

Characteristics of Radiographically Diagnosed Pneumonia in Under-5 Children in Salvador, Brazil

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Objective: To assess the association of demographic and clinical aspects with radiographically diagnosed pneumonia.

Design: By active surveillance, the admitted pneumonia cases by the pediatrician on duty were identified in a 2-year period. Demographic, clinical and radiographic data were registered into standardized forms.

Setting: A public university pediatric hospital in Salvador, Northeast Brazil.

Patients: Children <5 years-old.

Main outcome measures: Radiographically diagnosed pneumonia based on detection of pulmonary infiltrate/consolidation.

Results: 301 cases had the chest X-ray evaluated by a pediatric radiologist blinded to clinical information, among whom pulmonary infiltrate and consolidation were described in 161 (54%) and 119 (40%), respectively. Chest X-ray was read normal for 140 cases. Overall, the median age was 17 months (mean 20±14, range 12 days-

59 months). Pulmonary infiltrate was less frequently described among patients aged under 1 year (41.3% vs 59.9%, $P=0.002$, OR [95%CI] = 0.47 [0.29–0.76]) and hyperinflation was significantly more frequent in this age group (27.9% vs 4.1%, $P<0.001$, OR [95%CI] = 9.14 [4.0–20.9]). By multiple logistic regression, fever on admission was independently associated with pulmonary infiltrate (OR [95%CI] = 1.68 [1.03–2.73]) or consolidation (1.79 [1.10–2.92]), wheezing was independently associated with absence of pulmonary infiltrate (0.53 [0.33–0.86]) or of consolidation (0.53 [0.33–0.87]). The positive likelihood ratio of fever on examination for pulmonary infiltrate and consolidation was 1.49 (95%CI: 1.11–1.98) and 1.49 (95%CI: 1.14–1.94), respectively.

Conclusion: Presence of fever enhanced 2.5 times the chance of children hospitalized with lower respiratory tract disease to have radiographically diagnosed pneumonia.

Key words: Acute respiratory infection, Brazil, Children, Pneumonia, Respiratory distress, Wheezing.

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Acute respiratory infection (ARI) is the most common cause of illness in children, and community-acquired pneumonia (CAP) is the most serious ARI [1]. The accurate diagnosis of CAP is an important clinical issue even though it remains difficult [2]. Evaluation of suspected CAP is a frequent indication for imaging in children because findings on physical examination are less reliable in children than in adults. Auscultation and percussion are often harder to elucidate and evaluate, especially in infants [3]. The roles of imaging in these children

are multiple: confirmation or exclusion of pneumonia, exclusion of other causes of symptoms, evaluation of cases that fail to resolve, and evaluation of related complications [2]. Nonetheless, obtaining a chest X-ray (CXR) is not always feasible [4]. Therefore, it is of practical usefulness to identify simply recognized characteristics associated with CAP. Our aim was to assess the association of demographic and clinical aspects defined *a priori*, that is age ≥ 1 year, female gender, report of cough, fever and difficulty breathing, complete refusal of liquids, detection of fever, tachypnoea, chest

indrawing, somnolence, nasal flaring, cyanosis, reduced pulmonary sounds, wheezing and crackles, with radiographically diagnosed CAP.

METHODS

From March 2006 to February 2008, we attempted to identify the CAP cases among the patients aged less than five years admitted to the Professor Hosannah de Oliveira Pediatric Center, in Salvador, North-East Brazil. Demographic and clinical data were registered into a standardized form by the assistant pediatrician during health assistance and all CXR were evaluated by the same radiologist who was blinded to clinical information. CXR was done because of presence of respiratory complaints or fever on the report from the caregiver, added to the clinical suspicion of CAP on the evaluation by the assistant pediatrician based on lower respiratory tract findings on physical examination. Pneumonia was radiographically defined as presence of pulmonary infiltrate or consolidation. Pulmonary infiltrate was defined as linear and patchy densities (interstitial) or dense and fluffy opacity with or without air-bronchogram (alveolar) out of the hilar area. Consolidation was defined as alveolar infiltrate that occupies a portion or whole of a lobe or of the entire lung, and atelectasis as a dense streak on the film that radiates outward from the hilum [5]. Axillary temperature was measured by trained nurses before the medical examination and it was registered on the medical chart. Whenever fever was detected, the pediatrician repeated the temperature measurement before prescribing anti-pyretics. Fever was defined as axillary temperature $>37.5^{\circ}\text{C}$ [6] and tachypnea as respiratory rate ≥ 60 breaths/min in children aged less than 2 months, ≥ 50 breaths/min in children aged 2-11 months and ≥ 40 breaths/min in children as of 12 months of age [1].

