European Scholar Journal (ESJ)
Available Online at: https://www.scholarzest.com
Vol. 4 No.04, April 2023
ISSN: 2660-5562

CURRENT VIEW OF THE PROBLEM OF DESTRUCTIVE PNEUMONIAS IN CHILDREN (LITERATURE REVIEW)

Komiljon Zakirjanovich Kadirov
Associate Professor of Pediatric Surgery Department
Andijan State Medical Institute

Article history:

Received: 6th February 2023
Accepted: 6th March 2023
Published: 10th March 2023

Abstract:

The problem of community-acquired pneumonias in children remains acute at present. Complicated forms, which include pleural empyema, abscess, necrotizing or destructive pneumonia, bronchopleural fistula and acute respiratory distress syndrome are not becoming less, despite the modern antibacterial therapy and availability of vaccination against pneumococcus. The main pathogens associated with lung destruction in children remain S. pneumoniae and S. aureus, often MRSA. Much less often the role of other pathogens in necrotizing pneumonias is reported: Streptococcus pyogenes, Haemophilus influenzae, Pseudomonas aeruginosa, Fusobacterium nucleatum, Legionella pneumophila, Klebsiella pneumoniae, anaerobes. However, not only pathogenic factors of the causative agent are important in the pathogenesis of the disease. Often viral prodrome, often associated with influenza A (H1N1) virus, precedes the development of complicated pneumonia.

Keywords: community-acquired pneumonia, anticoagulants,children,etiology

INTRODUCTION: The problem of community-acquired pneumonia in children remains urgent at present primarily due to the persisting high morbidity rate [1]. Pulmonary complications of community-acquired pneumonia include pleural empyema, abscesses, necrotizing or destructive pneumonia, bronchopleural fistula formation and acute respiratory distress syndrome [2]. Frequency of purulent-destructive complications in community-acquired pneumonia, according to different authors, is from 7 to 15%. Lethality in such cases is 8.7-18.5%, being one of the highest among all purulent-septic diseases [3]. It is interesting, that in the last two decades incidence of complicated pneumonias all over the world has been growing, and despite introduction of vaccination, Streptococcus pneumoniae remains one of the main causative agents of lung destruction in childhood. Destructive (necrotizing) pneumonia is characterized by necrotic melting of lung tissue and can be caused by different strains of microorganisms [4]. In foreign literature the term necrotizing pneumonia is used to refer to this nosology, less frequently cavitary pneumonia. During the epidemic of new coronavirus infection endothelial damage with a high degree of probability was a predisposing factor for the development of secondary bacterial infection with necrosis of lung tissue. Until now the pathogenesis of destructive pneumonias has not been clearly described. Significant destruction and liquefaction of lung tissue can develop despite adequate antibiotic therapy. Great importance in the development of destruction is given to hemostasis activation and thrombosis in pulmonary vessels. The predominance of general symptoms over local ones, especially in young children, the presence of clinical syndromes masking the pulmonary process complicate timely diagnosis. Chest radiography is a standard diagnostic tool for pneumonia. However, diagnostic capabilities of this method in destructive pneumonia are limited. Ultrasound is preferable for evaluation of several parameters of pleural cavity and pulmonary tissue state. It is necessary to analyze current peculiarities of destructive pneumonias in children and develop clinical guidelines for the management of patients in the acute period and rehabilitation. In clinical practice, destructive pneumonia usually occurs in previously healthy children without a history of complications. Complicated pneumonia should be suspected in any case of out-of-hospital therapy in the absence of response to adequate antibiotic therapy within 48-72 h. In retrospective studies, the risk factors associated with complicated pneumonia in children were age less than 2 years, prolonged prehospital fever, asymmetric chest pain, high biochemical acute phase score, low white blood cell count, and iron deficiency anemia. Accurate characterization of risk factors is difficult due to the lack of unified indicators in the studies [5]. The possibility of destructive pneumonia in immunodeficiencies, disorders of protein-energy metabolism, chronic lung diseases and congenital cystic malformations, as well as foreign bodies of the airways should not be forgotten.

