COMMUNITY ACQUIRED PNEUMONIA IN CHILDREN WITH CONGENITAL HEART DISEASE: REVIEW ARTICLE

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Abstract

The most common cause of morbidity and mortality of children between the ages of 28 days and 5 years is still community-acquired pneumonia (CAP), it affects children worldwide and poses a serious risk to their health as well as a financial strain on healthcare systems. Congenital heart disease (CHD) is the most common cause of major congenital anomalies (approximately 28%), representing a major global health problem. Many previous studies showed that CHD are considered an underlying cause of recurrent pneumonia in children. According to multiple studies, the prevalence of bacteremia among hospitalized children who have community-acquired pneumonia has changed recently, and there have also been changes in the epidemiology and management of pneumonia. The risk factors etiology, complication, management of pneumonia will be summarized.

Keywords: community acquired pneumonia, congenital heart diseases,

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Introduction

Pneumonia can be broadly defined as a lower respiratory tract infection, but definitions vary depending on the organization, institution, or health care setting. For instance, the World Health Organization (WHO) defines pneumonia solely on the basis of clinical findings obtained by visual inspection and timing of the respiratory rate, another definition published by Bone and colleagues states that pneumonia is the "inflammation of the pulmonary parenchyma brought about by the presence of virulent pathogens; usually differentiated from isolated infections of the major airways."[1]. pneumonia was the cause for 14% of all deaths among children under 5 years old, killing more than 700 thousands children in 2019. With most of this mortality occurring in developing nations [2]. In Egypt, CAP is still one of the leading causes of death as it is responsible for about 10% of childhood mortality under the age of five [3].

Because congenital defects of the circulation are so common (approximately 7 infants per 1000 live births are affected) and the alterations in respiratory function are often so profound, it is essential that the physician interested in respiratory diseases be well acquainted with the spectrum of CHD and the ways in which it is manifested in infants and young children. Direct pulmonary complications of CHD are either by structural impact on the airways, abnormal pathophysiological mechanisms leading to increased lung water and/or significant pulmonary disease. Many children with CHD are at greater risk of infection including respiratory tract infections, which can cause prolonged hospitalization and delay of definitive cardiac repair[4].

Other risk factors of pneumonia

Community acquired pneumonia and clinically severe disease result from a complex interaction of host and environmental risk factors [5]

•Lack of exclusive breastfeeding for the first 4 months of life.

•Undernutrition.

•Household crowding .

•Indoor air pollution from use of solid or biomass fuels.

•Pneumococcal conjugate vaccination and Haemophilus influenzae type B conjugate vaccination protect children from invasive disease caused by these organisms.

Etiology:

Although the particular etiologic factor in many cases of CAP in children has not been determined, respiratory viruses such as respiratory syncytial virus (RSV) and parainfuenza are detected in more than half of the cases [6]. Recently in 2019, novel coronavirus COVID-19 was discovered causing pandemic worldwide [7]. Pyogenic bacteria are identifed in just a small percentage of CAP in children, but their early detection is crucial because they can cause severe and/or complicated pneumonia, as well as fatalities [8]. Streptococcus pneumoniae is considered the most communal bacterial cause of CAP. Mycoplasma, Chlamydia and Strep. pneumonia are the principal aetiologies of CAP in school-aged children. Haemophilus infuenza and group A Streptococci are the least predominant causes [9].

Clinical presentation\investigation

The symptoms of pneumonia are often nonspecific and can be very wide ranging, making it a potentially challenging condition to diagnose. Symptoms also vary with age, although the most accepted common presenting features of pneumonia in all age groups include fever, cough, rhinorrhea, dyspnea, malaise and lethargy.[8]

Important physical findings include fever, tachypnea, wheezing, cyanosis, nasal flaring, grunting ,use of accessory muscles, intercostal/subcostal/suprasternal retractions, rhonchi, crackles (rales, crepitations), decreased breath sounds (parenchymal consolidation), bronchial breath sounds (parenchymal consolidation), egophony (e to a change), bronchophony (distant transmission of sounds), whispered pectoriloquy, tactile fremitus (parenchymal consolidation), and dullness to percussion (parenchymal consolidation) [8].

