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PEDIATRIC NECROTIZING PNEUMONIA PEDIATRIC NECROTIZING PNEUMONIA

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Abstract: Objective: To analyze the factors associated with Pediatric Necrotizing Pneumonia, addressing diagnostic strategies, treatment options and the main clinical outcomes observed. **Methodology:** A literature review using the PubMed - MEDLINE electronic database. The search terms included "pediatrics", "necrotizing pneumonia" and their combinations. After screening, 15 articles were included in the analysis. **Results:** The main factors influencing the diagnosis of NPP include the overlap of symptoms between etiologic agents, making it challenging to differentiate between *Mycoplasma pneumoniae* and other causes. Methods such as lung ultrasound and radiomics applied to tomography are promising for early identification. Inflammatory biomarkers, such as MLR, PLR, neutrophilia and elevated D-dimer, help with risk stratification and predicting severity. Prolonged antibiotic therapy remains the mainstay of therapy, but the need for invasive interventions, such as pleural drainage and surgery, is controversial and depends on severity. Prognosis is associated with speed of diagnosis, response to treatment, age and comorbidities. Pneumococcal vaccination has reduced hospitalizations, but the persistence of resistant serotypes requires continuous epidemiological monitoring. **Final considerations :** PNP requires an individualized approach and agile diagnosis to reduce complications and optimize outcomes. Future studies should focus on identifying biomarkers, optimizing therapy and standardizing protocols to improve management.

Keywords: Pediatric Necrotizing Pneumonia; Mycoplasma pneumoniae; Diagnosis; Treatment.

INTRODUCTION

Pediatric necrotizing pneumonia (PNP) is a rare and severe complication of community-acquired pneumonia, characterized by the destruction of lung parenchyma and the formation of necrotic cavities. Its incidence has increased in recent decades, driven by the increased use of computed tomography (CT) for diagnosis and changes in antibiotic prescription patterns, allowing for more accurate identification (Masters *et al.*,2017) Mycoplasma pneumoniae (MP), although classically associated with mild conditions, has been recognized as an emerging pathogen in children, especially in patients with immune compromise. Its ability to induce vascular thrombosis and tissue necrosis increases the risk of pulmonary sequelae, such as fibrosis and bronchiectasis, making early diagnosis essential for effective management (Yang *et al.*, 2021; Zhang *et al.*,2024). However, several factors influence the diagnosis of PNP and its clinical outcomes, and its true incidence has not yet been fully established in comparison with other necrotizing pneumonias. Variables such as the child's age, the presence of chronic diseases and a history of previous antibiotic use can impact the clinical presentation and response to treatment (Zheng; Zhao; Cao, 2020). In addition, the differentiation between PNP due to Mycoplasma pneumoniae (MPNP) and necrotizing pneumonia not caused by Mycoplasma pneumoniae (N-MPNP) still represents a diagnostic challenge, since there is overlap in symptoms and radiological findings between the different etiological agents (Yang et *al.*, 2021).

Another determining factor for clinical outcomes is the therapeutic approach, which still lacks a well-established consensus. Although the prolonged use of antibiotics is widely accepted as part of the treatment, the indication of invasive interventions, such as pleural drainage and bronchoscopic lavage, continues to be debated and can vary depending on the severity of the condition. The prognosis of MPNP tends to be more favorable than that of N-MPNP, with shorter hospital stays and less severe symptoms. However, the possible pulmonary sequelae, such as pleural thickening, fibrosis and bronchiectasis, reinforce the need for early diagnosis and a more individualized therapeutic approach, in order to minimize the long-term impacts (Yang *et al.*, 2021).

Therefore, the complexity of the diagnosis, especially in differentiating between MPNP and necrotizing pneumonia due to other agents (N-MPNP), can impact the therapeutic choice and recovery time of patients. In addition, the lack of consensus on the need for invasive interventions and the variability in response to treatment reinforce the importance of an individualized approach (Zheng; Zhao; Cao, 2020). Given these uncertainties, the aim of this study is to analyze the factors associated with Pediatric Necrotizing Pneumonia, addressing diagnostic strategies, treatment options and the main clinical outcomes observed.

