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A comprehensive guide for managing antibiotic therapy in pediatric pneumonia

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Abstract

Pneumonia is a respiratory infection characterized by inflammation of the alveolar space and interstitial tissue of the lungs. Pneumonia has numerous potential etiologies, the most common of which is infectious and is classified according to several factors. Pneumonia is most transmitted via aspiration of airborne pathogens but may also result from the aspiration of stomach contents. The most likely causal pathogens can be narrowed down based on the patient's age, immune status, and where the infection was acquired. Pathogens that commonly affect the pediatric population often differ from those seen in adults. Typical pneumonia manifests with, fever, sudden onset of malaise, and a productive cough. On auscultation, crackles and bronchial breath sounds are audible. Atypical pneumonia manifests with the gradual onset of unproductive cough, dyspnea, and extrapulmonary manifestations. Diagnosis is based on history and exam. In some cases, supportive information is obtained through lab investigations and imaging reports. Management consists of empiric antibiotic treatment and supportive measures.

Keywords: Pneumonia; Pediatrics; Etiologic Agents; Antibiotic Use; Management

1. Introduction

Pneumonia, the most serious disease of acute lower respiratory infection, is the main cause of death in children under the age of five outside of the neonatal period. Pneumonia was first described by Hippocrates (460– 370 BC). The first descriptions of its clinical and pathological features were made 22 centuries later in 1819 by Laennec while Rokitansky in 1842 was the first to differentiate lobar and bronchopneumonia. During the next 47 years at least 28 terms were used to identify pneumonia [1]. Pneumonia accounts for 14% of all deaths of children under 5 years old, killing 740 180 children in 2019[2].

The term "pneumonia" refers to a lower respiratory tract infection (LRTI) that is often accompanied by a fever, respiratory symptoms, and physical or radiographic signs of parenchymal involvement. In terms of pathology, it reflects an inflammatory condition affecting the lungs' connective tissue, visceral pleura, airways, and alveoli. According to radiology, pneumonia is identified as an infiltrate on a child's chest radiograph who has signs of an acute respiratory disease.

2. Definition

The World Health Organization (WHO) defines "pneumonia" in children as the presence of cough or difficulty breathing associated with fast breathing or chest indrawing in children 2–59 months of age, whereas "severe pneumonia" is

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defined as pneumonia plus an inability to drink, persistent vomiting, convulsions, lethargy, stridor, or severe malnutrition [3].

It is generally well-recognized that pathogens that frequently affect children are different from those that affect adults. In routine clinical practice, a microbiological diagnosis is often not made, because current tests are insensitive. Etiology varies with geographical location, but approximately half of cases are viral [4]. Due to the lack of quick, reliable, commercially available laboratory tests for the majority of infections, determining the cause of pneumonia in children can be challenging. Thus, empirical therapy is the common course in most cases [5]. the initial diagnosis of pneumonia is usually based on clinical suspicion, which may be confirmed with characteristic radiological and possibly laboratory features. Not all features are present in any one child, and the emphasis on individual features may vary with age and likely etiology [6].

Clinical characteristics distinguish typical pneumonia from atypical pneumonia; each type has its spectrum of associated pathogens. The typical presentation of pneumonia is the sudden onset of malaise, fever, and productive cough. As a result of atypical pneumonia, a person may experience a gradual onset of coughing without producing any mucus, dyspnea, and extrapulmonary manifestations [7].

3. Age-Related Causative Organisms of Pneumonia

Considered across all age groups, pneumococcus is the most common bacterial cause of pediatric pneumonia, accounting for about 60% of cases. In close second place are viruses, which include respiratory syncytial virus (RSV), adenovirus, influenza, parainfluenza, enteric cytopathic human orphan (ECHO) virus, and coxsackie virus [8].

3.1. In Newborn

The three microorganisms Group B Streptococcus, Escherichia coli, and Listeria monocytogenes are most frequently encountered in early-onset newborn pneumonia, which appears during the first three days of life [9]. *Streptococcus pneumoniae*, Staphylococcus aureus, and Streptococcus pyogenes are the most ubiquitous pathogens in late-onset neonatal pneumonia, which expresses between the third day of life and the third week of life. Adenovirus, parainfluenza, influenza, and enteroviruses are also typically observed in this condition [10].

Chlamydia trachomatis is a concern, particularly in infants who develop a staccato cough and tachypnea, whether they both have conjunctivitis or a known history of maternal chlamydia. Staccato cough is described as short, loud coughing bouts that are commonly linked with croup and chlamydial pneumonia [11].