While pneumonia can be of bacterial or viral etiology, only 5% of bacterial pneumonia are bacteremic and can be termed as "pyogenic" pneumonia. Hence there is a diagnostic dilemma in differentiating viral from bacterial pneumonia which has led to investigating the role of various biomarkers for this purpose [10].

Measurements of these inflammatory markers should be considered for children with serious pneumonia requiring hospitalization [9] . A white blood cell count >15,000/mm^3 with a predominance of granulocytes and elevated C-reactive protein and erythrocyte sedimentation rate are suggestive of bacterial pneumonia . Peripheral eosinophilia may be seen in infants with afebrile pneumonia typically caused by *C. trachomatis* . [11]

The British Thoracic Society (BTS) guidelines state that, 'children with symptoms and signs

suggesting pneumonia who are not admitted to hospital should not routinely have a chest X-ray'. Chest radiographs should not be considered a routine investigation for children with mild suspected pneumonia, nor is necessary to make the diagnosis [9]. Reviewing the literature on studies of chest x-rays, there can be no significant links made between radiological findings and etiology [12]

Definite indications for chest radiographs include confirmation of diagnosis when clinical findings are inconclusive; exclusion of pneumonia in young children (< 3 years) with fever > 39ºC and leukocytosis (>20,000 white blood cells/_L) and in older children (3 to 10 years) years with fever > 38ºC, leukocytosis (> 15,000 white blood cells/_L), and cough; severe pneumonia with significant respiratory distress (to assess for complications); prolonged pneumonia; pneumonia unresponsive to antimicrobial treatment, and recurrent pneumonia [9]

Sputum gram stain and culture is a useful test to determine the underlying bacterial causative organism. However, sputum samples are difficult to be obtained in younger children and take several days to culture. They are particularly useful for the child who is severely unwell or not responding to treatment, in order to target antimicrobial therapy. Also, if admitted to the Intensive Care Unit, a bronchoalveolar lavage (BAL) sample is readily attainable via their endotracheal tube [13]

In general, blood cultures are not necessary for nontoxic looking children treated as outpatients but should be considered for those who require hospitalization, particularly those with complicated pneumonia . Recent studies have shown that blood cultures have a low yield (1 to 3%) and do not appear helpful when collected in all children without comorbidities hospitalized with uncomplicated community-acquired pneumonia [9] .

The diagnosis is usually based on the clinical findings of fever, cough,respiratory distress (e.g., tachypnea, intercostal/subcostal/suprasternal retractions, nasal flaring, grunting), and/or radiologic evidence of an acute pulmonary infiltrate/consolidation [11] .

Complications

Most children with community-acquired pneumonia go on to make a full recovery. However, both pulmonary and systemic complications occur in around 3%, resulting in significant morbidity and mortality. Regular reassessment of a child with pneumonia is recommended, including for children managed in the community

Increased effort of breathing, agitation and persistent or swinging fevers should prompt parents to return for further assessment and it is important that this information is provided. Pulmonary complications include parapneumonic effusion, empyema and lung abscess. Systemic complications can include multi organ failure, metastatic infection, bacteraemia and Acute Respiratory Distress Syndrome (ARDS) [14]

Management

The first step in managing children with pneumonia is deciding whether or not they can be managed safely in the community, or whether they need referring to a hospital. A thorough assessment of disease severity is needed on first presentation, with the premise that previously well children with mild disease are best managed at home. An assessment of severity will also influence the decision to investigate and initiate treatment, as well as guide the duration of treatment and level of medical and nursing care required in the hospital setting[15].

The initial assessment of a child presenting with infective symptoms will normally take place in the primary care or emergency department setting. Doctors will assess children based on their clinical presentation but will also need to consider associated risk factors as CHD. Underlying health conditions and the social background of the child can impact on the ability for the condition to be well managed in the community. Children with complex needs and chronic underlying lung conditions may be more vulnerable to severe disease and may have a lower respiratory reserve. As a result, there is a lower threshold for initiation of antibiotic treatment and admission to hospital[15].

