

Role of Chest X-ray, Inflammatory Markers and Blood Gases for Diagnosis and Assessment of Severity in Childhood Pneumonia: A Cross-sectional Study

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ABSTRACT

Introduction: Pneumonia is one of the leading causes of morbidity and mortality in under-five children. The utility of simple clinical signs forms the basis of early diagnosis and treating children with pneumonia. Inflammatory markers along with chest X-rays further help to differentiate between viral and bacterial causes and also help in the assessment of the severity of infections.

Aim: To find out the clinical spectrum, haematological and radiological parameters of the children admitted with Community-Acquired Pneumonia (CAP) and to relate the findings with the disease severities.

Materials and Methods: The present study was an observational, cross-sectional study done for the period of one year i.e. from July 2017 to June 2018 in the Department of Paediatrics, of RG Kar Medical College, Kolkata, West Bengal, India. A total of 100 children aged less than five years, suffering from severe and very severe pneumonia according to World Health Organisation (WHO) definition. They underwent a complete physical examination. Routine radiological and haematological investigations were done. The children were managed using a standard protocol. They were closely followed-up for the need for change in antibiotics, prolonged hospital stay, need for mechanical ventilation, and mortality. All data were collected

and subjected to statistical analysis with the help of Statistical Package for the Social Sciences (SPSS) Software (version 17.0). A p-value <0.05 was considered to be statistically significant.

Results: Out of 100 children, bronchopneumonia (72%) was the most common clinical diagnosis made at admission. Hurried breathing, cough, and fever were presenting features in most of the cases. According to WHO, the Acute Respiratory Infection (ARI) control program, 62% had severe pneumonia and 38% had very severe pneumonia. On investigation, radiological findings had high sensitivity and specificity to clinical findings. Inflammatory markers {C-Reactive Protein (CRP) >15.7 mg/dL and Erythrocyte Sedimentation Rate (ESR) >20 mm/hr} were a good tool for diagnosing the disease severity. Raised CRP was also associated with multiple antibiotics use and prolonged hospital stay. Increased platelet count >2.45 lacs, decreased pH, and increased PCO₂ at the time of admission were associated with the requirement for increased ventilatory support in the children. The median duration of hospital stay was 8 (6) days.

Conclusion: Bronchopneumonia is the predominant form of ARI in infants and toddler age group. Inflammatory markers provide valuable information regarding disease severity. Chest X-ray is important in the diagnosis of pneumonia and evaluation of the treatment response.

Keywords: Community-acquired pneumonia, Haematology, Radiology, Risk factors

INTRODUCTION

The CAP can be clinically defined as the presence of signs and symptoms of pneumonia in a previously healthy child due to an acute infection (<14 days duration) of the lower respiratory tract leading to a cough or difficult breathing, tachypnoea or lower chest wall retraction which has been acquired in the community outside the hospital [1]. It is very common in the developing world, estimated at 0.28 episodes per child per year and accounting for 95% of all cases [2]. According to a report published in 2010, 18% of the total 8.8 million global deaths among those under five years, pneumonia is one of the leading causes of morbidity and mortality [3]. Clinical and radiological features do not reliably distinguish between viral and bacterial aetiology. Obtaining cultures from the lower respiratory tract of a young child is tricky. More specific but invasive investigations such as pleural aspiration are infrequently needed. However, it is important to focus on the easily available test and clinical examinations to identify the children who are at increased risk of adversities.

Hypoxaemia with oxygen saturation <95% in room air is a key indicator for hospital admission. Level of CRP may not be useful in differentiating the bacterial aetiology from that of the viral but it can

guide in the management [4]. Various other inflammatory markers like platelet count, ESR, and Arterial Blood Gas (ABG) parameters (PaO₂ <60 mm Hg and with low or normal PaCO₂) on admission have marked prognostic clues on the disease sequences and condition [5-7]. Chest X-ray on the other hand has been considered the gold standard for the diagnosis of childhood pneumonia. It can roughly differentiate between a viral and bacterial aetiology and hence guide us regarding the choice of therapy [8].