METHODOLOGY

A literature review developed according to the criteria of the PVO strategy, which stands for: population or research problem, variables and outcome. This strategy was used to develop the research question "What are the main factors related to the diagnosis, treatment and prognosis of Pediatric Necrotizing Pneumonia, and how can they influence clinical outcomes?". The searches were carried out using the PubMed - MEDLINE (Medical Literature Analysis and Retrieval System Online) databases. The search terms were used in combination with the Boolean terms "AND" and "OR", using the following search strategy: ((“paediatrics” OR “pediatrics”[MeSH Terms] OR “pediatrics” OR “paediatric” OR “pediatric”) AND (“pneumonia, necrotizing”[MeSH

Terms] OR ("pneumonia" AND "necrotizing") OR "necrotizing pneumonia" OR ("necrotizing" AND "pneumonia")). From this search, 231 articles were found, which were then submitted to the selection criteria. The inclusion criteria were: articles in English; published between 2015 and 2025 and which addressed the themes proposed for this research, studies of the type (review, meta-analysis, observational studies, experimental studies). The exclusion criteria were: duplicate articles, articles available in abstract form, articles that did not directly address the proposal studied and articles that did not meet the other inclusion criteria. After applying the inclusion and exclusion criteria, 15 articles were selected from the PubMed database to make up this study's collection.

DISCUSSION

PNP is a serious condition characterized by rapid progression from lung consolidation to necrosis and cavitation, leading to high morbidity and mortality rates. Affected children often experience symptoms for prolonged periods before hospitalization, which contributes to a worsening clinical picture and the need for extensive hospitalizations. In addition, systemic inflammatory markers, such as the monocyte-to-lymphocyte ratio (MLR) and the platelet-to-lymphocyte ratio (PLR), have been shown to be elevated in patients with PNP, suggesting their potential as useful biomarkers for predicting the severity of the disease and aiding in the risk stratification of these patients (Elmeazawy *et al*., 2024).

The introduction of the 13-valent pneumococcal conjugate vaccine (PCV13) played a key role in reducing hospital admissions due to PNP between 2011 and 2016. However, since 2017, there has been a gradual increase in the number of hospitalizations, suggesting the continued need for epidemiological surveillance of Streptococcus pneumoniae, the predominant agent of the disease. This trend underscores the importance of regular immunization campaigns and constant monitoring of the evolution of bacterial serotypes, ensuring that vaccination strategies remain effective in preventing necrotizing pneumonia (Carloni *et al.*, 2021).

Early diagnosis of PNP is essential for proper and effective clinical management. Lung ultrasound (LUS) has stood out as a promising tool, demonstrating comparable efficacy to computed tomography (CT) in the early detection of the disease (Lai; Wong; Liao, 2015; Chen et al., 2021). LUS offers a less invasive approach, reducing the need for radiation exposure, as well as being more accessible and feasible in pediatric emergency settings. Its wider use can optimize the diagnostic approach in clinical practice, enabling early therapeutic interventions and improving patient outcomes (Carrard *et al.,* 2022).

In the most serious cases, surgical intervention may be necessary, especially when there are associated complications such as sepsis or failure of conservative clinical treatment. According to Da Silva *et al.* (2024), the majority of surgeries performed were on patients with sepsis, and although mild complications were recorded, they did not significantly impact post-operative outcomes. These findings reinforce that, when well indicated, surgery can be a viable therapeutic option, contributing to the recovery of patients with PNP refractory to conventional treatment (Cortina *et al.*, 2018).

In addition, radiomics applied to CT has emerged as an innovative diagnostic strategy for the early identification of PNP. Machine learning methods and medical image analysis have demonstrated high predictive capacity, allowing for a more accurate diagnosis and more agile interventions, as well as minimizing patient exposure to ionizing radiation. These new technologies can help personalize treatment and improve clinical decision-making, making them valuable tools in the field of pediatric pulmonology (Lai; Yang; Ming, 2017).