Unlike the CURB 65 score in adults, there is no reliable assessment tool for scoring severity of disease in children. As a result, clinical markers of severity (Table1) remain the gold standard for assessing children that need hospital care. One of the most important measures to guide the need for admission to hospital is oxygen saturations, with hypoxemia being a sensitive indicator of disease severity and prognosis. Also, tachypnea correlates with hypoxemia and so the respiratory rate requires careful assessment[16].

Table 1: Clinical indicators of severity in childhood pneumonia [16]

	Mild/moderate	**Severe**
Infants	Temp <38.5°C RR <50 breaths/minute Mild recession Taking full feeds	Temp >38.5°C RR >70 breaths/minute Moderate/severe recession Cyanosis Intermittent apnoea Poor feeding Capillary refill time >2 second Tachycardia
Older children	Temp <38.5°C RR <50 breaths/minute Mild breathlessness No vomiting	Temp >38.5°C RR >50 breaths/minute Severe difficulty in breathing Nasal flaring Grunting Cyanosis Signs of dehydration Tachycardia Capillary refill time >2 seconds

The severely unwell child may require admission to the Pediatric Intensive Care Unit (PICU). The two main scenarios where PICU is indicated are when the pneumonia is severe enough to cause respiratory failure, requiring ventilatory support, or when the pneumonia is complicated by septicemia. The diagnosis of respiratory failure is made following blood gas analysis [17]

Indication of hospitalization [9]

1. Children and infants who have moderate to severe CAP, as defined by several factors, including respiratory distress and hypoxemia (sustained saturation of peripheral oxygen (SpO2) 90 % .
2. Infants less than 3–6 months of age with suspected bacterial CAP are likely to benefit from hospitalization.
3. Children and infants with suspected or documented CAP caused by a pathogen with increased virulence, such as community-associated methicillin-resistant Staphylococcus aureus (CA-MRSA) should be hospitalized.
4. Children and infants for whom there is concern about careful observation at home or who are unable to comply with therapy or unable to be followed up should be hospitalized.

Indication for intensive care [9]

1. A child should be admitted to PICU if the child requires invasive ventilation via a non permanent artificial airway (eg, endotracheal tube).
2. If the child acutely requires use of non invasive positive pressure ventilation (eg, continuous positive airway pressure or bilevel positive airway pressure).
3. If the child has sustained tachycardia, inadequate blood pressure, or need for pharmacologic support of blood pressure or perfusion.
4. If the pulse oximetry measurement is less than 90% on inspired oxygen
5. Altered mental status, whether due to hypercarbia or hypoxemia as a result of pneumonia.

Outpatient treatment :

If viral pneumonia is suspected based on the history of gradual onset, preceding upper respiratory tract infection, mild symptoms, lack of toxicity, and diffuse auscultatory findings, some authors suggest that such patients should not be treated with antibiotics, especially if the child does not have respiratory distress . An antiviral agent such as oseltamivir , zanamivir , amantadine , or rimantadine should be initiated as soon as possible for influenza pneumonia, particularly for those with clinically worsening disease . Some authors suggest that antibiotic therapy should be initiated in children suspected to have viral pneumonia if there is deterioration in the clinical situation because of the possibility of bacterial superinfection [18]

The British Thoracic Society guidelines recommend that children with a clear clinical diagnosis of pneumonia should be treated with antibiotics, given that bacterial and viral pneumonia cannot be reliably distinguished from each other on clinical grounds. In addition, in children with viral pneumonia, coinfection with

bacteria has been reported in up to 30% of cases [19]

In practice, most children with pneumonia are treated empirically with antibiotics; the choice of which depends on the patient's age and the most likely pathogen. In previously healthy children under the age of 5 years, amoxicillin 80 to 90 mg/kg/day divided into two to three daily doses; maximum 3 g/day) is the treatment of choice because it is effective against the majority of pathogens which cause community-acquired pneumonia in this age group [1].