3.1.1. Three Weeks to Six Months

Viruses are the most prevalent pathogen in this age range, followed by bacteria including Chlamydia trachomatis, Bordetella pertussis, and *Streptococcus pneumoniae*. Herpes simplex virus (HSV), enterovirus, influenza, and RSV are some of the viral etiologies. Of these, HSV is the most concerning and frequent viral pneumonia in the first few days of infancy [12].

3.1.2. Six Months to 5 Years

The most common cause of pneumonia in children between the ages of a half year and five years old remains the same viruses, including RSV, flu types A and B, parainfluenza, and human metapneumovirus. *Streptococcus pneumoniae*, Staphylococcus aureus, Haemophilus influenzae, and less frequently, aberrant microscopic organisms such as Mycoplasma pneumoniae and Chlamydia pneumoniae are among the more infrequent bacterial causes [13].

3.2. Above 5 Years

Atypical bacteria are still more common in children over the age of five and cause diffuse pneumonia, while *Streptococcus pneumoniae* is the main cause of consolidated pneumonia [14].

3.3. Special Circumstances

Pseudomonas aeruginosa or fungi could be the cause of pneumonia in the intubated, intensive-care patient with central lines (Candida) [15].

Infants and children with reoccurring pneumonia and gastrointestinal problems should be evaluated for cystic fibrosis. Possible infections in a patient with chronic lung disease (cystic fibrosis) include pseudomonas and aspergillus [16].

Youngsters who have voyaged or had contact with a debilitated individual and have side effects that have continued for half a month ought to be associated with having tuberculosis [17].

Children who have been in contact with farm animals may acquire Q fever, which is brought on by Coxiella burnetii [18]. Patients can contract Coxiella Brunetti via sick sheep or cattle, while Histoplasma capsulatum can be acquired through spelunking or working on a farm east of the Rocky Mountains [19].

When a patient has pneumonia and common skin changes, the varicella-zoster infection should be suspected; the cytomegalovirus (CMV) should also be considered if retinitis is present [20]. considering that the patient has been exposed to stagnant water, Legionella pneumophila [21].

Hantavirus pneumonia in children may develop if they meet mouse droppings [22]. Chlamydia psittaci pneumonia can affect children who are receptive to birds like parrots and pigeons [23]. If a patient has aggressive asthma or a characteristic "fungal ball" on a chest radiograph, they may have aspergillus [24]. Children with White blood cell deficiencies and people from certain geographic areas frequently have parasite pneumonia comparable to coccidioidomycosis, histoplasmosis, and blastomycosis [25].

4. Types of Pneumonia

Using the American Thoracic Society's system of classification of pneumonia,

4.1. Community-Acquired Pneumonia (Cap)

This type has been developed in a setting outside of a hospital [26].

4.2. Hospital-Acquired Pneumonia

Pneumonia acquired in a hospital or other inpatient facility within 48 hours of admission and not developing at the time of hospitalization is referred to as "hospital-acquired pneumonia" (HAP). The terms "hospital-acquired pneumonia" and "pneumonia connected with healthcare". All pneumonia now belongs to the category of community-acquired pneumonia and therefore must occur in a hospital environment to be classified as HAP. This includes pneumonia acquired in the setting of assisted-living residences, rehabilitation centers, and other healthcare facilities [27].

4.3. Ventilator-Associated Pneumonia

VAP is recognized as any pneumonia that develops 48 hours following endotracheal intubation [28].

These classifications have made it quicker to determine the typical pathogens which induce each type of pneumonia and to construct treatment protocols for effective management in both in-patient and out-patient settings [29].

4.4. According to the Pattern of Involvement

Pneumonia has also been addressed historically as:

- Single lung lobe involvement in focal non-segmental or lobar pneumonia.
- Multifocal bronchopneumonia or lobular pneumonia
- Interstitial pneumonia, focal or diffuse [30].

4.5. Walking Pneumonia

Table 1 Risk Factors

S.no	Risk factors
1.	Environmental Risk Factors, Including Second-hand Smoke, Congested Areas, And Exposure to Airway Irritants
2.	Neuromuscular Disorders
3.	Altered Mental Status
4.	Impaired Airway Protection

5.	Anatomic Abnormalities of The Airway or Lungs
6.	Dysphagia

The phrase "walking pneumonia" is often applied to school-aged children and young people who have radiographic and clinical indications of pneumonia but have minor respiratory symptoms that do not disrupt daily activities. Usually, Mycoplasma pneumoniae has been named as the pathogen thought to oversee walking pneumonia [31].

