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Surgical treatment of necrotizing pneumonia in children: a 10-year assessment

Tratamento cirúrgico de pneumonia necrosante em crianças em um período de 10 anos

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ABSTRACT

Objective: Necrotizing pneumonia (PNZ) is a severe and rare complication of a community-acquired pneumonia, affecting mainly children. We aimed to analyze medical records of children undergoing surgical treatment for PNZ and compare our results with those found in the medical literature. **Methods:** Retrospective analysis of children's medical charts who underwent an operation for PNZ, between July 2006 and July 2016, in two hospitals in southern Santa Catarina, Brazil. **Results:** A total of 26 children with a median age of 2.70 years and mostly females (61.5%) were included in the current study. The main symptoms were fever (88.5%) and cough (65.4%). There was an average use of 4.31 antibiotics per patient. The primary etiological agent was *Staphylococcus aureus* (23.1%), but cultures were negative in 69% of the patients. Decortication and debridement of necrotic areas were performed in 23 patients (88.5%). The mean postoperative pleural drainage was 8.12 days. The presence of bronchopleural fistula occurred in 50.0% in the preoperative period and 46.2% in the postoperative. The total length of hospital stay was, on average, 27.52 days and the postoperative length of stay was 12.60 days (mean). Postoperative complications occurred in 13 children and there was no mortality. **Conclusion:** The surgical approach is indicated to patients with no response to clinical treatment. Late surgical intervention is associated with progressive parenchyma infection and higher rates of complications. Surgery can lead to better clinical outcomes and earlier recovery.

Keywords: Pneumonia, Necrotizing/surgery. Pneumonia/complications. Empyema. Child.

INTRODUCTION

Necrotizing pneumonia (PNZ) is a severe disease, which is a rare complication of community-acquired pneumonia (CAP). In recent years, even after advances in antimicrobial therapy, there has been an increase incidence[1].

The most common etiologic agents leading to necrotizing pneumonia vary according to different authors. Although the leading cause of CAP in children is *Streptococcus pneumoniae*, several reports are indicating that these bacteria are not detected, and the etiology is related to other microorganisms[2-4].

The pathophysiology of PNZ is associated with a decrease in the vascular supply due to thrombotic occlusion of the pulmonary vessels. Thus, necrosis and liquefaction of the pulmonary parenchyma occur, which can lead to multiple areas of cavitation within a consolidated area. Due to the hypoperfusion of one or more lobar segments, the supply of antibiotics is impaired, leading to uncontrolled infection and larger pulmonary tissue devitalization[3,5].

The presence of continuous fever, dyspnea, chest pain, worsening of the clinical condition or the appearance of new complications caused under the use of antibiotic therapy suggest the presence of pulmonary necrosis. In most cases, the diagnosis is made with a chest computed tomography showing the presence of multiple cavitations associated with pulmonary consolidations and the non-contrasting of the affected areas[5-7].

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The therapeutic approach of a PNZ remains a challenge due to the limited number of available data. The initial treatment is conservative. However, when there is no complete response to the treatment or there are complications, surgical intervention is necessary[4,5].

Although PNZ has high morbidity in its acute stage, leading to a prolonged hospital stay, the use of antibiotics along with the surgical intervention, in the long term, are associated to an excellent prognosis with low mortality. A total clinical recovery and minimal remnants of disease in imaging follow-ups are seen[7].

The knowledge about the clinical characteristics and the therapeutic approaches is based on a few reports in the literature, making it a relatively rare disease[8,9]. Therefore, this study aimed to analyze the data of children undergoing surgical treatment for PNZ, and compare the results with those found in the medical literature.

METHODS

This is an observational cross-sectional study of data pertaining medical records of children who underwent surgical treatment due to necrotizing pneumonia, confirmed by an anatomopathological diagnosis, from July 2006 to July 2016, in two general hospitals of high complexity in the south of Santa Catarina, Brazil. These patients had surgical records describing pulmonary necrosis. All medical records with the aforementioned descriptions were analyzed, and two patients were excluded due to the lack of information, totaling a sample of 26 patients. Patients with fibrinopurulent empyema or with the presence of small areas of necrosis were not included because they underwent a thoracoscopy approach, instead of thoracotomy.

This study was approved by the Research Ethics Committee of the included hospitals under protocol CAAE 57546116.0.0000.0119 and 57546116.0.3001.5364 and followed the ethical recommendations for research in humans (Ordinance 466/12 of the National Health Council).