ETIOLOGY AND PATHOGENESIS: According to literature data, in cases of destructive pneumonias etiologic factor can be identified in not more than 50% of cases. This is due to a number of reasons. In children it is often difficult to obtain material from the lower respiratory tract suitable for bacteriological examination. Interpretation of microbiological data is difficult, because causative pathogens are often part of the microbiome of healthy people. For example, S.

pneumonia is found in the upper respiratory tract in 40-50% of children and 20-30% of adults [6]. Bacteriological studies are often performed late in the course of the disease against the background of antibiotic therapy. In a number of cases a negative result of the study is associated with the peculiarities of the pathogen, for example, S. pneumoniae has the ability to autolysis. Research data testify to the leading role of S. pneumoniae in the development of pneumonias in children. Introduction of routine vaccination contributed to the decrease of pneumococcal infection incidence, the evidence of the reduction of the frequency of pleural empyema, associated with this pathogen was received. At the same time S. pneumoniae still occupies the leading position in the etiological structure of severe respiratory infections in childhood [7]. Destructive changes in lungs are most frequently associated with 1, 3, 7F and 19A serotypes of pneumococcus. They are included in the 13-valent polysaccharide antipneumococcal vaccine. However, it has been shown that vaccination efficacy against different serotypes varies. Thus, morbidity of pneumococcal strain 1 on the background of mass vaccination is reduced by 92%, while for serotype 3 the morbidity rate is reduced by 38% [8]. Prevention of pneumonia and its complications requires sufficiently high levels of antibodies to capsular polysaccharides, which may be unattainable for some serotypes with standard vaccination protocol [9]. S. aureus also remains a significant factor in the implementation of destructive pneumonias, often its methicillin-resistant strains. Staphylococcus aureus leukocidin Panton-Valentine (PVL) pore-forming toxin has potent lytic activity against granulocytes attracted to the inflammatory focus, causing necrosis of the pulmonary parenchyma. In addition, PVL can be a direct cause of leukopenia observed in patients with necrotizing pneumonia [10]. Another S. aureus pore-forming toxin, alpha-hemolysin, activates the NLRP3 inflammasome and may also play a role in the pathogenesis of necrotizing pneumonia [11]. The role of other pathogens in necrotizing pneumonias is reported much less frequently: Streptococcus pyogenes, Haemophilus influenzae, Pseudomonas aeruginosa, Fusobacterium nucleatum, Legionella pneumophila, Klebsiella pneumoniae, anaerobes [12]. Reports from China on the association of destructive pneumonia and Mycoplasma pneumoniae are interesting [13]. Viruses in isolation can very rarely be a cause of destructive pneumonia. However, one cannot ignore their important role in the pathogenesis of this condition. This is proved by descriptions of severe complicated pneumonias in children during influenza epidemics with confirmation of viral etiology and subsequent detection of bacterial pathogens by culture of pleural cavity or bronchoscopic material. In most patients flu-like prodrome precedes the development of lung destruction. In some cases pneumococcal or staphylococcal etiology of destructive process against the background of influenza H1N1 is confirmed. Currently, there is a clear notion that influenza virus increases the susceptibility of the organism to bacterial infections [14]. The virus disrupts macrophage-mediated bacterial clearance by damaging the epithelium. The subsequent accumulation of debris and impaired evacuation leads to blockage of the small airways, preventing removal of the bacteria. Neuraminidase destroys sialic acid of the respiratory epithelium, increases bacterial adhesion, epithelial cells are destroyed, mucociliary clearance is impaired, and the number of pulmonary alveolar macrophages decreases [15]. All this contributes to the realization of bacterial co-infection, and under certain characteristics of the pathogen - to the development of rapidly progressive necrotizing pneumonia. A large number of inflammatory cells in the respiratory tract against the background of influenza are quickly activated even by a small dose of S. pneumoniae and S. aureus toxins, causing mass cell death and necrosis [16]. In the COVID-19 pandemic, as a result of SARS-CoV-2 virus tropism to the angiotensin-converting enzyme receptor and ability to cause hyperactivation of cytokine response, we encountered a fundamentally new disease. Vascular endotheliitis with systemic inflammation and coagulopathy played a major role in the pathogenesis of the new coronavirus infection and its complications. Endothelial damage served as a major factor in the pathogenesis of acute respiratory distress syndrome, multiple organ failure and DIC [17]. Multisystem inflammatory syndrome in children after coronavirus infection is also referred to inflammatory vasculopathy [18]. Clinical portrait of destructive pneumonias during COVID-19 epidemic and early post-coVID period has changed. Peculiarities of necrotic destruction cavity type development give grounds to consider pulmonary vascular endotheliopathy as one of the causes of complicated course of pneumonia with development of destructive processes [19, 20].

