World Journal of Pediatric Surgery

Outcome of anatomical versus non-anatomical lung resection for necrotizing pneumonia in children

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To cite: Da Silva PSL, De Oliveira R, Tamura N, *et al*. Outcome of anatomical versus non-anatomical lung resection for necrotizing pneumonia in children. *World J Pediatr Surg* 2024;**7**:e000943. doi:10.1136/wjps-2024-000943

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/wjps-2024-000943).

Received 24 September 2024
Accepted 2 December 2024

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ABSTRACT

Objective We aimed to evaluate the characteristics, complications and outcomes of necrotizing pneumonia (NP) requiring surgical intervention.

Methods We conducted a retrospective study of all children who underwent surgical therapy for NP from January 2010 to December 2023. Patients were analyzed based on two surgical approaches: anatomic resection (AR) or non-AR (NAR).

Results A total of 66 patients (median age: 36 months) required a surgical intervention for NP. A total of 37 patients received AR, 29 received NAR. The AR procedures were segmentectomy (*n*=29), lobectomy (*n*=8), bilobectomy (*n*=1) whereas NAR included wedge resection (*n*=13) and necrosectomy (*n*=16). The most common reasons for surgery were failure to respond to treatment (43.9%) and sepsis/septic shock (42.4%). A significantly greater proportion of patients in the AR group underwent surgery due to sepsis (*p*=0.023). There was no difference in the proportion of patients experiencing complications between the AR group (40.5%) and the NAR group (27.5%) (*p*=0.266). The majority of complications in both groups (68.0%) were categorized as minor, with 59.0% of cases occurring in patients who underwent AR. Prolonged air leak was the most frequent complication in both groups. There was no difference in the postoperative hospital stay, or duration of mechanical ventilation between the groups. There were no deaths.

Conclusions Surgical intervention for NP may result in complications in one-third of patients, mostly minor and unlikely to significantly impact outcomes. Surgery should be tailored to the extent of parenchymal involvement.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There are limited data on the outcome of surgical management of necrotizing pneumonia, particularly comparing anatomical and non-anatomical resection.

WHAT THIS STUDY ADDS

⇒ Anatomical and non-anatomical approaches should be considered for patients who have failed conservative medical therapy.
⇒ Surgical intervention may lead to complications in one-third of patients; however, the majority of these complications are minor and do not affect the outcome.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ For children with necrotizing pneumonia that does not improve with conservative medical treatment, surgical resection should be considered.
⇒ Although anatomical lung resection can be a more aggressive surgery, this approach is not associated with worse postoperative outcomes compared to lesser lung resections.

INTRODUCTION

Necrotizing pneumonia (NP) is a rare but serious complication of bacterial community-acquired pneumonia, characterized by pulmonary inflammation leading to consolidation, peripheral necrosis and the formation of numerous small cavities in the lungs. Damage to the bronchial and pulmonary vascular systems can result in tissue death within the lung parenchyma.[1] This compromised blood supply hampers the delivery of antibiotics to poorly perfused regions, leading to uncontrolled infection and additional destruction of lung tissue. A delay in administering treatment may result in the development of severe sepsis, failure of multiple organ systems and potential death.[2]

While supportive care with appropriate antibiotics is considered the mainstay of treatment, some patients may need surgical intervention. Because refractory NP in children is rare, there are few pediatric studies investigating surgical interventions for this condition.[3–9] Several studies have documented a small number of patients with NP who required lung resection. The sample sizes in these studies ranged from 3[4] to 36[9] patients. In addition, the risk associated with surgical resection, compared with the risk of developing complications from NP, remains undefined.[1]

Managing patients with NP can be challenging due to the lack of consistent recommendations for transitioning from medical to surgical management. Conversely, surgical management and its outcome depend on several factors, such as the degree of underlying tissue damage, presence of comorbidities, pleural empyema, required extent of pulmonary resection, progression of diffuse pneumonia, septic shock and respiratory failure.[10 11]

For resection of the lung parenchyma, the following surgical approaches can be selected based on the extent and nature of the disease: pneumonectomy (removal of an entire lung), bilobectomy (removal of two adjacent lobes), lobectomy (removal of a single lobe), segmentectomy (removal of one or more segments) and wedge/partial resection (removal of wedge-shaped parenchyma, irrespective of bronchovascular anatomy).