Analysis of data

The collected data were analyzed using the software IBM *Statistical Package for the Social Sciences* (SPSS) version 22.0. Quantitative variables were expressed by the median and interquartile range (with Tukey's correction) when they did not show a normal distribution and by means and standard deviation when they followed this type of distribution. Qualitative variables were expressed by frequency and percentage.

Statistical tests were performed with a significance level of = 0.05 and, therefore, 95% confidence. Shapiro-Wilk, Levene, Student's t, Mann-Whitney's U and Pearson's chi-square tests were used for analysis, as indicated.

RESULTS

Twenty six children were included, with a median age of 2.70 years (1.83 - 4.00), with a predominance of white (n = 24, 92.3%) women (n = 16, 61.5%). The body weight was registered in 18 medical records, averaging 14.39 kilograms (± 4.71). The weight/age percentile was calculated based on data from the World Health Organization (WHO), and children had a percentile between 50th and 85th, featuring normal weight. None of the patients had associated comorbidities. The main symptoms were fever (n=23, 88.5%), cough (n=17, 65.4%) and dyspnea (n=12, 46.2%). The number of antibiotics used per

patient during hospitalization was 4.31 ± 1.37, being Ceftriaxone (n=25, 96.2%), Oxacillin (n=21, 80.8%) and Vancomycin (n=19, 73.1%) the most used (Table 1).

Table 1. *Clinical and demographic data*

Variable	n=(%)
	n=26
Age (years)*	2.70 (1,83 – 4.00)
Weight (Kg)**, n=18	14.39 ± 4.71
Sex	
Female	16 (61.5)
Male	10 (38.5)
Race	
White	24 (92.3)
Black	2 (7.7)
Morbid History	
No comorbidities	26 (100.0)
Clinical variables	
Fever	23 (88.5)
Cough	17 (65.4)
Dyspnea	12 (46.2)
Chest pain	6 (23.1)
Vomit	6 (23.1)
Tachypnea	6 (23.1)
Wailing	6 (23.1)
Intercostal circulation	6 (23.1)
Abdominal pain	5 (19.2)
Other symptoms[a]	11 (42.3)
Number of antibiotics at admission	4.31 ± 1.37
**Antibiotics	
Ceftriaxone	25 (96.2)
Oxacillin	21 (80.8)
Vancomycin	19 (73.1)
Cefepime	13 (50.0)
Crystalline Penicillin	8 (30.8)
Amikacin	7 (26.9)
Clindamycin	5 (19.2)
Meropenem	4 (15.4)
Other antibiotics°	9 (34.6)

** Median (interquartile range); ** Mean ± Standard Deviation; [a] Sputum, Diarrhea, Anorexia, Nose wing beat, Coryza, Constipation; ° Azithromycin, amoxicillin, ampicillin, ceftazidime, imipenem, metronidazole, piperacillin / tazobactam*

The most common isolated etiological agent was *Staphylococcus aureus* (n=6, 23.1%). However, there was no bacterial growth in 18 cases (69.2%). The most frequently affected pulmonary lobe was the upper right (n=9, 34.6%).

Preoperative chest drainage was performed on 24 patients (92.3%), with a median drainage time of 11 days (6.50 - 13.00). All patients underwent thoracotomy with pulmonary decortication, in most cases, this was associated with debridement of the necrotic areas (n=23, 88.5%) or lobectomy (n=3, 11.5%). The postoperative chest drainage time was, on average, 8.12 days (± 3.10) (Table 2).

The presence of preoperative bronchopleural fistula occurred in half of the cases (n=13, 50.0%) and 12 children (46.2%) in the postoperative period.

