have shown that the incidence of empyema is now reducing [11–13]. Others, however, have shown a continuing rise [14,15] and this may be because of evolving serotype replacement.

Our practice is to obtain a computed tomography (CT) thorax scan of all children presenting with empyema in whom we are contemplating operative intervention. This is to identify those with extensive PN or evidence of a BPF preoperatively and tailor the operative approach accordingly. We have previously described management of such patients with the use of a Serratus anterior digitation flap [16,17]. In the absence of these findings, we manage empyema with upfront TD. This study was initiated to review the current success rate of this approach in light of the increasing incidence of empyema associated with PN and to compare the results with our previous series.

1. Methods

All children undergoing upfront thoracoscopic debridement for empyema thoracis at our institution over a six year period from October 2010 until December 2016 were identified retrospectively. Patients who had radiological evidence of severe pulmonary necrosis or bronchopleural fistula (BPF) at presentation were excluded as they were not suitable for thoracoscopic debridement and instead required thoracotomy and insertion of a Serratus anterior digitation flap. These patients were managed by 6 pediatric surgical consultants experienced in TD. All used a 2 port technique with debridement of the pleural cavity using atraumatic grasping forceps and suction irrigation followed by placement of drain(s). Five of the surgeons routinely place 1 drain and the remaining surgeon placed 2 drains.

Data were collected from patient case note files and electronic radiology and microbiology reports. Information collected included patient demographics, time to operation and length of stay, microbiology PCR results and need for further intervention.

The success rate in our series was then compared to our previous published series. We also looked to identify factors pre- or intraoperatively that predict failure (need for a further operation).

Unless otherwise stated, data are presented as median (interquartile range IQR).

2. Results

We analyzed 106 empyema patients (Male = Female) admitted at a median age of 4 years and 3 months (IQR 2–6 years) (Table 1). Case notes were available for all patients identified as fulfilling inclusion criteria.

2.1. Preoperative

83 patients were transferred to our center from other hospitals after a hospital stay of 3 days (2–5 days). The remaining 23 patients presented directly to our emergency department.

Overall the median duration of symptoms prior to admission was 10 days (8–14 days). The most commonly recorded clinical signs and symptoms were fever (100 patients), cough (77), tachypnea (45) and chest or abdominal pain (43). Time from admission to our hospital to operation was 2 days (1–2 days).

All patients had a preoperative chest x-ray with 102 patients also having an ultrasound scan and 99 patients a computed tomography scan. These figures include imaging performed at the referring centers. The empyema affected the right hemithorax in almost double the amount of patients (68) as the left (38).

Twenty patients were excluded from the study as they had evidence of pulmonary necrosis and/or bronchopleural fistula on preoperative CT scan and instead underwent thoracotomy, debridement and insertion of a Serratus anterior digitation flap. These patients are in addition to the 106 studied patients.

2.2. Intraoperative

Grade of operating surgeon was consultant in 58 cases and registrar in 48. Three operations were converted to thoracotomy owing to bleeding resulting in loss of vision in 2 cases and obvious PN and BPF in a third. In a fourth case, PN and BPF were found and conversion was warranted but the patient was too unstable under anesthetic and so chest drains were left in-situ and a subsequent return to theater planned when the child's clinical condition improved. Full lung expansion was noted in 96 patients at the end of the procedure and in 11 patients it was noted that there was some residual parenchymal air leak. A single drain was left in 69 patients with 2 and 3 drains left in 36 and 1 patient respectively. Mean operative time was 73 min (95% confidence interval 67–79 min).

2.3. Postoperative

Of the 103 patients who had their initial procedure completed thoracoscopically, a further 10 required management of PN/BPF with a thoracotomy and Serratus anterior digitation flap. One of these patients was previously discussed as being identified intraoperatively but, being too unstable at the time to proceed to thoracotomy. One further patient required percutaneous drainage of a pericardial effusion. Failures of TD were therefore 3 intraoperative conversions and 10 thoracotomies with Serratus anterior digitation flap giving a success rate of 93/106 (88%). Further investigation of the failed cases was revealing. Of the ten cases that required return to theater for thoracotomy, 1 had no preoperative CT (but a BPF was evident on postoperative CT). During the initial TD, 5 had airleaks noted intraoperatively, in 2, necrotic lung was noted and in 3, full lung expansion was not achieved at the end of the procedure. No statistical difference was demonstrable in success rate compared to our previous series (93% (106/114) vs 88% (93/106)) (P value = 0.251 Fisher's Exact).

Single drains were removed at a median of 4 days postoperatively and if 2 drains were placed, the final drain was removed at 5 days. Postoperative stay was 7 days (5–9 days). The postoperative stay for the group that required thoracotomy (either conversion to open or as a second procedure) was 17 days (16–20 days).

The majority of patients were seen at 1 month follow-up with resolution of symptoms in all patients by their final follow-up which took place at a mean of 50 days following discharge.