Nutritional evaluation was performed by using the software Anthro, version 1.02 (Center for Disease Control and Prevention, and World Health Organization) and severe malnutrition was defined as Z-score for weight-for-age index under -3.00 by using the National Centre for Health Statistics standard [7]. Statistical analyses were performed by using Statistical Package for the Social Sciences 9.0 and STATA 9.0. Differences in proportions were

assessed by the Pearson Chi Square test or Fisher's exact test as appropriate and in continuous variable by the Student t test or Mann-Whitney U test as appropriate. Bivariate and multivariate analyses, using logistic regression models, were performed to identify associations between demographic/clinical aspects and radiographically diagnosed CAP. The positive likelihood ratio (LR) was estimated. The 95% confidence intervals (CI) were calculated. Informed consent was obtained from the patient's guardian and the study was approved by the Ethics Committee of the Federal University of Bahia.

RESULTS

Out of 34,533 patients seen at the Emergency Room due to various complaints, 321 (0.9%) were admitted because of suspected CAP on the evaluation by the pediatrician on duty. The CXR had been taken and read by a pediatric radiologist, member of this research project team. Due to poor CXR quality, 20 (6.2%) cases were excluded. Out of 301 evaluated cases, detection of pulmonary infiltrate and consolidation was described in 161 (54%) and 119 (40%) children, respectively. CXR was labelled normal for the others 140 cases. Among the radiographically confirmed CAP cases, pulmonary infiltrate was described as alveolar (135; 84%), interstitial (14; 9%), or alveolar-interstitial (12; 7%). Other radiographic findings among the radiographically confirmed CAP cases were: hyperinflation (37, 23%), atelectasis (36, 22%), peribronchial thickening (31, 19%), pleural effusion (23, 14%) and pulmonary abscess (2, 1%); there was no pneumatocele or pneumothorax. Overall, the median age was 17 months (12 days - 59 months) and there were 158 (53%) males.

The most frequent complaints reported in the history were cough (99%), fever (94%), difficulty breathing (77%); and the most frequent findings on physical examination on admission were tachypnea (73%), crackles (58%), wheezing (51%), fever (41%) and chest indrawing (35%). Out of 22 patients without complaint of difficulty breathing or tachypnea, 6 reported disease longer than 7 days, and crackles (5), reduced pulmonary sounds (4), chest indrawing (3), somnolence (3) and wheezing (1) were found. The significant differences found

between the cases with and without pulmonary infiltrates or consolidation are described in **Table I**. The frequency of complaint of fever (96% vs 94%, $P = 0.047$), difficulty breathing (71% vs 85%, $P = 0.003$), chest indrawing (30% vs 41%, $P = 0.04$) and decreased breath sounds (39% vs 21%, $P < 0.001$) was significantly different in the bivariate analyses when patients with and without pulmonary infiltrates were compared but there was no difference in the multivariate analysis. Likewise, the frequency of complaint of fever (97% vs 91%, $P = 0.03$), difficulty breathing (69% vs 83%, $P = 0.004$) and decreased breath sounds (41% vs 24%, $P = 0.002$) when patients with and without consolidation were compared. Overall, the positive LR of fever on examination for pulmonary infiltrates and consolidation was 1.49 (95% CI: 1.11 – 1.98) and 1.49 (95% CI: 1.14 – 1.94), respectively. Likewise, the positive LR of absence of wheezing for PI and consolidation was 1.45 (95% CI: 1.14 – 1.86) and 1.43 (95% CI: 1.14 – 1.79), respectively.

There were no significant differences between patients with and without PI for the following variables: underlying chronic illness (10% vs 15%), continuous medicine use (7% vs 10%), report of cough (99% vs 99%), complete refusal of liquids (0.6% vs 0%), duration (days) of illness (8 ± 5 vs 7 ± 5), of fever (6 ± 4 vs 6 ± 5), of cough (7 ± 6 vs 6 ± 5), presence of tachypnea (74% vs 71%), severe malnutrition (2% vs 3%), dehydration (6% vs 3%), somnolence (22% vs 19%), nasal flaring (7% vs 6%), cyanosis (0.6% vs 0.7%) and crackles (57% vs 59%).