The surgical procedures performed at the pulmonary hilum can be categorized into two main types: anatomic and non-anatomic resections (AR and NAR). AR for NP include pneumonectomy, bilobectomy, lobectomy and segmentectomy, while non-NAR involves wedge resection (WR) and lung necrosectomy (LN).[12–17] During anatomic resections, the amount of parenchyma removed is determined based on the perfusion extent of pulmonary vessels and the aeration extent of bronchi, which are dissected at the hilum. Conversely, non-anatomic resections entail removing parenchyma solely based on the lesion's location.[12]

Furthermore, AR may involve complex technical procedures, longer surgery times, increased blood loss and the removal of a larger area of healthy lung tissue compared with NAR.[17] Therefore, LN and WR may be performed when the necrotic tissue is located in the outer regions of the lung. Conversely, in cases of more extensive disease where the necrotic tissue affects an entire segment or lobe, segmentectomy or lobectomy may be necessary.[7]

Given that the patient outcome with NP may be impacted by the extent of necrosis as well as the complexity and complications of surgical treatment, we aimed to evaluate the characteristics, complications and outcomes of patients undergoing AR and NAR for NP. We hypothesized that patients undergoing a more limited approach (non-anatomic lung resection) for NP have a lower morbidity than those undergoing a more extensive approach (anatomic lung resection).

METHODS

Patients and study design

This is a retrospective, single-center study conducted in a pediatric intensive care unit (PICU) at a tertiary hospital specializing in thoracic surgical services for pediatric patients. We reviewed the data of all consecutive children aged between 1 month and 15 years who underwent LN or lung resection between January 2010 and December 2023. Patients undergoing thoracoscopic decortication alone were excluded from the study. All surgical procedures were performed by the same thoracic surgeon. All patients had a final diagnosis of NP confirmed by pathological analysis.

In all patients, intravenous antibiotics were initiated based on empirical judgment, with coverage for *Streptococcus* and *Staphylococcus*. If the response to antibiotics was deemed inadequate, the treatment was broadened to a wider spectrum before proceeding with surgical intervention. In addition, antibiotic management was adjusted according to culture and sensitivity results from blood, tracheal aspirate or pleural fluid, when available. Of note, molecular diagnostic tests were not available to our patients.

Data collection

A predetermined data collection form was utilized to gather the following patient variables: age, sex, presence of comorbidities, culture results, severity of illness score (Pediatric Index of Mortality II)[18] at PICU admission, laboratory results, preoperative details, blood transfusion requirement within 24-hour postsurgery, major complications and postoperative information (length of postoperative stay, major postoperative complications, chest tube days, need for reoperation and mortality). All patients were monitored for a minimum of 1 year after surgery.

Study groups

All patients who underwent dissection and ligation of hilar structures, including pneumonectomy, bilobectomy, lobectomy and segmentectomy, were classified as AR patients. In contrast, those who underwent WR or LN were classified as NAR patients.

Surgical indications and procedures

Surgical intervention for NP was indicated in patients unresponsive to clinical treatment, presenting with pulmonary sepsis, persistent or recurrent fever, respiratory distress (characterized by tachypnea or dyspnea requiring oxygen support), leukocytosis, sustained elevation of C reactive protein, bronchopleural fistula and radiographic evidence of parenchymal necrosis.

The lung surgical procedure is described in online supplemental file 1.

Definitions

Red blood cell transfusion was indicated as follows: (1) hemoglobin (Hb) level <7 g/dL; (2) Hb level between 7 and 9 g/dL with ongoing blood loss; (3) rapid bleeding with hemodynamic changes (hypotension, tachycardia or altered mental status) or evidence of tissue hypoxia (eg, lactic acidosis); or (4) estimated blood loss >15% of blood volume.[19]

NP was defined as pulmonary consolidation, microabscesses, and parenchymal hypoperfusion indicating the presence of lung destruction and necrosis on CT.[6]

For this study, we established the criteria for all postoperative complications by employing the thoracic morbidity and mortality (TM and M) classification system.[20] In this system, each complication receives a grade ranging from