Until now the pathogenesis of destructive pneumonias has not been clearly described. Significant destruction and liquefaction of lung tissue can develop despite adequate antibiotic therapy. Single fatal cases with autopsy demonstrated pulmonary vascular thrombosis [21]. High values of D-dimer and soluble fibrin monomer complexes in children in destructive pneumonias confirm the activation of the coagulation system. The possibility of genetic predisposition is also considered. According to modern concepts in the development of lung tissue destruction, on the one hand, the state of pulmonary vascular system is important. Pneumonia is always accompanied by microcirculatory disorders. It restricts the infectious process spreading. At the same time, endotheliopathy predisposes to thrombosis under inflammation and coagulation system activation, which leads to irreversible microcirculatory disorders. On the other hand, microbial pathogenic factors are involved in lysis of epithelial and interstitial cells. Disturbance of bronchial patency in the inflammation focus limits the access of oxygen and promotes necrosis.

CLINICAL PICTURE: In most cases, destructive (necrotizing) pneumonia is the diagnosis of children under 5 years of age. The disease usually begins with a virus-like prodrome. Prolonged high fever, poorly controlled by standard methods, weakness and lethargy of the child, refusal to eat serve as a reason for hospitalization. Cough may not start in the first few days of illness. Often, the predominance of general symptoms over local symptoms, especially in young children, the presence of clinical syndromes masking the pulmonary process, complicate timely diagnosis. Pain syndrome may suggest the development of pleural complications. Respiratory failure may join later. Absence of auscultatory data does not exclude development of necrotizing pneumonia. Thus, nonspecific symptomatology at the beginning of the disease

makes it difficult to make an early diagnosis. Therefore, during the period of respiratory viral morbidity rise, it is necessary to keep in mind the possibility of complicated pneumonia in children [22].
If pneumonia has been diagnosed on an outpatient basis and adequately prescribed antibiotic therapy is ineffective within 48-72 h, complicated forms should be suspected [1].
According to a number of studies, factors indicating a high probability of necrotizing pneumonia are prolonged fever (more than 11 days), high values of CRP (above 48 mg/L), high levels of D-dimer (above 4250 ng/mL) [23].

Diagnosis: Chest radiography is the standard diagnostic tool for pneumonia. However, the diagnostic potential of this method in patients with complicated pneumonia is limited. Severe effusion in pleural cavity does not allow adequate assessment of parenchyma condition [24]. In the initial phase of the necrotic process fluid-filled cavities have the same density as the adjacent consolidated lung, it is difficult to differentiate them on chest X-ray. In two comparative studies, cavities were detected on chest radiograph in only 33 (59%) of 56 and in 5 (22%) of 23 children with necrotizing pneumonia detected on chest CT [25]. Ultrasound (US) is currently positioned as the primary imaging modality for the evaluation of the pleural cavity [26]. This method is more sensitive to detect a small effusion, allows to distinguish the nature of the effusion, reveals fibrinous septa. Ultrasound allows to determine the stage of inflammatory process with more accuracy, formulate indications for invasive treatment benefits [27]. Computed tomography (CT) of the chest organs confirms the presence of cavities of destruction. However, according to some authors, in most cases, conventional chest radiography combined with ultrasound is sufficient for the diagnosis of complicated pneumonia. CT scan is shown when it is necessary to exclude tumors, malformations, to determine the plan of surgical intervention. The use of lung ultrasound instead of chest CT reduces costs without changing outcomes [28].