5. Pathophysiology

To make it impossible for pathogens to enter the lower airways and alveoli, the upper respiratory tract was created. Therefore, an imbalance between the pathogen and host components is necessary for infection to develop. The physique, toughness, and immune competency of the host are compared to the virulence and size of the pathogen's inoculum. Many of the physical changes brought on by aging can lessen the flexibility and ventilatory capacity of the lungs, and an aging immune system is less effective. Cigarette smoke exposure in utero and during infancy has been associated with increased pneumonia in children [32].

Since they have already managed to get beyond the host's physical defenses, any infectious organisms that make it to the alveoli are likely to be extremely virulent. Because of this, they might overwhelm the macrophages, which are white blood cells that serve as the immune system's initial line of defense and can identify foreign objects or creatures. If this occurs, an inflammatory reaction develops, leading to a fibrin-rich exudate that fills the diseased and surrounding alveolar spaces, causing them to adhere to one another and become airless. Neutrophils multiply because of the inflammatory reaction. Fibrosis and pulmonary edema, which also limit lung expansion, can harm lung tissue and cause damage [33].

Up to 40% of cases of pneumonia are likely to become complicated by the pleural effusion that might result from the inflammatory response [33]. Reduced gas exchange is the outcome of these alterations, and the effects will vary depending on how much lung tissue is affected and how well the person's lungs are already functioning. Not only is there a deficiency in oxygen reaching the essential organs, but the change in normal physiology will also cause each breath to require more respiratory effort. Falling oxygen levels and rising carbon dioxide will cause an increase in breathing and heart rate [34].

6. Clinical manifestations

The age of the patient and the severity of the illness have an impact on the clinical presentation [35]. Fever is not always present. In newborn pneumonia, there may be some temperature instability. Tachypnea, which is a relatively sensitive sign of pneumonia, is a process that the pneumonia stage that may yield minimal findings, or it may present with increased labor of breathing indicated as nasal flaring, accessory muscle use, or pneumonia [36].

There may be accompanying symptoms including fatigue, nausea, emesis, headaches, or abdominal pain. Clinically, reduced or irregular breathing might be a sign of pneumonia (rales or wheezing). Particularly with newborns, a chest exam may be equivalent. By noticing localized decreased breath sounds or rubs, pneumonia complications (pleural effusion) can be diagnosed [37]. Fever, poor feeding, lethargic behavior, and even apnea are common symptoms of pneumonia in newborns and young children. Children who've been older typically have a cough, fever, and tachypnea. Pleuritic chest discomfort, which would be pain that becomes worse with inspiration, can be due to an infection that is adjacent to the pleural surface [38].[39].

7. Symptoms based on pathogen

The pathogen can have a modest impact on the symptoms. Therefore, symptoms in individuals with bacterial pneumonia typically appear rapidly, are much worse, and don't usually have included the upper airways [40]. On the other hand, viral pneumonia typically has milder symptoms and a more gradual onset [41]. Pneumonia triggered by uncommon bacteria is in the middle. These are typically focused bronchial breath sounds or crackles in bacterial pneumonia, whereas viral and atypical pneumonia exhibit diffuse, bilateral auscultatory abnormalities. Additionally, viral, and atypical pneumonia are the most common causes of wheezing [42].

8. Severity of symptoms

A chest X-ray is not typically performed when pneumonia only causes minor symptoms [43].

A temperature of 38.5°C or higher, moderate to severe respiratory distress, or hypoxemia with oxygen saturation below 90% are all considered symptoms of severe pneumonia [44]. It's also regarded as serious when an infant has trouble eating or when older kids are dehydrated.

An x-ray of the chest should be taken in cases of severe pneumonia. Furthermore, a chest x-ray usually reveals either a diffuse, interstitial infiltration or a lobar consolidation [45].

The severity of pneumonia cannot be accurately predicted by respiratory rate. Tachypnoea indicates that a youngster with a cough may also have moderate pneumonia if there is no chest indrawing. Respiratory rate is a very poor indicator of the severity of pneumonia in a child with chest tightness since children with very severe pneumonia frequently have sluggish, labored breathing [46].

9. Typical/atypical pneumonia

9.1. Typical pneumonia

Rapid onset of symptoms caused by lobar infiltration is a hallmark of typical pneumonia [47].

- High fever
- Chills
- Severe malaise
- Productive cough with purulent discharge
- Chest pain [pain radiating to the abdomen and epigastric region].
- Chest pain while breathing [pleuritic chest pain].
- Tactile fremitus
- Dullness to percussion
- Use of accessory muscles to breathe
- Decreased breath sounds
- Hypoxia

9.2. Atypical pneumonia

Extrapulmonary symptoms are a classic symptom of atypical pneumonia, and it often has an indolent course (delayed onset) [48].