I to V, indicating a progressive escalation in severity and management complexity, without regard to the specific type of complication. Hence, patients were grouped based on whether they had no adverse events (AEs), one or more minor AEs (grade I or II—either requiring no intervention or only pharmacologic intervention, respectively), and one or more major AEs (grade IIIa, IIIb, IVa, IVb—surgical/endoscopic/radiological intervention without general anesthesia, with general anesthesia, admission to ICU and multiorgan failure, retrospectively) as well as grade V, indicating death of the patient.[20 21] Also, a prolonged air leak classified under grade II was defined as a persistent air leak beyond 5 days.[22] For patients with multiple complications, we considered only the most severe one, as suggested elsewhere.[20]

Outcome measures

The primary outcome was the incidence of complications in patients undergoing AR and NAR for NP. Secondary outcomes included the length of postsurgery hospital stay, duration of mechanical ventilation and blood transfusion requirement within 24 hours of surgery.

Statistical analysis

The data are presented as numerical values and percentages for categorical variables and as medians and interquartile range (IQR) for continuous variables. The data analysis process involved employing the non-parametric Mann-Whitney U test to compare continuous variables that did not adhere to a normal distribution. The comparison between patients who underwent LN and those who underwent lung resection was carried out using the Mann-Whitney U test for continuous variables and the χ^2 test or Fisher's exact test for categorical variables. A p value below 0.05 was considered statistically significant. The statistical analysis was performed using SPSS software (Chicago, Illinois).

RESULTS

Patient characteristics

A total of 66 patients (range: 1 to 120 months, median: 36 months) were included in the study, with 37 undergoing AR and 29 undergoing NAR. Demographic data are presented in table 1. Microbial culture of surgical samples was positive in 16 out of 66 patients (24.2%). The isolated etiological agents were *Staphylococcus aureus* (n=8), *Haemophilus influenzae* (n=2), *Stenotrophomonas maltophilia* (n=2), *Candida albicans* (n=2), *Streptococcus pneumoniae* (n=1) and *Mycobacterium tuberculosis* (n=1). Cultures were negative, and no etiological agent was identified in the remaining 50 patients.

Patients were receiving the following antibiotic therapies prior to the surgical procedure: vancomycin plus cefepime (n=23), oxacillin plus ceftriaxone (n=21), vancomycin plus meropenem (n=12), vancomycin plus piperacillin/tazobactam (n=7), cefepime (n=1), vancomycin (n=1) and sulfamethoxazole/trimethoprim alone (n=1). Additionally, two patients received micafungin.

A total of 8 patients with NP did not receive surgical treatment, Among which, 4 were men, and 2 required mechanical ventilation. The median age was 30.5 months (IQR: 24.8–54.5), the median severity of illness score was 0.2 (IQR: 0.1–0.4) and the median lengths of stay in the PICU and hospital were 5.0 days (IQR: 3.3–14.0) and 12.0 days (IQR: 7.0–16.3), respectively. Compared with patients who underwent surgical treatment, non-surgical patients with NP were less severely ill (p=0.005) and had a shorter length of hospital stay (p<0.001). There were no significant differences in age (p=0.912) or PICU stay (p=0.423).

Preoperative assessment

There was no difference in laboratory results between both groups (table 1). Chest X-rays displayed consolidated areas (figure 1), whereas contrast CT scans revealed pulmonary consolidation, intraparenchymal cavity formation and parenchymal hypoperfusion, suggesting the presence of lung destruction and necrosis (figure 2).

Preoperatively, chest tube drainage for empyema was performed in 60 patients, 28 in the AR group and 22 in the NAR group (p=0.986). Fourteen patients (21.0%) developed pneumothorax, with no difference between the AR and NAR groups (table 1). Similarly, the incidence of pneumatocele was comparable between groups.

Surgery was most often indicated for failure to respond to treatment (43.9%) and sepsis/septic shock (42.4%), with a higher proportion of patients in the AR group undergoing surgical treatment because of sepsis (54.0% *vs.* 27.5%, p=0.023). The decision to proceed with surgery was made after a median PICU stay of 11.0 days (7.8–15.0).