Table 2. *In-hospital data*

Variable	n (%)
	n = 26
Isolated etiologic agent	
Staphylococcus aureus	6 (23.1)
Pseudomonas aeruginosa	1 (3.8)
Staphylococcus saprophyticus	1 (3.8)
None	18 (69.2)
Affected pulmonary lobe	
Upper right	9 (34.6)
Lower left	7 (26.9)
Upper left	5 (19.2)
Right middle	4 (15.4)
Lower right	4 (15.4)
Preoperative drainage	
Yes	24 (92.3)
No	2 (7.7)
Preoperative drainage time (days)*, n = 24	11.00 (6.50 – 13.00)
Type of operation	
Decortication + Debridement	23 (88.5)
Decortication + Lobectomy	3 (11.5)
Postoperative drainage time (days)**	8.12 ± 3.10
Presence of preoperative bronchopleural fistula	13 (50.0)
Presence of postoperative bronchopleural fistula	12 (46.2)
Total hospital stay (days)**	27.52 ± 6.10
Preoperative length of stay (days)**	14.92 ± 6.51
Postoperative length of stay (days)**	12.60 ± 4.19
Need for preoperative ICU	4 (15.4)
Preoperative ICU time (days)*, n = 4	5.50 (4.00 – 7.00)
Need for postoperative ICU	8 (30.8)
Postoperative ICU time (days)*, n = 8	6.00 (4.50 – 7.50)
Presence of postoperative complications	13 (50.0)

** Median (interquartile range); ** Mean ± Standard Deviation*

The mean total length of hospital stay for patients was 27.52 days (± 6.10). The length of hospital stay (LOS) before the operation was 14.92 days (± 6.51) and postoperative LOS was 12.60 days (± 4.19). Only in 4 cases (15.4%) intensive care unit (ICU) before the surgical intervention was required, with a median length of stay of 5.50 days (4.00 - 7.00). Postoperative ICU admission occurred in 8 cases (30.8%), with a median of 6 days (4.50 - 7.50).

The presence of one or more postoperative complications occurred in 13 patients (50.0%), with the presence of postoperative fistula (n=12) (same patients who had preoperative fistula), ICU after operation (n=8), encysted pneumothorax (n=2), arterial hypertension (n=1), cardiopulmonary arrest in the immediate postoperative period (n=1). There were no deaths.

Complications were more common in younger children, with a median of 2.50 years (1.83 - 3.25). Females was more affected (n = 9, 56.2%). The complication rate was higher in those with the highest average number of antibiotics (4.54 ± 1.45). However, none of these variables had statistical significance (p> 0.05).

The presence of complications was also more frequent in patients with longer preoperative pleural drainage (median of 11.50 days (7.00 - 13.00)), with longer pre-surgical hospital stay (mean of 16.15 days (± 6.97)) and presence of preoperative fistula (n=8, 61.5%). The most often performed operation - pulmonary decortication with debridement of necrotic areas - was associated with complications in 11 cases (47.8%), whereas the most aggressive approach - pulmonary decortication with lobectomy - was related to 2 out of 3 cases (66, 7%). The need for preoperative ICU did not result in further complications (n=1, 25%). However, these variables were not statistically different (p> 0.05) (Table 3).

Table 3. *Comparisons of postoperative complications according to different factors*

Variables	Postoperative Complications		P-value
	Yes	No	
	n = 13	n = 13	
Age (years)*	2,50 (1.83-3.25)	2.83 (1.96-4.25)	0.644
Sex			
Male	4 (40.0)	6 (60.0)	0.420
Female	9 (56.2)	7 (43.8)	
Number of antibiotics**	4.54 ± 1.45	4.08 ± 1.32	0.405
Preoperative Drainage Time*	11.50 (7.00-13.00)	10.50 (5.50-12.00)	0.416
Type of Operation			
Decortication + Debridement	11 (47.8)	12 (52.2)	0.539
Decortication + Lobectomy	2 (66.7)	1 (33.3)	
Presence of Preoperative Broncopleural Fistula			
Yes	8 (61.5)	5 (38.5)	0.239
No	5 (38.5)	8 (61.5)	
Preoperative length of stay**	16.15 ± 6.97	13.58 ± 5.97	0.335
Need for Preoperative ICU			
Yes	1 (25.0)	3 (75.0)	0.277
No	12 (54.5)	10 (45.5)	

** Median (interquartile range); ** Mean ± Standard Deviation*

The presence of postoperative fistula occurred in 12 patients (2/3), and in seven cases (53.8%), it occurred in patients with preoperative FBP (p> 0.05) (Table 4).

The longer length of stay was related to the older age of the patient, more antibiotics and longer preoperative drainage time (p> 0.05).

The longer postoperative hospital stay was associated with younger patients, a higher number of antibiotics, less preoperative drainage time and shorter preoperative hospital stay (p> 0.05) (Table 5).

A shorter postoperative hospital stay for pulmonary decortication associated with debridement of necrotic areas was observed when compared to pulmonary decortication and lobectomy (p = 0.528) (Table 6).