- Non-productive cough [dry cough].
- Extrapulmonary symptoms,
- Headache
- Sore throat
- Fatigue
- myalgia

Since it is not always possible to discriminate between typical and atypical pneumonia, this classification does not substantially impact patient care [49].

10. Children with pneumonia and respiratory distress criteria

10.1. Tachypnoea

- Ages 0–2 months: > 60 breaths/min
- Ages 2–12 months: > 50 breaths/min
- Ages 1–5 years: > 40 breaths/min
- Ages > 5 years: > 20 breaths/min

Dyspnea

Nasal flaring

Pulse oximetry < 90%

Apnoea

Retractions (use of accessory muscles)

Grunting

Altered mental status [50].

11. Early/ late onset pneumonia

Early-onset pneumonia develops within the first week of life and results from perinatal pathogen exposure, either intrauterine or during passage through the birth canal [51][52].

Late-onset pneumonia (including ventilator-associated pneumonia; VAP): develops after the first week of life from environmental, often nosocomial, pathogen exposure [51][53].

11.1. Diagnosis

Imaging may be used to confirm or clarify a diagnosis based on a patient's medical history and physical examination. Most methods and recommendations that direct empirical treatment is based on research on bacterial pneumonia from the 1980s, making the diagnosis of pneumonia extremely challenging [54].

11.1.1. Laboratory Results

The patients with elevated WBC (>15.0 109/l) or elevated ESR (>30 mm/h) had pneumonia caused by either bacteria or viruses [55]. Children with a low risk of pneumonia could be identified by clinical symptoms accompanied by inflammatory markers. Pneumonia risk was reduced in children with negative clinical symptoms and low CRP. Since a high CRP level (greater than 100 mg/l) does offer strong specificity for bacterial pneumonia but a low CRP level does not exclude it, several studies have employed a CRP level that is too low [56].

11.1.2. Microbiological studies

To manage pneumonia in children, effective studies are still needed, either to identify the etiologic agent and begin the right antibiotic treatment sooner and use fewer antibiotic courses or to determine the prognosis of the illness [57]. Blood culture, sputum culture, serology for atypical bacteria (Mycoplasma spp. and Chlamydia spp.), pneumococcal antigen detection/PCR, and culture of pleural fluid where samples are available are examples of routine microbiological tests for bacterial etiology of CAP. Blood cultures have a small part in CAP diagnoses. Only 9.89% of blood cultures collected from hospitalized children with severe CAP are positive, according to a new meta-analysis, with high false-positive rates [58].

11.1.3. Radiologic findings

Although many guidelines only call for imaging to diagnose pneumonia in ambiguous or hospitalized cases, consolidation, and interstitial patterns, which can be seen on chest radiography or lung ultrasonography, are distinguishing characteristics of pneumonia. For instance, the Pediatric Infectious Diseases Society advises against using chest radiography for community-acquired pneumonia unless the child is hypoxemic, experiencing respiratory distress, has failed initial treatment, or is hospitalized. Moment-in-time imaging with lung ultrasound offers the ability to allay worries about radiation exposure and expense that have hampered imaging in the past [59].

Although doing a CXR has no impact on the outcome in mild, uncomplicated disease, it is necessary for conclusive confirmation (and exclusion) of pneumonia, determining the degree of disease, and identifying fluid. On an x-ray, lobar pneumonia, which characterizes normal pneumonia, typically contrasts with interstitial pneumonia, which characterizes atypical pneumonia.

In cases of LRTI, radiographic results may be minimal, nonexistent, or delayed relative to clinical symptoms, particularly in dehydrated patients. Pleural effusion and the development of an abscess are possible findings that are more consistent with a bacterial infection. Pneumococcal or staphylococcal pneumonia, perihilar lymphadenopathy, or single

or multilobar consolidation (mycobacterial pneumonia). Alternately, an interstitial pattern (mycoplasmal pneumonia) and air trapping with a flattened diaphragm may predominate (viral pneumonia with bronchospasm) [60].

11.1.4. Pneumonia Severity Index

The PSI was developed to help with the identification of CAP patients who would need ambulatory (outpatient) or hospitalized (inpatient) care. Additionally, the PSI may understate the severity of CAP because it was designed to identify patients with low mortality risks [61].A severity-of-illness score is generated by the PSI prognostic model based on 20 distinct patient factors (demographic, clinical, and laboratory), including underlying comorbidities.