Operative and postoperative assessment

Surgical interventions included segmentectomy (44.0%), lobectomy (12.0%), bilobectomy (1.5%), WR (19.6%) and necrosectomy (24.2%). All patients underwent decortication. Figure 3 presents the intraoperative finding of an extensive pulmonary necrosis.

Thirty-one patients (47.0%) received blood transfusions, with a similar rate between AR and NAR groups. There were no transfusion-related complications.

There were only three intraoperative complications: two cases of bradycardia and hypotension (one in each group) required epinephrine administration, and one case of bronchial pus spillage in the AR group, which was managed successfully. None of these complications affected the operative outcome.

Outcomes

Out of the 66 patients who underwent thoracic surgical procedures, 23 (34.8%) experienced at least one complication. There were 25 postoperative complications. The distribution of postoperative complications by grade and frequency according to the TM and M

Table 1 Baseline characteristics

Variables	Overall population (*N*=66)	Anatomic resection (*n*=37)	Non-anatomic resection (*n*=29)	*P* value
Age (continuous, months)	36.0 (17.8–60.0)	36.0 (17.5–66.5)	34.0 (17.0–57.0)	0.526*
Age (distribution)				
≤12 months	9 (13.6)	4 (10.8)	5 (17.2)	0.175†
1–5 years	43 (65.1)	23 (62.1)	20 (68.9)	
5–10 years	14 (21.2)	10 (27.0)	4 (13.7)	
Male	39 (59.0)	23 (62.1)	16 (55.2)	0.567†
Weight (kg)	14.0 (11.0–22.2)	15.8 (11.0-23.0)	14.0 (10.3–19.4)	0.481*
PIM	0.8 (0.3–1.9)	0.9 (0.3–5.5)	0.8 (0.3–1.1)	0.159*
Comorbidities	5 (7.5)	3 (8.1)	2 (6.8)	1.000‡
Empiema	50 (75.7)	27 (72.9)	23 (79.3)	0.545‡
Pneumatocele	14 (21.2)	8 (21.6)	6 (20.6)	0.927†
Pneumothorax	14 (21.2)	11 (29.7)	3 (10.3)	0.073‡
Time of tube drainage (days)	10.0 (7.0–13.0)	10.0 (6.0–13.0)	9.0 (7.0–15.5)	0.796*
Preoperative antibiotic therapy duration (days)	12.0 (9.0–18.0)	12.0 (9.0–17.0)	12.0 (9.5–24.5)	0.376*
Respiratory support prior surgery				
Invasive mechanical ventilation	19 (28.8)	12 (32.4)	7 (24.1)	0.453†
Supplemental oxygen	41 (62.1)	21 (58.3)	20 (68.9)	0.371†
Non-invasive ventilation	6 (9.0)	4 (11.1)	2 (6.8)	0.684‡
Use of vasoactive drugs	10 (15.1)	8 (21.6)	2 (6.8)	0.166‡
White blood count (x 10^3 mm^3)	15.3 (11.2–20.9)	17.2 (12.3–24.7)	12.8 (10.4–20.6)	0.157*
Platelets count (x 10^3 mm^3)	552.5 (417.0–708.7)	557.0 (446.5–758.0)	475.0 (367.5–648.5)	0.173*
C reactive protein (mg/L)	60.9 (21.9–168.2)	69.5 (25.4–151.6)	53.9 (17.6–195.2)	0.892*
Indications				
Sepsis	14 (21.2)	9 (24.3)	5 (17.2)	0.474†
Sepsis/ARF	6 (9.0)	5 (13.5)	1 (3.0)	
Sepsis/ARF/BPF	8 (12.1)	6 (16.2)	2 (6.8)	
BPF	4 (6.0)	2 (5.4)	2 (6.8)	
ARF	3 (4.5)	1 (2.7)	2 (6.8)	
ARF/BPF	2 (3.0)	1 (2.7)	1 (3.4)	
Medical therapy failure	29 (43.9)	13 (35.1)	16 (55.1)	
Sepsis with or without ARF	28 (42.4)	20 (54.0)	8 (27.5)	0.023†