High dose amoxicillin is chosen because of the possibility of resistant *S. pneumoniae*; the resistance of which can be overcome at higher drug concentrations . For those with type 1 (immediate, anaphylactic-type) hypersensitivity to penicillin, clindamycin , azithromycin, clarithromycin , and levofloxacin are reasonable alternatives . For children with a non-type 1 hypersensitivity to penicillin, cephalosporins such as cefixime , cefprozil , cefdinir, cefpodoxime , and cefuroxime should be considered [20].

In previously healthy children over the age of 5 years, macrolides such as azithromycin and clarithromycin are the drugs of choice given that in addition to *S. pneumoniae*, *M. pneumoniae*, and *C. pneumonia* are common pathogens in children in this age group . In communities with a high rate of pneumococcal resistance to penicillin, levofloxacin , moxifloxacin , and linezolid should be considered [21].

The usual duration of antimicrobial therapy is 5 days for azithromycin and 7 to 10 days for other antimicrobial agents in patients with uncomplicated community acquired pneumonia . The duration of treatment is considerably longer in those patients with severe pneumonia caused by virulent pathogens, notably methicillin-resistant *S. aureus* (MRSA), and those patients with complications [1]

Symptomatic therapy includes antipyretic and analgesic medications such as acetaminophen/paracetamol and ibuprofen and maintenance of adequate hydration [21]

Inpatient treatment :

Hospital care :

The mainstay of hospital treatment is supportive management. This may involve:

- oxygen therapy if pulse oximetry reveals oxygen saturations lower than 92%.
- Intravenous fluids may be indicated when the child is struggling to maintain oral input due to breathlessness and fatigue, to prevent dehydration.
- Nasogastric tubes, although useful for providing hydration in many scenarios, should be avoided where possible in smaller children as they can cause further breathing compromise by obstructing the smaller nasal passages.
- With the use of intravenous fluids comes the risk of electrolyte imbalance, made more pronounced in pneumonia by the potential development of the syndrome of inappropriate anti-diuretic hormone (SIADH). Therefore, electrolyte and sodium monitoring are required to prevent hyponatremia in instances where prolonged intravenous fluids are administered [12].
- Chest physiotherapy is not felt to be beneficial in children with uncomplicated pneumonia. Chest physiotherapy may potentially prolong fever duration and exacerbate breathing difficulties and is not recommended as part of management for children with pneumonia by the British Thoracic Society. Chest physiotherapy,
- Along with the use of mucolytic agents, continues to play a role in airway clearance in some children with complex needs who may struggle to independently clear secretions. In addition, where acute airway collapse is secondary to mucoid secretions causing plugging in the bronchi, assisted airway clearance will again be an important part of the management strategy[22]

Children hospitalized with influenza pneumonia should be treated with an antiviral agent such as oseltamivir, zanamivir , amantadine , or rimantadine as soon as possible . Unless one is certain that the cause of pneumonia is viral and uncomplicated by secondary bacterial infection, treatment of inpatients with pneumonia is empirical and often requires the use of antibiotics [23]

Parenteral antibiotics are indicated when oral fluid/medication cannot be tolerated or if there are signs of septicemia or complications .

Ampicillin (150 to 200mg/kg/day divided into 4 doses; maximum, 12 g/day), cefotaxime (150 mg/kg/day divided into 3 doses; maximum, 10g/day), and ceftriaxone (50 to 100 mg/kg divided into 2 doses, maximum, 4 g/day)

are the drugs of choice . Ampicillin is usually given intravenously while cefotaxime and ceftriaxone can be given either intravenously or intramuscularly.[1]

The parenteral route can be transitioned to the oral route after the patient has become afebrile for 24 to 48 hours and is able to tolerate oral medication . A macrolide such as azithromycin or clarithromycin may be added if *M. pneumoniae* or

C. pneumonia is suspected. Levofloxacin and moxifloxacin are reasonable alternatives for the older child or adolescent with suspected atypical pneumonia who may actually have pneumococcal pneumonia . Vancomycin or clindamycin should be used if MRSA is a consideration . Once a pathogen has been identified, antibiotic therapy can be adjusted to target the specific pathogen[24]

Micronutrients

Vitamin A is effective for measles-associated pneumonia. Given as an adjunct to the treatment of severe pneumonia in children, zinc significantly reduces mortality. There is no evidence for the use of other micronutrients in the treatment of acute pneumonia in well-nourished children. However, nutritional support including vitamins and zinc should be given in malnourished children [25] .