TREATMENT

There is currently no consensus on the management of children with destructive pneumonia. Recommendations are largely based on expert opinion rather than on high-quality randomized controlled trials. Hospitalization is necessary in institutions with experience in the treatment of complicated pneumonia.
The basis of treatment is antibiotic therapy. Parenteral administration of high-dose ampicillin, amoxicillin-clavulanate, or second- or third-generation cephalosporins is warranted. In regions with a high prevalence of methicillin-resistant Staphylococcus aureus, vancomycin should be used as adjunctive first-line therapy until culture results are available. If markers of M. pneumoniae infection are detected, macrolides are added to therapy. Macrolides should never be used in isolation in complicated pneumonia [1].
In a number of cases complicated pneumonia requires surgical treatment, but radical surgery in acute suppurative destructive processes in children is not currently used. Modern conservative intensive and antibacterial therapy is combined with modified surgical methods of sanation of purulent-destructive foci. Absence of bronchial drainage of inflammation foci at early stages of destructive process, confirmed by absence of air bronchogram at lung ultrasound, is an indication for sanation bronchoscopy. Extensive empyema, pneumothorax and pyopneumothorax are indications for pleural cavity drainage. In case of persisting air discharge due to bronchopleural fistula formation a bronchoblocker is installed. At fibrinothorax thoracoscopy with closed lung decortication and ultrasound sanation of the pleural cavity with antibiotic solution is effective. Intrapleural fibrinolytic agents are not currently used due to the risk of air leakage from peripheral necrotized areas of the lung [29, 30]. Considering peculiarities of destructive pneumonia pathogenesis in the form of coagulation system activation, microthrombosis, it is reasonable to prescribe anticoagulants to children with destructive pneumonia. The literature provides evidence for the effectiveness of anticoagulants in such patients. It has been demonstrated to reduce the risk of pulmonary necrosis when using low-molecular-weight heparins [31].
Outcomes of destructive pneumonia in children are usually favorable. In almost all cases there is complete recovery, normalization of radiological picture according to CT 6-9 months after discharge. However, children after destructive pneumonia are recommended to be monitored, since there remains a risk of re-infection of residual cavities after necrotizing pneumonia. Repeated chest radiography is recommended 2-4 weeks after discharge.Lethality in destructive pneumonia in children is low, <0.5%. Retrospective studies have shown that lung function is usually not impaired [1].

CONCLUSION: Thus, to date, there are many controversial questions about destructive pneumonia in children. The pathogenesis of the disease is not definitively clear, there are difficulties of early detection, questions of optimal diagnostic approach, treatment and determination of indications for surgical intervention, the protocol of rehabilitation measures has not been developed. The management of such patients should involve a team of specialists: pediatricians, pediatric surgeons, radiation diagnosticians, and rehabilitation therapists. Careful analysis of cases of destructive pneumonia in children, a detailed comprehensive study of this problem will allow to develop an optimal protocol of management and rehabilitation of patients.

LITERATURE

1. Baranov A.A., Kozlov R.S., Namazova-Baranova L.S., Andreeva I.V., Bakradze M.D., Vishneva E.A. et al. Community-acquired pneumonia in children: clinical guidelines. 2022.
2. Mashkov A.E., Yelin L.M., Slesarev V.V., Filyushkin Y.N. The role of superinfection in the etiological structure of acute purulent destructive pneumonia in children. Pediatric Surgery. 2018;22(5):241-245.