The patients are divided into 5 classes (I-V) or categories based on their overall score and the likelihood of death within 30 days. Patients in Classes I through III have mild CAP (low chance of death, between 0.1% and 2.8%); Classes IV have intermediate risk (risk of death, between 8.2% and 9.3%); and Classes V have a high risk (risk of death, between 27 and 31%). Except in cases of hypoxemia (PaO2 60 mm Hg or O2 Sat 90%), outpatient treatment is advised for Classes I through II, observation in short-stay units is advised for Classes III, and hospitalization is advised for Classes IV through V [62].

Australian academics came up with the idea for the SMART COP scale. The S in its name stands for systemic arterial pressure, the M for multilobar involvement on radiography, the A for albumin, the R for respiratory rate, the T for tachycardia, the C for confusion (abnormal mental state), the O for oxygenation, and the P for arterial ph. There is no disputing the importance attached to the results that were shown to be prevalent, including arterial pressure, oxygen saturation, arterial pH, and radiographic evidence of involvement [63].

The British Thoracic Society recommends CURB-65. the CURB65 is an acronym for Confusion, Urea (urea >7 mml/l), Respiratory rate (RR ≥30), Blood pressure (diastolic BP ≤60 mm Hg or systolic BP [64].

11.1.5. Pediatric community-acquired pneumonia hospitalization requirements

Children assessed for CAP in the ED do not typically respond well to traditionally detected biomarkers, such as CRP and procalcitonin, in terms of forecasting the severity of their disease [65]. child hospitalization criteria may include groaning or apnea,92% oxygen saturation, a respiratory rate of more than 70 breaths per minute, inadequate nourishment, advanced age Grunting, having trouble maintaining oral intake, and breathing more than 50 times per minute.

11.2. Approach to pediatric pneumonia

11.2.1. General management of children with uncomplicated pneumonia

It's critical to provide adequate analgesia. Coughing and deep inhalation are hindered by pleuritic discomfort. Referred stomach pain and headache are two other forms of discomfort.

Usually, simple analgesia is enough to keep children at ease. Ibuprofen has been linked in two studies to an increased risk of empyema in the future, although these results are likely since children with empyema are typically sicker than kids with the uncomplicated disease. When the oxygen saturation goes below 92%, more oxygen should be administered.

In little infants, nasal cannulae or a headbox can be necessary. Children who have pneumonia are more likely to become dehydrated because of increased, irreversible water loss and insufficient fluid intake. More physiologically sound than intravenous (IV) fluids are the maintenance of enteral intake using either a nasogastric (NG) tube or regular small-volume meals.

It is unknown whether the obstruction and reduced airflow caused by NG tube implantation have any real clinical importance. Acute pneumonia does not benefit from physical therapy. It makes the patient uncomfortable, does nothing to help the accumulation resolve, and may lengthen the duration of the fever [66].

It's generally accepted that some children deserve supportive care [67].

11.3. management

Two more factors, in addition to the selection of antibiotic therapy, are crucial in the management of pediatric pneumonia:

11.3.1. Outpatient Versus Inpatient Care

Age, level of respiratory distress, oxygen needs, toxic appearance, family's ability to care for the youngster, ability to feed and hydrate, inability to respond to prior outpatient treatment, underlying disease, and whether it is a case of recurrent pneumonia should all be considered when deciding whether to hospitalize a child with pneumonia. The availability of medications allowing for outpatient therapy will also have an impact on this choice [68].

11.3.2. Oral Versus Parenteral Therapy

Early consideration of oral antibiotics and shorter treatment times as opposed to IV medications. Intravenous penicillin administration over a period of several days has been the most popular method of treating severe pneumonia. However, this necessitates the use of specialized medical personnel to provide injections, which are uncomfortable for kids and upsetting for their parents and is presumably more expensive than utilizing oral medication. Currently, the evidence from a thorough search reveals that there is no appreciable difference in the management of severe pneumonia in children under the age of five between oral and parenteral antibiotic therapy. According to the current data, parenteral treatments and oral antibiotic treatment plans could both be equally beneficial in treating this group of young patients [69].

Managing pneumonia involves deciding if the child needs to be treated as an outpatient, an inpatient, or an intensive care unit patient. At least initially, the use of antibiotics that target common, typical bacterial respiratory infections is recommended to lower the morbidity and perhaps even death of pneumonia in hospitalized children [70].

According to recommendations, early-onset infections should get monotherapy with narrow-spectrum antibiotics, and late-onset infections should receive broad-spectrum therapy [71].

When empirical treatment is narrow spectrum compared to broad-spectrum medication, clinical outcomes and expenses for children hospitalized with CAP are not different [72].

11.4. ICU admission

Antibiotic therapy typically lasts between 7 and 10 days in straightforward situations and up to four weeks in complex ones.