Prevention

Breastfeeding should be encouraged since breastfeeding has been shown to confer some protection to community acquired pneumonia especially in the first year of life [26] .

Vaccines play a critical role in the prevention of community- acquired pneumonia. The use of the 13-valent conjugate pneumococcal vaccine in children younger than 2 years of age plus the use of the 23-valent polysaccharide pneumococcal vaccine for children older than 2 years of age who have certain underlying conditions (e.g., immunodeficiency, asplenia, chronic heart disease, chronic lung disease) have resulted in a significant reduction in the incidence of community- acquired pneumonia attributable to the pneumococcal vaccine serotypes [27] .

Conclusion:

Childhood pneumonia is a clinically severe disease results from a complex interaction of host and environmental risk factors , a major risk factor is congenital heart diseases. they are common causes of recurrent pneumonia and hospitalization and lead to sever pulmonary complications, so good management of such cases is mandatory .

References

1. Schauner, S., Erickson, C., Fadare, K., & Stephens, K. (2013). Community-acquired pneumonia in children: a look at the IDSA guidelines. *The Journal of family practice*, *62*(1), 9–15.
2. WHO I (2014) Revised WHO classifcation and treatment of pneumonia in children at health facilities: evidence summaries. World Health Organiza- tion, Geneva
3. El Seify MY et al (2016) Microbial etiology of community-acquired pneumonia among infants and children admitted to the pediatric hospital, Ain Shams University. Eur J Microbiol Immunol (bp) 6(3):206–214
4. Healy, F., Hanna, B. D., & Zinman, R. (2012). Pulmonary complications of congenital heart disease. *Paediatric respiratory reviews*, *13*(1), 10-15.
5. Jackson, S., Mathews, K. H., Pulanic, D., Falconer, R., Rudan, I., Campbell, H., & Nair, H. (2013). Risk factors for severe acute lower respiratory infections in children: a systematic review and meta-analysis. *Croatian medical journal*, *54*(2), 110–121.
6. Angeles Marcos M et al (2006) The role of viruses in the aetiology of commu- nity-acquired pneumonia in adults. Antivir Ther 11(3):351–359
7. Ye Z et al (2020) Chest CT manifestations of new coronavirus disease 2019 (COVID-19): a pictorial review. Eur Radiol 30(8):4381–4389
8. Qin Q, Shen KL (2015) Community-acquired pneumonia and its complications. Indian J Pediatr 82(8):745–751
9. Hussien, S. M., Hamed, T., Mohamed, M. H. A., Rashad, M. M., Elnady, H. G., Metwally, H. M. S. E. D., ... & Sarhan, D. T. (2023). Diagnosis, treatment, and prevention of community-acquired pneumonia in children: an evidence-based clinical practice guideline adapted for the use in Egypt using 'Adapted ADAPTE'. *Bulletin of the National Research Centre*, *47*(1), 169.
10. Yadav, K. K. & Awasthi, S. 2023. Childhood Pneumonia: What's Unchanged, and What's New? *Indian J Pediatr,* 90, 693-9.
11. Atkinson, M., Yanney, M., Stephenson, T., & Smyth, A. (2007). Effective treatment strategies for paediatric community-acquired pneumonia. *Expert opinion on pharmacotherapy*, *8*(8), 1091–1101.
12. Oliwa, J. N. & Marais, B. J. 2017. Vaccines to prevent pneumonia in children - a developing country perspective. *Paediatr Respir Rev,* 22, 23-30.
13. Davidson, K. R., Ha, D. M., Schwarz, M. I. & Chan, E. D. 2020. Bronchoalveolar lavage as a diagnostic procedure: a review of known cellular and molecular findings in various lung diseases. *J Thorac Dis,* 12, 4991-5019.
14. Harris, M., Clark, J., Coote, N., Fletcher, P., Harnden, A., McKean, M., et al. 2011. British Thoracic Society guidelines for the management of community acquired pneumonia in children: update 2011. *Thorax*, 66 Suppl 2, ii1-23.