3. Vecherkin V. A., Toma DA, Ptitsyn VA, Koryashkin P. V. Destructive pneumonias in children. Russian Bulletin of Pediatric Surgery, Anesthesiology and Critical Care. 2019;9(4):108-115. https://doi.org/10.30946/2219-4061-2019-9-3-108-115.Elemraid M.A., Thomas M.F., Blain A.P., Rushton S.P., Spencer D.A., Gennery A.R. et al. Risk factors for the development of pleural empyema in children. Pediatr Pulmonol. 2015;50:721-726. https://doi.org/10.1002/ppul.23041.
4. Dion C.F., Ashurst J.V. Streptococcus Pneumoniae. [Updated 2022 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022. Available at: https://www.ncbi.nlm.nih.gov/books/NBK470537.
5. Azzari C., Serranti D., Nieddu F., Moriondo M., Casini A., Lodi L. et al. Significant impact of pneumococcal conjugate vaccination on pediatric parapneumonic effusion: Italy 2006-2018. Vaccine. 2019;37(20):2704-2711.
6. Lewnard J.A., Hanage W.P. Making sense of differences in pneumococcal serotype replacement. Lancet Infect Dis. 2019;19(6):213-220
7. Andrews N.J., Waight P.A., Burbidge P., Pearce E., Roalfe L., Zancolli M. et al. Serotype-specific effectiveness and correlates of protection for the 13-valent pneumococcal conjugate vaccine: a postlicensure indirect cohort study. Lancet Infect Dis. 2014;14(9):839-846. https://doi.org/10.1016/S1473-3099(14)70822-9.
8. Gillet Y., Issartel B., Vanhems P., Fournet J.C., Lina G., Bes M. Association between Staphylococcus aureus strains carrying gene for Panton-Valentine leukocidin and highly lethal necrotising pneumonia in young immunocompetent patients. Lancet. 2002;359(9308):753-759. https://doi.org/10.1016/S0140-6736(02)07877-7.
9. Tong S.Y.C., Davis J.S., Eichenberger E., Holland T.L., Fowler V.G.Jr. Staphylococcus aureus infections: epidemiology, pathophysiology, clinical manifestations, and management. Clin Microbiol Rev. 2015;28:603-661. https://doi.org/10.1128/CMR.00134-14.
10. Tsai Y.-F., Ku Y.-H. Necrotizing pneumonia: a rare complication of pneumonia requiring special consideration. Curr Opin Pulm Med. 2012;18:246-252. https://doi.org/10.1097/MCP.0b013e3283521022.
11. Zheng B., Zhao J., Cao L. The clinical characteristics and risk factors for necrotizing pneumonia caused by Mycoplasma pneumoniae in children. BMC Infect Dis. 2020;20(1):391. https://doi.org/10.1186/s12879-020-05110-7.
12. Krutikov M., Rahman A., Tiberi S. Necrotizing pneumonia (aetiology, clinical features and management). Curr Opin Pulm Med. 2019;25(3):225-232. https://doi.org/10.1097/MCP.0000000000000571.
13. McCullers J.A. The co-pathogenesis of influenza viruses with bacteria in the lung. Nat Rev Microbiol. 2014;12:252-262. https://doi.org/10.1128/CMR.00134-14.
14. Loffler B., Niemann S., Ehrhardt C., Horn D., Lanckohr C., Lina G. et al. Pathogenesis of Staphylococcus aureus necrotizing pneumonia: the role of PVL and an influenza coinfection. Exp Rev Antiinfect Ther. 2013;11:1041-1051. https://doi.org/10.1586/14787210.2013.827891.
15. M. I. Kamalova, N.K.Khaidarov, Sh.E.Islamov,Pathomorphological Features of hemorrhagic brain strokes, Journal of Biomedicine and Practice 2020, Special issue, pp. 101-105
16. . Kamalova Malika Ilkhomovna, Islamov Shavkat Eriyigitovich, Khaidarov Nodir Kadyrovich. Morphological Features Of Microvascular Tissue Of The Brain At Hemorrhagic Stroke. The American Journal of Medical Sciences and Pharmaceutical Research, 2020. 2(10), 53-59
17. McGonagle D., Bridgewood C., Ramanan A.V., Meaney J.F.M., Watad A. COVID-19 vasculitis and novel vasculitis mimics. Lancet Rheumatol. 2021;3(3):224-233. https://doi.org/10.1016/S2665-9913(20)30420-3.
18. McMurray J.C., May J.W., Cunningham M.W., Jones O.Y. Multisystem Inflammatory Syndrome in Children (MIS-C), a Post-viral Myocarditis and Systemic Vasculitis-A Critical Review of Its Pathogenesis and Treatment. Front Pediatr. 2020;16(8):626182. https://doi.org/10.3389/fped.2020.626182.
19. Толстова Е.М., Зайцева О.В., Хаспеков Д.В., Шолохова Н.А. Роль системы гемостаза в развитии деструктивной пневмонии у детей: обзор литературы и клинические наблюдения. Педиатрия. Журнал имени Г.Н. Сперанского. 2022;101(4):146-155. https://doi.org/10.24110/0031-403X-2022-101-4-146-155.
20. Pachauri A., Singh S.N., Verma S.K., Awasthi S. Thrombocytosis, haemorrhagic pleural effusion and fibro-infiltrative patches with cavitary lung lesions in a child with COVID-19 pneumonia. BMJ Case Rep. 2022;23;15(6):249466. https://doi.org/10.1136/bcr-2022-249466.
21. Hsieh Y.-C., Hsiao C.-H., Tsao P.-N., Wang J.-Y., Hsueh P.-R., Chiang B.-L. et al. Necrotizing pneumococcal pneumonia in children: the role of pulmonary gangrene. Pediatr Pulmonol. 2006;41(7):623-629. https://doi.org/10.1002/ppul.20411.
22. Chen K.C., Su Y.T., Lin W.L., Chiu K.C., Niu C.K. Clinical analysis of necrotizing pneumonia in children: three-year experience in a single medical center. Acta Paediatr Taiwan. 2003;44(6):343-348. Available at: https://pubmed.ncbi.nlm.nih.gov/14983656.
23. Qian J., Wei Y.J., Cheng Y.J., Zhang Y., Peng B., Zhu C.M. Analysis of clinical features and risk factors of necrotizing pneumonia in children. Beijing Da Xue Xue Bao Yi Xue Ban. 2022;18;54(3):541-547. https://doi.org/10.19723/j.issn.1671-167X.2022.03.021.
24. Hallifax R.J., Talwar A., Wrightson J.M., Edey A., Gleeson F.V. State-of-the-art: radiological investigation of pleural disease. Respir Med. 2017;124:88-99. https://doi.org/10.1016/j.rmed.2017.02.013.