If pneumonia necessitates ICU hospitalization, typically begin IV vancomycin in addition to IV azithromycin, IV ceftriaxone, or IV cefotaxime [73].

Methicillin-resistant When compared to infections brought on by nonresistant strains of Staphylococcus aureus, MRSA infections constitute a significant contributor to both hospital-onset and community-onset pneumonia [74]. To treat methicillin-resistant Staphylococcus aureus or MRSA, severe pneumonia is finally treated with either IV ceftriaxone or cefotaxime in combination with either clindamycin or vancomycin.

The child is typically given IV antibiotics for the first few days, up until the point at which the youngster has been afebrile for one or two days and can handle oral food.

11.5. Inpatient care

Having a serious illness or a mild illness but being less than three to six months of age, having complications from pneumonia such as a lung abscess or a pleural effusion, and having underlying disorders like cardiac disease or immunodeficiency are all reasons for receiving inpatient care. severe pneumonia was a factor in most pediatric hospitals and post-discharge mortality, frequently in children with underlying comorbidities [75].

If none of these are present, the child is treated as an outpatient, and if there is no improvement after three days, the child is often treated as an inpatient.

Direct admission to the ICU was advised if a child's respiration rate surpassed 80–90 breaths per minute and apnoea was anticipated because of exhaustion, or if intubation was performed in the emergency room as a life-saving treatment [76].

The requirement for mechanical ventilation or noninvasive positive pressure ventilation in children, as well as a cardiovascular impairment that is resistant to intravenous fluids, all point to the necessity for treatment in an intensive care unit.

Choose antibiotics for empiric treatment.

Since there is significant overlap in the clinical symptoms present at the presentation, organ involvement, and empiric treatment regimens, the World Health Organization does not distinguish between newborn pneumonia and other severe forms of sepsis, such as bacteremia. Treatment for early-onset neonatal pneumonia, which affects newborns within the first three days of life, involves administering IV ampicillin and gentamicin [77].

A combination of IV vancomycin and an aminoglycoside is used to treat late-onset neonatal pneumonia, which affects newborns between the ages of four days and three weeks. Vancomycin has been administered to children at a dose of 15 mg/kg per dose, by the British National Formulary's recommendations [78].

Ceftriaxone or cefotaxime is infused intravenously into infants between the ages of 3 weeks and 6 months. Ceftaroline has minimal pediatric expertise, and it was a rather unusual option. It may play a significant role in the focused therapy of extremely difficult-to-treat pneumococcal and staphylococcal infections [79].

They are likely infected with Chlamydia trachomatis and can be treated with oral erythromycin in a non-hospital setting. The American Academy of Pediatrics updated its advice for asymptomatic newborns exposed to C trachomatis; the previous advice called for a 14-day course of oral erythromycin prophylaxis [80].

Moving on, inpatient treatment for moderate pneumonia after 6 months often entails IV ampicillin, IV cefotaxime, or IV ceftriaxone. Patients with pneumonia have frequently received ceftriaxone, either by themselves or in conjunction with other medications [81]. Treatment for severe pneumonia involves administering IV ceftriaxone or cefotaxime together with one of the following antibiotics: azithromycin, erythromycin, or doxycycline.

In empirical therapy for community-acquired pneumonia, for patients who, at the doctor's discretion, need initial treatment as inpatients, gatifloxacin as monotherapy (initially IV then orally until completion of treatment) is effective and safe, comparable to ceftriaxone IV alone or in combination with a macrolide (initially IV then orally until completion of treatment) [82].

WHO created standardized case management guidelines (IMCI), which suggest that children with severe pneumonia, which is determined by the presence of lower chest wall indrawing (LCI), be admitted to a hospital and treated with parenteral antibiotics (penicillin G or ampicillin) (World Health Organization 2005a). This will help decrease child mortality from pneumonia and rationalize antibiotic treatment [83].

11.6. Out patient

High-dose oral amoxicillin is used as an outpatient treatment for children aged 6 months to 5 years. but the first-line treatments for inpatients are ampicillin, aqueous penicillin G, or amoxicillin (first provided intravenously) [84]. High-dose oral amoxicillin, on the other hand, should be administered if typical bacterial pneumonia is suspected

When a child is more than five years old, a macrolide like an erythromycin, azithromycin, or clarithromycin is administered. The medication of choice for hospitalized patients who require parenteral therapy for CAP is cefuroxime, often known as penicillin G [benzylpenicillin]. If M. pneumoniae or C. pneumoniae infection is suspected, macrolides should be taken concurrently [85]. Except for azithromycin, which is administered for just five days throughout treatment, the typical duration is 7 to 10 days.