Though, there were few previous studies in this context regarding the various laboratory parameters and their predictive skills in the patterns and severity of pneumonia separately, in present study authors have tried to interpret the clinical spectrum, haematological, and radiological parameters simultaneously to diagnose and assess the severity of children admitted with CAP.

MATERIALS AND METHODS

The present study was an observational cross-sectional study carried out after approval from Institute Ethics Committee (IEC) (registration no- ECR/322/inst/WB/2013), on under five years children, admitted to RG Kar Medical College, a tertiary care hospital in eastern India with severe and very severe pneumonia for the period of one year

i.e. from July 2017 to June 2018. According to the WHO case definition of ARI, very severe disease is a condition only found in <two-month-old where pneumonia is associated with convulsions, unconsciousness, stridor, poor feeding, etc., and severe pneumonia is the presence of increased respiratory rate and severe chest in drawing in children of zero months-five years [9].

Inclusion criteria: Severe or very severe pneumonia in children <5 years of age were included in the study.

Exclusion criteria: Children having congenital defects of the heart and lungs, cleft lip and cleft palate, foreign body aspiration, immunocompromised states were excluded from the study.

Sample size: Assuming a large population (one million) with an incidence of severe pneumonia of 6.8% [10], and a 95% of confidence level, the estimated sample size was 98, but 100 children were taken as study population.

Procedures

Detailed history regarding the onset, progress, and duration of the disease were recorded. A complete clinical examination of each child was carried out. Microbiological tests consisting of blood culture and inflammatory markers and biochemical analysis of blood samples comprising blood electrolytes were done. Chest radiography was taken at the time of admission. Most patients were started with 1st line antibiotics. Those who had severe respiratory failure were given ventilator support. ABG analysis with a special interest in PaO₂, PaCO₂, and pH at the time of admission was done. Those with type 1 respiratory failure were shifted to Paediatric Intensive Care Unit (PICU). Factors influencing the need for ventilation and time on ventilation were studied with special interest.

STATISTICAL ANALYSIS

All data were collected, compiled, and subjected to statistical analysis with the help of SPSS software (version 17.0). Categorical variables were compared in two groups with the help of the Chi-square test and continuous variables with t-test. Receiver Operating Characteristic (ROC) curve and the criterion value was estimated depending on the sensitivity and specificity. The Area Under the Curve (AUC) was measured for measuring diagnostic performances of the molecular inflammatory markers. A p-value <0.05 was considered statistically significant.

RESULTS

Out of the total 100 children, 59 were male and 41 were female with slight male preponderance (M:F=1.439:1), 58% of the study population was within infantile (<1 year) age group. Of 100 total population, 38 children suffered from very severe disease while 62 suffered from severe pneumonia.

Fast breathing was present in 100 (100%) children, followed by fever in 90 (90%) patients. Poor feeding and grunting were found mainly in infants. Increased respiratory rate (90%) and chest retractions (96%) were commonest clinical findings [Table/Fig-1]. The mean±SD duration of fever was found to be marginally more in very severe

Symptoms (n)	<1 y (%)	1-2 y (%)	>2 y (%)
Cough (83)	51 (61.44)	15 (18.07)	17 (20.48)
Fever (90)	48 (58.33)	19 (21.11)	23 (25.55)
Fast breathing (100)	58 (58)	19 (19)	23 (23)
Poor feed (38)	34 (89.47)	4 (10.52)	0
Convulsion (35)	33 (94.28)	2 (5.71)	0
Grunting (28)	28 (100)	0	0
Chest pain (4)	4 (100)	0	0

[Table/Fig-1]: Clinical features of pneumonia in study population.

pneumonia (6.27±1.75 days) than severe pneumonia (6.02±1.96 days) and duration of cough showed the same trend- 7.18±2.17 days in very severe pneumonia versus 7.70±1.58 days in severe pneumonia without any statistical significance.