25. Koşucu P., Ahmetoğlu A., Cay A., İmamoğlu M., Özdemir O., Dinç H. et al. Computed tomography evaluation of cavitary necrosis in complicated childhood pneumonia. Australas Radiol. 2004;48:318-323. https://doi.org/10.1111/j.0004-8461.2004.01314.x.
26. Ольхова Е.Б., Хаспеков Д.В., Сар А.С., Кузнецова Е.В. Эхографическая оценка плеврального выпота у детей. Радиология - практика. 2020;(6):16-30. Режим доступа: https://www.radp.ru/jour/article/view/122.
27. Зайцева О.В., Ольхова Е.Б., Хаспеков Д.В., Топилин О.Г., Сафин Д.А. Современные подходы к диагностике и лечебной тактике при лобарной пневмонии и ее осложнениях у детей и подростков. Педиатрия. Журнал им. Г.Н. Сперанского. 2012;91(4):49-54. Режим доступа: https://pediatriajournal.ru/files/upload/mags/324/2012_4_3461.pdf?ysclid=lecgvvx0ex666332700.
28. Quick R.D., Auth M.J., Fernandez M., Meyer T., Merkel K.G., Thoreson L.M., Hauger S.B. Decreasing exposure to radiation, surgical risk, and costs for pediatric complicated pneumonia: a guideline evaluation. Hosp Pediatr. 2017;7:287-293. https://doi.org/10.1542/hpeds.2016-0077.
29. Meier A.H., Hess C.B., Cilley R.E. Complications and treatment failures of video-assisted thoracoscopic debridement for pediatric empyema. Pediatr Surg Int. 2010;26:367-371. https://doi.org/10.1007/s00383-010-2562-0.
30. Хаспеков Д.В., Ольхова Е.Б., Топилин О.Г., Сафин Д.А., Ткаченко Н.В., Соколов Ю.Ю. Современные методы диагностики и лечения деструктивной пневмонии у детей. Российский вестник детской хирургии, анестезиологии и реаниматологии. 2015;5(2):7-12. Режим доступа: https://rps-journal.ru/jour/article/view/152.
31. Zheng B., Zhao J., Cao L. The clinical characteristics and risk factors for necrotizing pneumonia caused by Mycoplasma pneumoniae in children. BMC Infect Dis. 2020;1;20(1):391. https://doi.org/10.1186/s12879-020-05110-7.