

Indicators of severity in Pediatric pneumonia: A review article**Khaled A. Abdelbaseer^a, Mohammed H. Hassan^b, Gehad M. Ahmeda^{*}, Hala M. Sakhr^a**^aDepartment of Pediatrics, Faculty of Medicine, South Valley University, Qena, Egypt.^bDepartment of Medical Biochemistry, Faculty of Medicine, South Valley University, Qena, Egypt.**Abstract**

Background: Pneumonia and other lower respiratory tract infections are the most leading causes of death worldwide. Pneumonia is common and is associated with significant morbidity and mortality between children. Good and early diagnosis is a very important factor to avoid severe complications and drawbacks, and proper management of patients is vital in the prognosis of pneumonia. Although in the developed world the diagnosis depends mainly on the radiographic findings, but the World Health Organization has classified and defined pneumonia subjected to the clinical findings found by visual inspection and on the timing of the respiratory rate.

Objectives: The aim of this review: is to evaluate the indicators of pneumonia severity in children under-five years of age.

Conclusion: Pneumonia in children is related to significant morbidity and mortality; however, data are limited in predicting which children will have negative outcomes, including clinical deterioration, severe disease, or development of complications.

Keywords: Pneumonia, Pediatric, Severity.

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Introduction

The definition of “pneumonia” in children according to World Health Organization (WHO) is the presence of difficulty breathing and cough accompanying with faster breathing, but “severe pneumonia” had different criteria as it is defined as usual pneumonia plus the incapability to drink, severe vomiting, fatigue, and convulsions or severe undernourishment (World Health Organization, 2014).

Pneumonia is a serious infection in the lung which may be caused by virus, bacteria, or fungi (Jo et al., 2012). streptococcus pneumonia and mycoplasma pneumonia are the most common causes of bacterial pneumonia mainly in school-aged children. While viral pneumonia is mostly caused by influenza and respiratory syncytial virus, particularly in younger children (Shrestha et al., 2019).

The incidence of pneumonia varies by age groups and between developing and developed countries and is considered the most infectious cause of death worldwide among children. In 2015, pneumonia killed about 920,136 children under the age of 5 that represents about 15% of all under 5 years old children's death (Hoang et al., 2019).

pneumonia in children under the age of 5 years is mostly presenting with cough and/or difficult breathing, with or without fever, also could be presented by the presence of either fast breathing or lower chest wall indrawing where their chest retracts during inhalation (During inhalation in a healthy person, the chest expands). Infants who are severely ill also may be presenting with unable to eat or drink and may suffer from unconsciousness, hypothermia, and convulsions (UNICEF, 2017).

Pneumonia severity indicators

1. Clinical factors

1.1- Age

According to the instructions of The Pediatric Infectious Diseases Society (PIDS) and the Infectious Diseases Society of America (IDSA), children under one year and young children are exposed to high risk for severe illness (Sonego et al., 2015).

If we looked at the developed countries, infants have increased odds of serious illness compared with those of 2-year-olds, especially for pneumonia (adjusted odds ratio, 1.37; 95% confidence interval, 1.14–1.61). regarding the hospitalized children due to pneumonia in the poor countries, infants below six months were the highest group age had treatment failure among the children from 3 to 59 months, but those below 4 months had the highest mortality rates among all groups (Dean and Florin, 2018).

1.2- Hypoxemia

According to the guidelines obtained from the PIDS and IDSA, we find that severely ill children who need a fraction of inspired oxygen (FiO₂) more than 0.50 to keep an oxygen saturation more than 92%, in real need for intensive care unit (ICU) plus regular cardiorespiratory monitoring to maintain live. Moreover, hypoxemia is one of the Pediatric Early Warning Score (PEWS), which is a confirmed general early threatening score to predict how in need for ICU care among children. The relationship between hypoxemia and bad outcomes is established and confirmed but, the exact levels for describing hypoxemia are inconstant (British Thoracic Society (BTS) consider hypoxemia when oxygen saturation <92%, while PIDS/IDSA <90%) (Bradley et al., 2011).