Clinical features and radiological findings: Most common clinical diagnosis was bronchopneumonia (72%), followed by lobar pneumonia (16%), pleural effusion and empyema (10%) and pneumothorax (2%). The common radiological findings were bilateral patchy opacity (47%), lobar consolidation (15%), diffuse air space consolidation (25%), pneumothorax with consolidation (2%) and pleural effusion with consolidation (10%). Clinical findings showed tachypnoea and chest retraction and crepitations had high sensitivity but ronchi and decreased breath sound had a high specificity with radiological (chest skiagram) findings [Table/Fig-2].

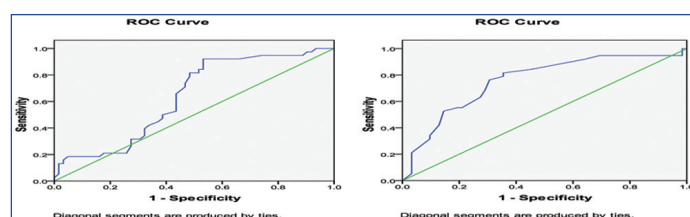
Symptoms	Positive Radiological findings	Negative Radiological findings	Total	Sensitivity (%)	Specificity (%)
Tachypnoea	94	6	100	97.67	57.14
Chest retractions	90	6	96	98.90	33.33
Crepitations	66	09	75	98.51	72.73
Ronchi	37	01	38	80.43	98.15
Decreased breath sounds	22	0	22	68.75	100

[Table/Fig-2]: Validity of radiological features with clinical findings in pneumonia.

Laboratory features and severity of disease: A raised CRP level (>15.7 mg/dL) and ESR (> 20 mm/hr) were found in those suffering from very severe disease [Table/Fig-3,4].

CRP	Very severe pneumonia	Severe pneumonia	Sensitivity (SN), Specificity (SP), Area under curve (AUC)
>15.7 mg/dL	31	29	SN- 81.6% SP- 53.2% AUC- 0.63
<15.7 mg/dL	07	33	
ESR			
>20 mm/hr	30	21	SN- 78.95% SP- 66.13 % AUC- 0.77
<20 mm/hr	8	41	

[Table/Fig-3]: Validity of CRP and ESR in relation to severity of disease.



[Table/Fig-4]: ROC curve for CRP and ESR respectively.

Most children (84%) had responded to the first line of antibiotics (amoxycylav+gentamicin). An 81% children discharged with oral antibiotics. Raised CRP (>15.7 mg/dL) was found to be associated with multiple antibiotic use (p-value=0.032). Raised CRP was also found to be associated with prolonged hospital stay (r=0.82, p-value=0.023).

There was a significant association (p-value=0.048) between disease severity and presence of other associated illness in the form of septicaemia, meningitis and diarrhoea in children. Case fatality was 10%, of which eight (80%) children was of infantile age group. About 90% of the children with pneumonia were discharged with median (IQR) period hospital stay of 8 (6) days.

ABG analysis was done initially to those who were shifted to PICU. Twelve children needed ventilatory support in the PICU. Of the various parameters during the ventilator use, pH (p-value=0.017), PaCO₂ (p-value=0.003) and platelet count (p-value=0.001) had been found to be statistically significant with their disease course.

DISCUSSION

Pneumonia continues to pose a threat to children in developed and developing countries despite improvements in socio-economic status, immunisation, early diagnosis and treatment. [11] Age is an important predictor of mortality and morbidity in paediatric pneumonia. In the present study conducted between the age group of two months to five years majority (58%) were less than one year. This was in line with the studies done by Sehgal V et al., in their study 52.2% population was in infantile age group [12]. In present study, it was observed that males outnumbered the females. Similar inference was drawn by previous studies also [11,13].