11.7. Based on age

The most frequent bacteria that cause CAP is *Streptococcus pneumoniae* [86]. Because H. influenzae is present and some strains of S. pneumoniae are resistant to penicillin, procaine penicillin is not a suitable medication for patients under the age of five. The young child and infant must therefore get parenteral treatment with B-lactamase-stable antibiotics.

Most recommendations call for taking antibiotics for 7–10 days (except azithromycin, which has a recommended treatment duration of 5 days). If there is no progress after two days, therapy needs to be reevaluated.

11.8. Based on causes

If HSV is detected, acyclovir is a crucial factor to take into account. Mycoplasma and common bacteria are the targets of antibiotics in this age group of those older than 5 years (pneumococcus). Cephalosporins (ceftriaxone or cefuroxime) and macrolides (azithromycin) are two possible treatments [87].

Broad-spectrum antibiotics, such as ampicillin plus cefotaxime or gentamicin, are typically administered to newborns with pneumonia. Viral pneumonia in the first few days of infancy caused by HSV is the most dangerous and common. Ribavirin therapy has been shown in numerous clinical trials to enhance clinical outcomes in kids with RSV-related LRI[23].

Children who had *M pneumoniae* or *C pneumoniae* infections and were given macrolide or azalide antibiotic treatment did not appear to have a better prognosis [88].

12. Discharge criteria

Children who exhibit any of the following after being hospitalized for pneumonia are eligible for discharge:

- A clinical improvement in appetite and activity level, as well as a prolonged drop in fever.
- Continuous pulse oximetry readings of 90% or higher in room air for a minimum of 12 to 24 hours [89].

12.1. Follow-up

To ensure continuing recovery and adherence to the prescribed antibiotic course, pediatric patients hospitalized with pneumonia must follow up with their primary care physician shortly after discharge. It is crucial to explain to caregivers that a cough may linger for several weeks to four months following a CAP and for three to four months following viral pneumonia or pertussis. Children in recovery may experience mild dyspnea for another two to three months when they exert themselves.

The categories include a better understanding of the causes of both severe and non-severe pediatric pneumonia, employing the best diagnostic testing, a better understanding of treatment failure causes, determining the most systematic technique for first-level healthcare personnel to assess treatment failure, and selection of antibiotics to enhance patient outcomes [90].

12.2. Complications and failure to improve

Persistent pyrexia or failure to improve by 48 h after admission reflects various possibilities including resistant pathogen; ineffective antibiotic regime (inappropriate antibiotic or dose); lung complication like empyema or abscess; unresponsiveness to treatment due to immunosuppression or coexistent disease such as cystic fibrosis. Re-evaluation is necessary and further investigations may be needed including a chest radiograph, ultrasound of the chest to assess the amount of fluid if present, and CT scan of the chest if a lung abscess is suspected.

12.3. Complications

Parapneumonic pleural effusion develops in about 40% of patients with bacterial CAP admitted to the hospital. If present and the patient remains pyrexial, empyema may be developing, and pleural fluid should be drained.

Lung abscess is a rare complication in children and prolonged antibiotic treatment is required until the fever settles.

Metastatic infection can occur rarely including septic arthritis, osteomyelitis, septicemia, and meningitis.

Pneumatoceles and subsequent pneumothorax can occur especially with S. aureus pneumonia. The long-term outlook for these is good with normal lung function.

Mycoplasma can involve virtually any body system including the heart, brain, liver, meninges, spine, joints, bone, and pancreas, and can cause hemolytic anemia and severe rash [91].

Recommendations for Management of Community-Acquired Pneumonia

It is paramount to consider the management as the first/alternative and second lines, which will fit into management at primary, secondary, and tertiary levels.

12.4. A stepwise approach to management is preferred:

In children with a history of fever, cough, and/or difficulty breathing

- **Step 1**: Count the respiratory rate for one full minute when the child is awake and calm, or asleep. If the breathing is fast, consider as pneumonia.
- **Step 2**: Look for evidence of increased work of breathing (difficult breathing): in-drawing of the lower chest wall when the child breathes in and nasal flaring
- **Step 3**: Check for cyanosis (bluish discoloration) by looking at the tongue and buccal mucosa. observe the oxygen saturation using a pulse oximeter.
- **Step 4**: Palpate for the position of the trachea
- **Step 5:** Percuss the chest for dullness, or hyper resonance
- **Step 6**: Auscultate for bronchial breath sounds, crepitations, or rhonchi.
- **Step 7**: Look for complications such as heart failure (tachycardia, tender hepatomegaly), pleural effusion (stony dull percussion note, reduced/absent breath sound over the region of either or both chest regions), pneumothorax (hyper-resonance and reduced/absent breath sound over the upper and lateral region of the involved lung field).
- **Step 8**: observe the signs of other organ involvement. Ask to determine if convulsion, lethargy, inability to drink or feed, or not responding to calls is present. The presence of these features or any of the complications listed above indicates severe pneumonia.
- **Step 9**: Classify the severity of pneumonia
- **Step 10**: Decide who needs hospitalization.