Frequent researches in the poor world confirm a strong relationship between hypoxemia and increased mortality rates regarding childhood pneumonia. In the developed countries, incremental oxygen requirements are considered the most factor to determine the time for hospitalized children due to community-acquired pneumonia (CAP) to become clinically stable (**Karunaratne et al., 2020**).

1.3- Tachypnea

Tachypnea is a very important indicator of pneumonia severity as it is included in the definition of pneumonia by WHO, the severity criteria of PIDS/IDSA, and in the Pediatric Early Warning Score (PEWS). In poor countries, WHO considered tachypnea is one of the signs of increasing mortality (**World Health Organization, 2019**). Regarding the developed countries, tachypnea-for-age is not considered a warning sign in infants but presented higher associations with increasing age (**Williams et al., 2016**).

Considering tachypnea one of the indicators of severity has many restrictions, containing a relationship with acidosis, fever, variation of measuring breathing rate by physicians and variation in respiratory rates according to different age groups (**World Health Organization, 2014**).

1.4- Dyspnea

Dyspnea is represented with many signs during patient Check, consist of additional muscle contraction, nasal flaring, retractions, and grunting. Williams et al showed that chest indrawing was in relation to bad results in their studied groups of children (**Williams et al., 2016**). Similar results were obtained from Reed et al as they showed that in infants below one year who had lower respiratory tract infections and were hospitalized for that reason, chest indrawing was an

independent sign of increasing mortality rates in South Africa (**Reed et al., 2012**).

1.5- Tachycardia

The causes of tachycardia vary from one to one it may be due to stress, increasing body temperature, loss of body fluids, and severe illness processes. The PIDS/IDSA recommended that hospitalization and ICU admission with persistent vital signs monitoring is very important in cases with sustained tachycardia. There was a lack in data about specifically investigating tachycardia in children suffering from pneumonia (**Dean and Florin, 2018**).

1.6- Altered mental status

Altered mental status in children with community-acquired pneumonia (CAP) is due to many causes, it may be due to high-grade fever, sepsis, severe dehydration. It is one of the WHO criteria. AMS was one of the factors associated with serious outcomes in the Williams et al study (**Williams et al., 2016**).

1.7- Dehydration and Decreased Perfusion

In poor countries, clinical dehydration in association with poor nourishment in children suffering from pneumonia admitted to the ICU was associated with higher mortality rates. The Delay in the capillary refill is a sign that dehydration has progressed to decreased perfusion (**Fritz et al., 2019**).

1.8 -Hypotension

Hypotension is an important factor of uncompensated septic shock (**Dean and Florin, 2018**). There were not enough data about hypotension definitely in pediatric pneumonia. **Williams et al., 2016** showed that systolic blood pressure less than the 5th percentile-for-age was not an indicator for serious results (aOR, 0.95–1.15). Some studies revealed that in poor countries, there no association between hypotension and severity of CAP in children; but, **Araya**

et al., 2016 showed a strong association between mean arterial pressure more than 2 and increasing mortality rates in children admitted to hospital with pneumonia.

2. Laboratory markers

2.1-Complete Blood Count

Leukocytosis if presented alone is considered a poor predictor of severity of pneumonia; moreover, Araya et al showed that leukopenia less than 4000 was associated with increased mortality rates. For evaluation of the severe complications of CAP mainly hemolytic-uremic syndrome (HUS), The PIDS/IDS instructs that complete blood count must be done. (Fernandes et al., 2019).

2.2- Inflammatory markers

C-reactive protein (CRP) resulting in acute phase reactant which occurs in last or severe stages of the disease in bacterial infections in pediatric; but, their no studies confirmed relations between C-reactive protein and CAP severity (Florin et al., 2020).

2.3- Electrolytes

Many researches showing that there was a relation between hyponatremia and the severity of CAP in pediatrics, but there were many limitations to confirm that. In an Indian study, hyponatremia was found to be associated with length of admission in ICU, severity, and increasing mortality rates (Florin et al., 2020).