Changes in circulating pathogens also significantly influence the epidemiology of PNP. The increase in cases may be associated with the growing prevalence of Staphylococcus aureus producing Panton-Valentine leukocidin (PVL), a highly aggressive bacterial toxin capable of inducing tissue necrosis and leukocyte destruction. In addition, bacterial resistance to antibiotics and the interaction between viral and bacterial infections can impact the severity of the disease and the response to treatment, making it essential to develop combined and more effective therapeutic approaches (Masters; Isles; Grimwood, 2017).

Evidence suggests that antibiotic therapy alone may not be enough to modify the course of infection in severe cases of PNP. The combination of immunoglobulins and surgical interventions, such as the drainage of pleural empyema and the control of bronchopleural fistulas, has shown important benefits in the prognosis of patients, reducing the risk of long-term pulmonary complications (Krutikov; Rahman; Tiberi, 2019). In addition, retrospective studies, such as those by Zhang *et al.* (2024), have identified that leukocytosis (> 12.3 $\times$ 10^9/L), neutrophilia (> 73.9%) and high levels of D-dimer (1367.5 ng/mL) are associated with more severe stages of the disease, suggesting that these markers can be used to guide the treatment and clinical monitoring of patients.

In the therapeutic field, low molecular weight heparin (LMWH) has shown beneficial effects in reducing pulmonary necrosis and reducing hospitalization time, especially in patients with hypercoagulability associated with PNP (Zheng; Zhao; Cao, 2020). In addition, Wang *et al.* (2024) highlighted the importance of anticoagulation in patients with PNP complicated by pulmonary embolism, reinforcing the role of this treatment in certain subgroups of patients. Other therapeutic approaches include bronchoscopic lavage for plastic bronchitis and the early use of macrolides and corticosteroids to minimize the exacerbated inflammatory response and reduce pulmonary complications (Yang *et al.*, 2021).

The impact of PCV13 on the epidemiology of PNP was significant, resulting in a reduction in hospitalizations. However, the persistence of serotype 3 suggests a possible substitution effect of bacterial serotypes, justifying the need for continuous monitoring of bacterial resistance and adjustments to vaccine formulations to include emerging serotypes (Carloni *et al.*, 2021).

Despite advances in understanding PNP, there are still several scientific gaps that need to be explored. The main uncertainties include the interaction between the host and the pathogen, the standardization of diagnostic criteria and the optimization of therapeutic approaches. In addition, the early identification of risk factors, such as immunosuppression and chronic respiratory diseases, remains fundamental for the prevention and proper management of the disease (Masters; Isles; Grimwood, 2017).

Given this scenario, it is essential that future research focuses on validating new inflammatory biomarkers, evaluating the impact of new immunological and precision therapies, and standardizing clinical protocols. In this way, it will be possible to improve diagnosis, optimize treatment and improve the clinical outcomes of patients affected by this serious condition (Janapatla *et al.*, 2016).

FINAL CONSIDERATIONS

Pediatric Necrotizing Pneumonia (PNP) is a serious condition with a challenging diagnosis due to the overlapping of symptoms between different etiological agents. Methods such as lung ultrasound and radiomics applied to tomography have shown promise for early detection. Inflammatory biomarkers, such as MLR, PLR, neutrophilia and elevated D-dimer, help with risk stratification and predicting severity. Treatment is based

on prolonged antibiotic therapy, while invasive interventions such as pleural drainage and surgery are indicated depending on the severity of the condition. The prognosis depends on the speed of diagnosis, the response to treatment, the patient's age and the presence of comorbidities. Pneumococcal vaccination has contributed to a reduction in hospitalizations, but bacterial resistance requires continuous monitoring. The main current limitation is the heterogeneity of the studies, making it difficult to generalize the findings. Future research should focus on identifying inflammatory biomarkers, optimizing therapy and standardizing clinical protocols to improve disease management and reduce complications.