15. Crame, E., Shields, M. D. & McCrossan, P. 2021. Paediatric pneumonia: a guide to diagnosis, investigation and treatment. *Paediatr Child Health,* 31, 250-7.
16. Bradley, J. S., Byington, C. L., Shah, S. S., Alverson, B., Carter, E. R., Harrison, C., Kaplan, S. L., Mace, S. E., McCracken, G. H., Jr, Moore, M. R., St Peter, S. D., Stockwell, J. A., Swanson, J. T., & Pediatric Infectious Diseases Society and the Infectious Diseases Society of America (2011). The management of community-acquired pneumonia in infants and children older than 3 months of age: clinical practice guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America*, *53*(7), e25–e76.
17. Orloff, K. E., Turner, D. A. & Rehder, K. J. 2019. The Current State of Pediatric Acute Respiratory Distress Syndrome. *Pediatr Allergy Immunol Pulmonol,* 32, 35-44.
18. Kelly MS, Sandora TJ. community-acquired pneumonia. In: Kliegman RM, Stanton BM, St. Geme J, Schor NF, Behrman RE, eds. Nelson Textbook of Pediatrics, 20th edition. Philadelphia: Elsevier Saunders, 2015, pp2088-94..
19. Cardinale, F., Cappiello, A. R., Mastrototaro, M. F., Pignatelli, M., & Esposito, S. (2013). Community-acquired pneumonia in children. *Early human development*, *89 Suppl 3*, S49–S52.
20. Hazir, T., Fox, L. M., Nisar, Y. B., Fox, M. P., Ashraf, Y. P., MacLeod, W. B., Ramzan, A., Maqbool, S., Masood, T., Hussain, W., Murtaza, A., Khawar, N., Tariq, P., Asghar, R., Simon, J. L., Thea, D. M., Qazi, S. A., & New Outpatient Short-Course Home Oral Therapy for Severe Pneumonia Study Group (2008). Ambulatory short-course high-dose oral amoxicillin for treatment of severe pneumonia in children: a randomised equivalency trial. *Lancet (London, England)*, *371*(9606), 49–56.
21. Chee, E., Huang, K., Haggie, S., & Britton, P. N. (2022). Systematic review of clinical practice guidelines on the management of community acquired pneumonia in children. *Paediatric respiratory reviews*, *42*, 59–68.
22. Chaves, G. S., Freitas, D. A., Santino, T. A., Nogueira, P. A. M., Fregonezi, G. A. & Mendonça, K. M. 2019. Chest physiotherapy for pneumonia in children. *Cochrane Database Syst Rev,* 1, Cd010277.
23. Wilder R. A. (2011). Question 1 Are oral antibiotics as efficacious as intravenous antibiotics for the treatment of community acquired pneumonia?. *Archives of disease in childhood*, *96*(1), 103–104.
24. Tramper-Stranders G. A. (2018). Childhood community-acquired pneumonia: A review of etiology- and antimicrobial treatment studies. *Paediatric respiratory reviews*, *26*, 41–48.
25. Das, R. R., Singh, M. & Naik, S. S. 2018. Vitamin D as an adjunct to antibiotics for the treatment of acute childhood pneumonia. *Cochrane Database Syst Rev,* 7, Cd011597.
26. Leung, A. K., & Sauve, R. S. (2005). Breast is best for babies. *Journal of the National Medical Association*, *97*(7), 1010–1019.
27. Hasegawa, J., Mori, M., Ohnishi, H., Tsugawa, T., Hori, T., Yoto, Y., & Tsutsumi, H. (2017). Pneumococcal vaccination reduces the risk of community-acquired pneumonia in children. *Pediatrics international : official journal of the Japan Pediatric Society*, *59*(3), 316–320.