2.4- D-dimer

During the stage of catabolization of fibrin by plasmin, D-dimer (DD) is produced as a metabolic substance. D-dimer levels have been increased in patients with sicknesses that activate fibrin production and catabolization; one of them is pulmonary emboli (PE), deep vein thrombosis (DVT). A few studies have examined the association between community-acquired pneumonia and plasma levels of DD. A number of

researches recommend that increasing levels of D-dimer is strongly and directly with relation to the extra and intra-vascular coagulation that happens in acute and chronic lung destruction in community-acquired pneumonia patients (Arslan et al., 2010).

2.5- Acidosis

Araya et al., 2016, found that $\text{HCO}_3^- < 15$ was associated with mortality (OR, 26.7; 95% CI, 13–54). Moreover Wang et al., 2013 showed that there was no association between metabolic acidosis and mortality rates in children hospitalized with pneumonia.

2.6- Bacteremia

Regarding developed nations, uncommon to see bacteremia in childhood pneumonia, with rates <1% for outpatients, 2.5% for hospitalized children, and 13% for complicated pneumonia. Although blood cultures upon admission are recommended by the PIDS/IDSA guideline, the major of organisms which isolated from blood cultures in children hospitalized due to pneumonia were found to be very sensitive to a penicillin (Shah et al., 2011).

Bacteremia in childhood pneumonia has been associated with hypoxemia, LOS, and complications including empyema and effusions; but, data are inadequate for more strict measures (Heine et al., 2013).

3. Radiographic factors

Although there was a common use of chest radiographs (CXR), there were many limitations of their truth and usefulness, and the clinical state of the patient like the status of hydration, the extent of atelectasis, and time of management may affect interpretation (Williams et al., 2013).

International single-center researches propose that different anatomic sites are linked with the degree of community-acquired pneumonia severity

in children (upper lobes, left lung, unilateral or bilateral, localized, or spread). These studies evaluated the degree of severity based on length of stay in ICU, duration of symptoms, and status of hydration and did not take into consideration more severe markers (McClain et al., 2014).

Recently, studies in the poor and developed world (including well-powered prospective multicenter studies) have shown multilobar infiltrates are associated

with severe outcomes including ICU admission, mechanical ventilation, vasoactive medications, and death (Grafakou et al., 2004).

Conclusion

Community-acquired pneumonia in pediatric is related to a significant increase in mortality and morbidity; but, data are inadequate in predicting which one of the children will have negative outcomes, including clinical deterioration, severe disease, or development of complications.

➤ Summary of the most significant clinical Indicators of severity in Pediatric pneumonia:

Parameters	Significant	Reference
1. Age	When age under one year or younger the severity of illness increased.	(Sonego et al., 2015). (Dean and Florin, 2018).
2. Hypoxemia:	Mostly when oxygen saturation less than <92%	(Bradley et al., 2011).
3. Tachypnea:	WHO considered tachypnea is one of the signs of increasing mortality	(World Health Organization, 2019)
4. Altered mental status(AMS):	AMS was one of the factors associated with bad prognosis of sever pneumonia.	(Williams et al., 2016).
5. Dehydration and Decreased Perfusion:	Clinical dehydration in children suffering from pneumonia admitted to the ICU was associated with higher mortality rates.	(Fritz et al., 2019).

➤ Summary of the most significant laboratory Indicators of severity in Pediatric pneumonia:

Parameters	Significant	Reference
1) Complete Blood Count:	Leukocytosis and leukopenia less than 4000 was associated with increased mortality rates of pneumonia.	(Fernandes et al., 2019).
2) D-dimer:	There was strong association between severity of pneumonia and increased plasma levels of D-Dimer.	(Arslan et al., 2010).
3) Electrolytes:	Many researches showing that there was a relation between hyponatremia and the severity of CAP in pediatrics.	(Florin et al., 2020).
4) Bacteremia:	Bacteremia in childhood pneumonia has been associated with hypoxemia, LOS, and complications including empyema and effusion.	(Shah et al., 2011). (Heine et al., 2013).

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