Data are expressed as median (IQR) or number (%).
*Mann-Whitney test.
†Chi-squared test.
‡Fisher exact test.
ARF, acute respiratory failure; BPF, bronchopleural fistula; IQR, interquartile range; MV, mechanical ventilation; PICU, pediatric intensive care unit; PIM, Pediatric Index of Mortality.

classification system is presented in table 2. Grades I and II, categorized as minor complications, accounted for 32.0% and 36.0% of all complications, respectively. The incidence of major complications (grades III and IV) was 0.0% and 32.0%, respectively. There was no significant difference in the proportion of patients

Figure 1 Preoperative posteroanterior chest X-ray showing consolidation in the right upper and middle lobes of a 3-year-old boy without comorbidities.

experiencing complications between the AR group (40.5%) and the NAR group (27.5%) (p=0.266). The majority of complications in both groups (68.0%) were categorized as minor, with over half (59.0%) of cases occurring in patients who underwent AR.

The most frequent complication was the occurrence of prolonged air leak in 5 patients in the AR group and 4 patients in the NAR group (table 2). One patient who underwent segmentectomy experienced recurrent empyema and a persistent air leak for >2 weeks, requiring further surgical intervention (lobectomy). There were no deaths in both groups.

The length of postoperative hospital stay did not differ significantly between patients with major complications (19.5 days, IQR: 16.5–24.8) and patients with minor complications (13.0 days, IQR: 8.0–20.0) (p=0.081). Similarly, there was no significant difference in the length of postoperative hospital stay between patients who underwent AR and those undergoing NAR (p=0.178).

Table 3 displays the patient outcomes based on the type of surgical management. A higher proportion of patients in the AR group required postoperative mechanical ventilation compared with those in the NAR group (p=0.042). After 1 year of follow-up, all patients had an uneventful clinical course, presenting adequate lung expansion and age-appropriate thriving.

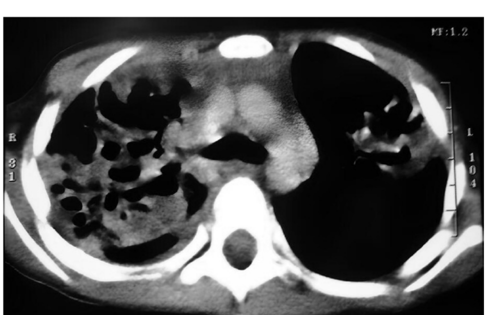

Figure 2 Chest CT scan with contrast showing pulmonary consolidation with multiple areas of hypodense necrosis involving the right lung lobe in a 3-year-old boy.

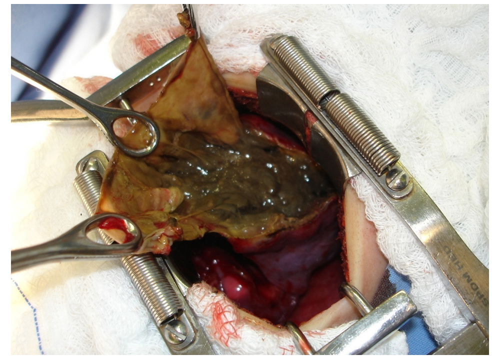

Figure 3 Extensive pulmonary necrosis without perfusion in the upper right lung lobe. Lobectomy in a 3-year-old boy.

DISCUSSION

To the best of our knowledge, this retrospective study evaluated the largest sample of children undergoing surgery for the treatment of NP. We found that AR was necessary for the majority of patients who underwent surgical treatment, accounting for 56.0% of cases. Additionally, we observed that the type of surgical approach did not have an impact on the incidence of complications, blood transfusion requirements and length of hospital stay. Moreover, the majority of complications were graded as minor complications.

Our findings align with previous studies only evaluating surgical resection for necrotizing lung infection, which indicated that patients were typically young, ranging in age from 3 months to 32 months.[3–9 23] The overall preoperative morbidities included pleural empyema (75.7%), preoperative endotracheal intubation for respiratory distress (28.7%), pneumothorax (21.0%) and sepsis (42.0%), highlighting the severity of this disease.