DISCUSSION

Necrotizing pneumonia is an uncommon complication of lung infection, associated with high morbidity, seen mainly in children[1]. Our patients were young (2.70 years old), majority girls (n=16, 61.5%) and white (n=24, 92.3%), corresponding to the general population of southern Santa Catarina.

In general, these patients present no comorbidities[11,13], and the main signs/symptoms of the disease were fever, cough, dyspnea and chest pain, which are the main findings of pneumonia[3.12].

The mean number of antibiotics during hospitalization was 4.31 ± 1.37 (ranging from 2 to 8), similar to that presented by Barreira, in Portugal[3].

Table 4. *BPF Recurrence after the operation*

Variable	Postoperative fistula		P-value
	Yes	No	
	n = 12	n = 14	
Postoperative FBP			
Yes	7 (53.8%)	6 (46.2%)	0.431
No	5 (38.5%)	8 (61.5%)	

Table 5. *Correlations between total hospitalization time and postoperative.*

	Age	Amount of antibiotics	Preoperative drainage time	Preoperative length of stay
The total length of stay	0.078*	0.303*	0.242*	-
Postoperative length of stay	-0.093*	0.181*	-0.282*	-0.269*

** Values according to the Pearson, Spearman and Kendall correlation coefficients (p> 0.05)*

Table 6. *Comparison between the type of operation and postoperative length of stay*

Type of operation	n	Postoperative length of stay*	P-value
Decortication + Debridement	23	12.59 ± 4.45	0.528
Decortication + Lobectomy	3	12.67 ± 1.52	

** Mean ± Standard Deviation*

The most common etiologic agents in necrotizing pneumonia vary according to different authors. Some report that such complication of pneumonia, with necrosis of the lung parenchyma, is associated with *Staphylococcus aureus* and Gram-negative bacteria[3]. Similar to the literature, we observed mostly *Staphylococcus aureus* (n = 6, 23.1%)[1,14,15]. However, in the last few years, the incidence of PNS caused by *Streptococcus pneumoniae* has increased, a condition that was considered rare in children. This agent was not isolated in our patients[1,8,9,12]. This is associated with the introduction of the pneumococcal conjugate vaccine for prophylaxis, causing the selection of more virulent serotypes, not present in the vaccine[2].

Similar to other authors, we found several patients with the absence of microbial growth (n=18, 69.2%) in cultures. Blood cultures and pleural fluid analysis, in the presence of pleural effusion, were mostly used. Previous use of antibiotic therapy, which is very common in patients with necrotizing pneumonia, could be an implicating factor for the low rate of etiological identification[3,8,13,15,16].

Although any pulmonary parenchyma site may be affected, we observed that the majority of the patients had the right upper lobe involved (34.6%), similar to the report by Hsieh *et al*. (40%)[11].

Similar to data, in the literature, the need for pleural drainage before the operation - due to the presence of complicated pleural effusion or pneumothorax - occurred in most patients (n = 24, 92.3%)[3.8-10]. The median preoperative drainage time was 11 days (6.50-13.00), which was also similar to that reported by others[8,12,13].

There is still controversy about the precise indications and the most appropriate moment for the operation. A surgical approach is recommended in cases where there is a deterioration of the clinical condition or the presence of complications, despite the appropriate use of antimicrobials and less invasive procedures[4]. It is recommended an early approach, while the disease is still localized, as the delay in surgery is associated with progressive infection of the lung parenchyma and higher rates of complications[1].

Thoracotomy, cavity washing, pleuropulmonary decortication and closure of air leaks in those with bronchopleural fistula were performed in all children. Other procedures were also performed, as in 23 cases (88.5%), debridement of the necrotic areas was performed, and in 3 (11.5%) lobectomy of the affected area was necessary. Similar data were found[9], where there was debridement of necrosis focus in 38 cases (67.8%) and lobectomy in 4 (7.1%).

All patients, after the surgical approach, had pleural drainage, and the time for removal was 8.12 days (± 3.10), similar to authors who showed an average of 7.00 days (± 4.00)[3].

The presence of fistula occurs when there is a progression of necrosis to the lung periphery, adjacent to the pleura[13]. Before the operation, half of the cases had fistula (n=13, 50.0%), and in 12 (46.2%), this was seen after the operation, as observed by other authors[1,10].