REFERENCES

CARLONI, Ines *et al.* Necrotizing pneumonia among Italian children in the pneumococcal conjugate vaccine era. **Pediatric pulmonology**, v. 56, n. 5, p. 1127-1135, 2021.

CARRARD, Johann *et al.* Necrotizing pneumonia in children: Chest computed tomography vs. lung ultrasound. **Frontiers in Pediatrics**, v. 10, p. 898402, 2022.

CHEN, Xin *et al.* Early recognition of necrotizing pneumonia in children based on non-contrast-enhanced computed tomography radiomics signatures. **Translational Pediatrics**, v. 10, n. 6, p. 1542, 2021.

CORTINA, Gerard *et al.* Prolonged extracorporeal membrane oxygenation for pediatric necrotizing pneumonia due to Streptococcus pneumonia and influenza H1N1 co-infection: how long should we wait for native lung recovery?. **Journal of Artificial Organs**, v. 21, p. 367-370, 2018.

DA SILVA, Paulo Sérgio Lucas *et al.* Outcome of anatomical versus non-anatomical lung resection for necrotizing pneumonia in children. **World Journal of Pediatric Surgery**, v. 7, n. 4, p. e000943, 2024.

ELMEAZAWY, Rehab *et al.* Role of systemic immune-inflammatory index and systemic inflammatory response index in predicting the diagnosis of necrotizing pneumonia in children. **BMC pediatrics**, v. 24, n. 1, p. 496, 2024.

JANAPATLA, Rajendra Prasad *et al.* Low serum fetuin-a as a biomarker to predict pneumococcal necrotizing pneumonia and hemolytic uremic syndrome in children. **Medicine**, v. 95, n. 13, p. e3221, 2016.

KRUTIKOV, Maria; RAHMAN, Ananna; TIBERI, Simon. Necrotizing pneumonia (aetiology, clinical features and management). **Current Opinion in Pulmonary Medicine**, v. 25, n. 3, p. 225-232, 2019.

LAI, Jin-Yao; YANG, Wendy; MING, Yung-Ching. Surgical management of complicated necrotizing pneumonia in children. **Pediatrics & Neonatology**, v. 58, n. 4, p. 321-327, 2017.

LAI, Shen-Hao; WONG, Kin-Sun; LIAO, Sui-Ling. Value of lung ultrasonography in the diagnosis and outcome prediction of pediatric community-acquired pneumonia with necrotizing change. **PLoS One**, v. 10, n. 6, p. e0130082, 2015.

MASTERS, I. Brent; ISLES, Alan F.; GRIMWOOD, Keith. Necrotizing pneumonia: an emerging problem in children?. **Pneumonia**, v. 9, p. 1-19, 2017.

WANG, Chenlu *et al.* Characteristics and Outcomes of Mycoplasma pneumoniae pneumonia associated with pulmonary embolism and necrotizing pneumonia in children. **Infection and Drug Resistance**, v. 17, p. 1961, 2024.

YANG, Beilei *et al.* Differences of clinical features and prognosis between Mycoplasma pneumoniae necrotizing pneumonia and non-Mycoplasma pneumoniae necrotizing pneumonia in children. **BMC Infectious Diseases**, v. 21, n. 1, p. 797, 2021.

ZHANG, Xue *et al.* Clinical characteristics of lung consolidation with Mycoplasma pneumoniae pneumonia and risk factors for Mycoplasma pneumoniae necrotizing pneumonia in children. **Infectious Diseases and Therapy**, v. 13, n. 2, p. 329-343, 2024.

ZHENG, Baoying; ZHAO, Jing; CAO, Ling. The clinical characteristics and risk factors for necrotizing pneumonia caused by Mycoplasma pneumoniae in children. **BMC infectious diseases**, v. 20, p. 1-6, 2020.