Table 2 Most common complications resulting from a thoracic procedure

Complications	Anatomic resection, *n*	Non-anatomic resection, *n*
Grade I		
Pneumothorax	3	1
Wound infection	1	1
Subcutaneous emphysema	1	1
Grade II		
Prolonged air leak	5	4
Grade IV		
Septic shock	3	0
Respiratory failure	3	2
Total complications	16	9

Table 3 Patient outcomes

Variables	Overall population (*N*=66)	Anatomic resection (*n*=37)	Non-anatomic resection (*n*=29)	*P* value
Postoperative drainage time (days)	5.0 (4.0-6.0)	5.0 (4.0-6.0)	5.0 (4.5–6.5)	0.408*
Transfusion requirement	31 (47.0)	18 (48.6)	14 (48.2)	0.976†
Patients on MV				
Preoperative	19 (28.7)	12 (32.4)	7 (24.1)	0.468†
Postoperative	22 (33.3)	16 (43.2)	6 (20.6)	0.042†
Duration of MV (days)				
Preoperative	12.0 (8.0–15.0)	13.0 (10.3–15.8)	9.0 (6.0-14.0)	0.252*
Postoperative	4.0 (2.0–7.3)	4.0 (2.3–7.5)	3.0 (1.0-8.0)	0.393*
Length of hospital stay (days)				
Preoperative	12.5 (9.0–17.3)	12.0 (9.0–16.0)	14.0 (9.0–24.5)	0.334*
Postoperative	17.0 (10.0–24.0)	18.0 (13.0–23.0)	12.0 (9.5–24.0)	0.178*
Length of PICU stay (days)	6.0 (4.0-20.0)	7.0 (4.0-23.0)	6.0 (3.0–16.5)	0.152*
Patients with complications	23 (34.8)	15 (40.5)	8 (27.5)	0.266†

Data are expressed as median (IQR) or number (%).
*Mann-Whitney test.
†Chi-squared test.
‡Fisher exact test.
.IQR, interquartile range; MV, mechanical ventilation; PICU, pediatric intensive care unit.

While *S. pneumoniae* is the most common cause of bacterial pneumonia in children, we found that *S. aureus* was the most common organism isolated in our study. This finding is consistent with that of other studies.[24 25] We speculate that the use of the pneumococcal conjugate vaccine for prophylaxis in our population, or even the prior use of antibiotics, may help explain this finding.

Some authors suggest that surgery should be the last option for treating NP.[4] However, others argue that once a necrotic process is diagnosed, the affected segment or lobe should be promptly removed, especially in cases with high-output bronchopleural fistula and respiratory distress.[26] In our study, the main reasons for thoracotomy were therapeutic failure, sepsis, acute respiratory failure and bronchopleural fistula.

Our data regarding the median preoperative length of stay for both approaches (median 12.5 days) are similar to other studies reporting an average time between 10 and 15 days.[5 6 8] The optimal timing for surgery remains uncertain. Reimel *et al.*[27] recommend for postponing surgery until patients are medically stabilized, which has been associated with improved surgical outcomes.[10] Conversely, Chatha *et al.*,[1] express concerns that delaying surgical intervention may lead to deterioration in the patient's condition during the interim period. At our institution, we adopt an early surgical approach, initiating it as soon as there is no improvement in the clinical course and the NP is confirmed by a CT scan.

In six previous pediatric studies,[3 5–9] postoperative complications were reported with rates ranging from 8.3%[9] to 50.0%,[8] with an overall average of 21.0%. However, the definition of complications varies among different authors, making comparisons difficult. Using the TM and M system, it was found that 34.8% of patients experienced at least one complication, which is similar to the complication rates reported in adults undergoing pulmonary resections using the same classification system, which range from 30.0%[21] to 38.7%.[20]

We should expect that the type of surgery may be predictive of the time to discharge. This is because minor surgeries like LN typically have a shorter recovery time and lower risk of complications compared with major surgeries like AR. However, our study did not show a significant difference in complication rates between patients who underwent AR and those who underwent NAR. Since the study is underpowered to detect this difference, a larger study would be needed to make definitive conclusions.