Data regarding pre and postoperative length of stay and incidence of complications were similar to those found in the literature[3,9]. However, our average total length of stay was less than that found by Barreira *et al*.[3], suggesting that earlier intervention results in a shorter LOS.

The presence of complications was more common in younger female children, which may be related to the immaturity of the immune system. Also, there were more complications in patients with a higher mean number of antibiotics, longer postoperative drainage time, presence of a preoperative fistula, longer hospital length of stay before surgery and more aggressive surgical approach, which can be associated with higher bacterial resistance and virulence of pathogens, leading to more severe disease. However, this was not statistically significant ($p > 0.05$), and there are no data in the literature to compare our results. The definition of complications is variable, according to different authors, hampering comparisons. Similar to other reports in the literature, no mortality was observed[8,9,12,13].

As it is a rare complication of community-acquired pneumonia, the results may differ from other authors due to the small number of participants in our study.

The presence of postoperative fistula was more common in patients who had it before the surgical procedure, indicating that recurrence of fistula is frequent after the operation, despite the correct intraoperative approach. However, our data was not statistically significant ($p > 0.05$). There are no similar reported results in the literature.

The longer length of stay was associated with older patients, an increased number of antibiotics and longer preoperative drainage time, but we have no explanation for this.

Other associations indicated that the postoperative hospital stay was longer in younger patients, which may be related to increased immunological defenses in older patients, a shorter preoperative hospital stay, a shorter preoperative drainage time or a higher number of antibiotics. However, there was no statistically significant difference for any of these variables ($p > 0.05$), and there are no similar data in the literature.

Regarding the type of surgery, we observed that for those patients who only underwent decortication with debridement or decortication with lobectomy, similar averages in the postoperative hospitalization time (respectively 12.59 ± 4.45 and 12.67 ± 1.52 days) were seen. In contrast, other authors have demonstrated a much longer hospital stay for patients with complicated necrotizing pneumonia - massive pulmonary necrosis in more than 50% of the lobes - who underwent debridement in relation to lobectomy (respectively 23.6 ± 9.9 and 9.0 ± 2.1 days)[9].

CONCLUSION

Although PNZ is associated with high morbidity and requires hospitalization, a surgical approach is necessary for patients who do not respond to conservative clinical treatment, and this may be associated with earlier clinical evolution. Randomized prospective studies are complicated because this is a rare disease. Therefore, analysis of data from patients admitted to several institutions, and the development of protocols could better elucidate the need for a surgical approach.

R E S U M O

Objetivo: *A pneumonia necrosante (PNS) é uma grave e rara complicação da pneumonia adquirida na comunidade, acometendo principalmente crianças, sendo assim, objetivamos analisar prontuários de crianças submetidas ao tratamento cirúrgico de PNS e comparação dos resultados obtidos com os presentes na literatura médica.* **Métodos:** *Análise retrospectiva dos prontuários de crianças submetidas ao tratamento cirúrgico por PNS entre julho de 2006 a julho de 2016 em dois hospitais do sul de Santa Catarina, Brasil.* **Resultados:** *Do total de 26 crianças, com mediana de idade 2,70 anos, maioria mulheres (61,5%). Os principais sintomas foram febre (88,5%) e tosse (65,4%). Houve média de 4,31 antibióticos utilizados por paciente. O principal agente etiológico foi o Staphylococcus aureus(23,1%) mas as culturas foram negativas em 69% dos pacientes. Em 23 pacientes realizou-se decorticação e desbridamento das áreas necróticas (88,5%). A média de drenagem pleural pós-operatória foi 8,12 dias. Fístula broncopleural ocorreu em 50,0% no pré-operatório e 46,2% após a cirurgia. O tempo total de internação hospitalar foi, em média, de 27,52 dias e tempo pós-operatório com média de 12,60 dias. Complicações pós-operatórias ocorreram em 13 crianças e não houve mortalidade.* **Conclusões:** *Propõe-se abordagem cirúrgica nos pacientes sem resposta ao tratamento clínico, pois o atraso na intervenção cirúrgica associa-se a infecção progressiva no parênquima pulmonar e taxas maiores de complicações. A cirurgia pode conduzir a melhor evolução clínica e recuperação mais precoce.*

Palavras chave: *Pneumonia Necrosante/cirurgia. Pneumonia/complicações. Empiema. Criança.*

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