Table 1
Patient characteristics / progress.

Characteristic	*n* (%)
Preoperative	
Gender	
Male	53 (50)
Female	53 (50)
Median age (IQR)	4 years (2–6 years)
Preoperative duration of symptoms	10 days (8–14 days)
Intraoperative	
Empyema location	
left	38 (36)
right	68 (64)
Operative time - mean (95% CI)	73 min (67–79 min)
Conversion to open procedure	3 (3)
Postoperative	
Return to theater for thoracotomy	10 (9)
Success rate	93 (88)
Total length of stay	7 days (5–9 days)
unless stated, averages are median (IQR)	

2.4. Microbiology

Most patients received either co-amoxiclav monotherapy or in combination with either clindamycin or clarithromycin. Alternative agents were used if indicated by positive blood or pleural fluid cultures for other organisms. In most cases, the pathogen was not identified but, where known, *Streptococcus pneumoniae* was most commonly identified by pleural fluid polymerase chain reaction (PCR) (Table 2). This organism was identified in six of the 10 patients who returned to theater for a thoracotomy (compared to one third of the study group as a whole).

3. Discussion

Although not statistically significantly different, our current series has a lower success rate than our previous report (88% versus 93%). This success, however, remains higher than reported in the two largest RCTs [4,6]. As discussed earlier, there have been changes in the incidence and severity of empyema since these RCTs finished recruiting. In our original series (2004–2008) only 8 children underwent upfront thoracotomy for PN/BPF [9]. The figure was 20 in the current series (18.9% versus 7.0%). Taking cases that failed owing to BPF into consideration, there was double the number of cases with severe PN in the current time period (2010–2016) than the previous (2004–2008). We certainly experienced a disproportionate increase in the severity of pneumonia/empyema with a smaller increase in the overall incidence of empyema and this may have been a factor in the slight worsening of our treatment success rate. It would be interesting to see if an RCT comparing TD with ICD and fibrinolysis performed in this increased severity era in centers experienced in the use of TD would show similar results to the previous RCTs.

A learning point for us to consider from this series is that a number of the treatment failures were predictable from intraoperative or preoperative findings. For example, 99/106 patients had a preoperative CT scan but 1 of the patients who was found to have BPF postoperatively did not. Half of the patients who had an air leak noted at the end of their initial TD failed treatment and required a return to theater for thoracotomy. By comparison, in the London series, there were 5 treatment failures for VATS and 4 of these were conversions to thoracotomy for thick peel [4]. This gave them an intraoperative conversion rate of 13% compared to our rate of 3% and their conversions were for thick peel as opposed to PN. There are two points to make about this figure. Firstly, the thoracoscopic experience of the involved surgeons is not known but this rate may have been lower with a more experienced minimally invasive surgeon. Secondly, although these were recorded as failures (as they were in our series), the child's empyema was successfully treated with only one trip to theater. The series from Bristol reported a 13% failure rate for TD compared to a 37% failure rate for ICD and urokinase [18]. Similarly however, half of the failures were resolved at the first operation with a conversion to thoracotomy and so 93% of cases going to theater for a TD did not require a further intervention.

The question of experience of a center has also been highlighted in two studies by the same group in Canada. In a single center study, the standard treatment was switched from TD to ICD and fibrinolytics and their failure rate tripled from 4% with TD to 13% with fibrinolysis [19]. When they looked across several hospitals in Ontario they found a one third failure rate of fibrinolysis although the definition of failure was need for a second procedure or LOS > 14 days [20]. The point is that centers and their multidisciplinary teams develop expertise in a particular treatment pathway/modality and RCTs, particularly with small numbers, may not truly reflect how these treatments function in experienced hands. We believe that our low failure rate for TD is accounted for by a surgical team experienced in TD.

Table 2
Causative organism where identified.

Organism	Number of cases
Streptococcus pneumoniae	38
Streptococcus pyogenes	4
Staphylococcus aureus	3
(Panton–Valentine leukocidin toxin producing)	(2)
Streptococcus anginosus	2
Varicella zoster	3
Pseudomonas aeruginosa	1

4. Conclusion

In the era of increased incidence of childhood empyema and worsening severity of underlying pneumonia, upfront thoracoscopic debridement of empyema is a successful treatment option. Preoperative computed tomography scanning identifies children with pulmonary necrosis and bronchopleural fistula at presentation and allows them to be more appropriately treated with thoracotomy and Serratus anterior digitation flap. Children who will go on to fail thoracoscopic debridement can often be identified from intraoperative findings of air leak, obvious pulmonary necrosis or failure to fully expand the lung.

In summary we recommend a preoperative CT scan for all children prior to thoracoscopic debridement with early aggressive therapy utilized for those with pulmonary necrosis identified. Consideration of conversion to thoracotomy is recommended when an air leak associated with previously unrecognized pulmonary necrosis is made at thoracoscopy.

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