We also found that 68.0% of the complications observed in patients who underwent surgical treatment for NP were classified as minor according to the TM and M scale. This indicates that most of the complications experienced by our patients had a minimal impact on their postoperative course and required no treatment or only pharmacologic or minor interventions. It is worth noting that over 60% of the complications in patients who had AR were also classified as minor, and this percentage did not differ significantly from patients who had NAR.

The need for blood transfusions highlights the severity of tissue inflammation and the challenging surgical techniques involved in managing NP. In a study conducted by Lai *et al.*,[6] the authors reported a blood transfusion rate of 35.7%, with a higher rate in complicated NP compared with uncomplicated NP (68.0% *vs.* 9.7%, p=0.030). Although the requirement for blood transfusion was higher in our patients (47.0%), there was no difference between the AR and NAR groups. Of note, different definitions of the blood transfusion period and the severity of the population may explain these results.

Our findings showed that patients who experienced major complications had a postoperative stay 6 days longer compared with those with minor complications, although this difference was not statistically significant. This result aligns with a study by Seely,[20] which showed that patients with lower grade complications (*i.e.*, grades I and II) were less likely to have prolonged hospital stays compared with patients with higher grade (*i.e.*, III and IV) complications. However, a larger study would be needed to validate these findings.

The incidence of persistent air leak after surgery can be as high as 20.0%[5] to 46.0%[8] in some pediatric studies. In our study, we found that 36.0% of all complications were due to persistent air leak, with most cases occurring in patients in the NAR group.

In our study, we did not have any deaths. However, other researchers have reported mortality rates of 4.0%,[7] 5.5%,[9] 14.0%[3] and 20.0%,[5] respectively. Our findings, consistent with other investigators,[28] suggest that septic shock and respiratory failure should not be considered absolute contraindications for lung resection in individuals with NP. Therefore, for patients who experience septic shock and achieve hemodynamic stability, surgical resection might be considered if complications arise due to necrotic pulmonary parenchyma.

Surgical procedures for treating NP should be tailored to each individual patient based on their specific clinical situation, CT scan assessments and intraoperative findings. While some authors recommend formal lobectomy or pneumonectomy for most cases,[3 4 29 30] others advocate for decortication or LN to preserve lung parenchyma.[7]

We should note that a higher number of patients (54.0%) who received a more extensive surgical management (AR) had sepsis, with or without respiratory distress, compared with those who received a more limited procedure (NAR) (27.0%). Given that the severity of NP is significantly impacted by the extent of necrosis, treatment decisions should be guided by the level of tissue destruction and the presence of any associated complications. Interestingly, we observed that a more extensive surgical management that includes AR was associated with a non-significant difference in postoperative morbidity compared with a lesser resection approach, that is, NAR.

In our study, we found that the small group of patients with NP who did not require surgery were less severely ill and had a shorter length of hospital stay compared with those who underwent surgery. Importantly, no data are available in the literature comparing outcomes between medically and surgically managed patients. In fact, interpreting such comparisons may be challenging due to differences in patient selection (PICU *vs.* non-PICU populations), variations in illness severity, the presence of complex chronic conditions and the lack of a clear consensus on what level of treatment constitutes failure of medical therapy.

The main strength of our study is the utilization of a classification system for monitoring complications. This system has been validated in a large cohort of patients who underwent several surgical procedures and has universal applicability.[20 21]

Our study has some limitations. First, this was a retrospective study, which inherently carries certain limitations due to its design. Second, as this was a small single-center study, its findings may not be entirely generalizable. Finally, comparing our results with those of other studies is challenging due to variations in the definitions used to assess complications.

In conclusion, while surgical intervention may lead to complications in one-third of patients, the majority of these complications are minor and do not significantly affect the outcome. Therefore, the timing and type of surgery should be individualized based on the varying degrees of pleural and parenchymal involvement in each patient.

Contributors PSLDS and RO contribute to give the initial idea and draft the manuscript. PSLDS, RO, NT, LC and EYK contribute to patients' treatment and data collection. All authors read, revised and approved the final manuscript. PSLDS is the guarantor of this statement.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This retrospective clinical study was approved by the Institutional Review Board (IRB) of State Hospital of Diadema (Research Approval Number: 997856-B), and the requirement for written consent was waived.

Provenance and peer review Not commissioned; externally peer-reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

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