12.5. Criteria for management in the hospital are

- Age less than 2 months
- Severe pneumonia
- Presence of complications or co-morbidities
- SpO2 90% or less in room air.
- Step 11: Decide on relevant investigations:
  - Chest radiography is NOT required in children with pneumonia to be managed as an outpatient
  - Do chest radiography in children with pneumonia needing hospitalization, more so in those children suspected of having complications such as parapneumonic effusion (pleural effusion, empyema) or pneumothorax
  - Routine full blood count is NOT required for children suspected of having pneumonia to be managed in the outpatient
  - A full blood count should be obtained for all children with severe pneumonia or sick enough to be hospitalized.
  - Because malaria is a common co-morbidity in this environment, screen for malaria parasite
  - Blood culture should be obtained in sick children requiring hospitalization Serum electrolytes, urea and creatinine, and random blood sugar should be obtained in children with severe pneumonia

12.6. Other supportive measures

- Clear the airway using gentle suction as needed, always mouth before nose
- Give supplemental oxygen if oxygen saturation is 90% or less, in-room air, or signs of severe respiratory distress are present. If pulse oximetry is not available give oxygen if signs of respiratory distress and or cyanosis are present.
- Give oxygen via nasal prongs or nasal catheters: 0.5 -1L/min for children 0-2months, 2-3L/min for children 3 months to 5 years; maximum of 4L/min for older children)
- Allow small frequent feeds/fluids if tolerated; feeding may also be done using an appropriate-size nasogastric tube
- If feeds are not tolerated give intravenous isotonic fluid. Ensure it contains at least 5% glucose (e.g., 5% dextrose in 0.9% saline or ringer's lactate with added glucose)
- For high-grade fever (temperature ≥39oC), give paracetamol 10-15mg/kg 4-6 hourly, and ibuprofen if required.
- If widespread rhonchi are present (high-pitch continuous sound during expiration only or during both phases of respiration) give the first dose of short-acting bronchodilators such as salbutamol or Albuterol and re-assess
- Nursing care should be provided at least every 3 hours: check vital signs including oxygen saturation
- The doctor should review the child at least twice daily [92].

Drugs to Refrain from Using When Managing Pneumonia cough syrups with opioids or antihistamines such as codeine and hydro codeine, as they are only slightly the treatment of pneumonia and might be harmful to some children

12.7. Prevention

Immunizations against the two most common bacterial causes of pediatric pneumonia deaths, Haemophilus influenzae type b (Hib) and by averting roughly 1075000 child deaths annually, *Streptococcus pneumoniae* (pneumococcus) can further increase child survival year.

When it comes to preventing radiologically confirmed pneumococcal and Hib infections, conjugate vaccines are both safe and efficacious [93].

Pneumonia among children, especially in developing and low-income nations. WHO suggests both for inclusion in national programs and, at steeply tier-pricing, these vaccines typically fulfill international standards of cost-effectiveness for low-income individual countries. To supplement vaccines, which only target specific pneumonia bacteria and are only partially effective, treatment and further preventive measures [94].

13. Conclusion

Pneumonia, the most serious disease of acute lower respiratory infection, is the main cause of death in children under the age of five outside of the neonatal period. Pneumonia is a lung infection that can be acute or persistent. Alveoli or the fluid being injected into them may have an inflammatory issue. It is frequently caused by bacteria, fungi, and viruses, as well as sporadically by harmful chemicals and physical agents. It frequently exhibits respiratory problems, chest tightness, fever, sputum production, coughing, and breathing difficulties. Common pneumonia in infants is brought on by group B streptococcus and E. coli. Viruses and other common causes, such as the rotavirus (RSV), respiratory syncytial mycoplasma, chlamydia, and others, are found in children between the ages of four weeks and eighteen. Managing pneumonia involves deciding if the child needs to be treated as an outpatient, an inpatient, or an intensive care unit patient.

Teaching high-risk patients, prevention education can play a significant role in reducing the spread of pneumonia. Tobacco use should be discouraged, as should contacting those who have active infections, hand washing, maintaining a healthy diet, getting enough sleep, and drinking enough fluids. And continue to be active.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

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