Tachypnoea has been found to be a sensitive and specific indicator of pneumonia. Also, the traditional method of making a clinical diagnosis of pneumonia has been by the auscultatory signs, in particular crepitations, in a child with cough. In present study, tachypnoea (94%) and chest retraction (90%) were the important signs for making clinical diagnosis of pneumonia. Fever, crepitations and rhonchi were other associated signs. Margolis P and Gadomski A had similar inference in their studies [14].

In present study, pneumonia was associated with diarrhoea (8% cases), meningitis (5%) and septicaemia (5%). Deivanayagam N et al., observed that risk factors for death in pneumonia were associated with illness {OR=22.2, p-value <0.001} [15].

Although clinical symptoms and signs are helpful indicators of the presence of disease, radiographic investigation is often used to confirm a clinical diagnosis and to sort out whether extensive work up is necessary. In present study, chest X-ray was consistent with pneumonia in most of the cases. Clinical symptoms and signs help the clinicians to determine the need for chest radiography. In present study, clinical data with radiological findings were compared and found that tachypnoea and chest retraction and crepitations had a high sensitivity and crepitations, ronchi and decreased breath sound had a high specificity with chest skiagram findings. In a study conducted by Zukin DD et al., it was found that the sign with the highest positive predictive value for pneumonia was tachypnoea, crepitations and abnormal breath sounds [16]. A recent study by Hassen M et al., showed that children with fever had more radiological abnormalities (p-value=0.033) [17].

Management of pneumonia includes supportive care and antibiotics. As definitive information about causative pathogens is seldom available, treatment of pneumonia is most often empiric. In present study all patients received antibiotics. Majority (84%) responded to first line antibiotics (amoxycylav+gentamicin). Rest required second line drugs consisting of ceftriaxone, vancomycin and azithromycin. Increased CRP level showed significant relation (p-value=0.032) with the need for multiple antibiotic use. Raised CRP, was also found to be associated with prolonged hospital stay ($r=0.824$, p-value=0.023). Twelve children needed ventilator support. Increased platelet count (>2.5 lacs) at the time of PICU admission showed a predilection for the need of assisted ventilation. In a study by Mirsaedi M et al., they had shown abnormal thrombocyte count <1 L and >4 L was associated with 30 days mortality [18]. A study by Baruah A and Paul N also showed a significant relationship between abnormal platelet count and complications (p-value <0.001). Thrombocytosis was related to respiratory complications and thrombopenia was related to systemic complications and mortality in patients with CAP [19].

The present study also showed the marked importance of ABG analysis of the children who needed PICU care. Rising PCO_2 level and falling pH level showed statistical significance with the need for mechanical ventilatory support. A similar study conducted by Almeida-Júnior AA et al., in 2005 had shown these two parameters had significant bearing with the ventilator stay of the patients [20].

Case fatality rate was 10%, out of which five had died within 24 hours of presentation in the hospital indicating the disease severity with causality associated with it.

During the past few years biomarkers have emerged as an indispensable tool in the diagnosis of pneumonia. To find an ideal diagnostic biomarker is not an easy task perhaps. Ongoing research is being done in this field. Procalcitonin and soluble triggering receptor expressed on myeloid cells-1 have emerged as reliable diagnostic markers as compared to CRP, ESR and platelet count [21]. Although inflammatory markers like CRP, ESR, platelet count are not specific, but are proved to be important in a resource-limited setting like ours, in providing insights into the disease course.

Limitation(s)

This was a cross-sectional study. Factors that influence the occurrence of the disease in the community could not be explored. Further research needs to be done on the biomarkers.

CONCLUSION(S)

CAP continues to be a looming danger in childhood. Although diagnosed clinically, radiological investigations are necessary, not only to confirm the clinical findings, but also for the management of the disease. Inflammatory makers may not help establish the aetiological organisms but they give valuable information regarding disease severity, the number of antibiotics to be needed, and also about the treatment time in terms of hospital stay. ABG picture at the time of PICU admission also throws light on the need for ventilatory support.

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