Pulmonary infiltrates were less frequently described among patients aged under 1 year (41.3% vs 59.9%, $P=0.002$, OR[95% CI] = 0.47 [0.29-0.76]) and hyperinflation was significantly more frequent in this age group (27.9% vs 4.1%, $P<0.001$, OR[95% CI] = 9.14 [4.0-20.9]). For those patients aged 1 year onwards ($n=197$), pulmonary infiltrates was detected in 118 (60%) and it was associated with decreased breath sounds (45% vs 29%, $P=0.03$, OR[95% CI] = 2.0 [1.1-3.6]); absence of pulmonary infiltrates was associated with complaint of difficulty breathing (80% vs 66%, $P=0.04$, OR [95% CI] = 2.02 [1.04-3.9]) and wheezing (60% vs 35%, $P=0.001$, OR [95% CI] = 2.8 [1.5-5.0]).

TABLE I SIGNIFICANT DIFFERENCES BETWEEN PATIENTS WITH AND WITHOUT PULMONARY INFILTRATE OR CONSOLIDATION ON THE CHEST X-RAY

Characteristic	Pulmonary infiltrate			Consolidation			Adj OR (95% CI) *
	Present (n = 161)	Absent (n = 140)	OR (95% CI)	Present (n = 119)	Absent (n = 182)	OR (95% CI)	
Age \geq 1 year	118 (73)	79 (56)	2.12 (1.31-3.44)	87 (73)	110 (60)	1.78 (1.08-2.94)	1.49 (0.88-2.51)
Female gender	85 (53)	58 (41)	1.58 (1.00-2.50)	60 (50)	83 (46)	1.21 (0.76-1.93)	1.19 (0.74-1.93)
Fever on admission	78 (48)	45 (33)	1.94 (1.21-3.11)	61 (51)	62 (34)	2.00 (1.25-3.21)	1.79 (1.10-2.92)
Wheezing	69 (43)	85 (61)	0.49 (0.31-0.77)	48 (40)	106 (58)	0.48 (0.30-0.78)	0.53 (0.33-0.87)

Results in n (%); *OR adjusted for complaint of fever, difficulty breathing, chest indrawing, decreased breath sounds and the other variables in the table.

WHAT IS ALREADY KNOWN?

- Tachypnea is the most sensitive simple sign to detect pneumonia cases among children under 5 years-old with respiratory complaints.

WHAT THIS STUDY ADDS?

- Presence of fever enhances the probability of pneumonia 2.5 times among children with lower respiratory tract disease.

DISCUSSION

The study showed that either fever or absence of wheezing was independently associated with radiographically diagnosed CAP, if the end-point analyzed was presence of pulmonary infiltrate or consolidation. On the other hand, tachypnea was equally frequent among patients with and without radiographically diagnosed CAP. These results are in disagreement with those reported by the earlier studies in which tachypnoea had been identified as the most sensitive and specific simple sign to identify CAP among children with ARI and fever was not [8-11]. The selection of patients in the studies conducted by Shann, *et al.* [8], Campbell, *et al.* [9], Cherian, *et al.* [10] and Spooner, *et al.* [11] excluded children with wheezing. In these investigations, the authors concluded that tachypnea was the most sensitive simple sign to detect lower respiratory compromise among children with respiratory complaints. As wheezing children were excluded, the most frequent lower respiratory disease was pneumonia.

Wheezing has been recognized as a confounding variable in order to distinguish children with CAP and proposals to refine the use of tachypnea in differentiating asthma from ARI in children have been published [12,13]. Moreover, wheezing may be present both in children with asthma or bronchiolitis. The association of absence of pulmonary infiltrates as well as hyperinflation with children aged under 1 year suggests that bronchiolitis was the correct diagnosis of many patients in this age group, initially diagnosed with suspected CAP by the assistant pediatrician [14]. Results from a recent study have shown that most children with tachypnea had normal chest X-ray when children with wheezing were not excluded [15]. Therefore, it is necessary to

implement additional steps in order to accurately identify children with CAP among children with respiratory symptoms in daily practice.

In this investigation, the inclusion criteria selected patients aged <60 months who underwent CXR because of suspicion of pneumonia by the pediatrician on duty. This strategy selected children with lower respiratory tract disease. Therefore, the studied group was different from the other studies which identified tachypnea as the most sensitive simple sign to detect pneumonia cases.

Fever has been used as a marker for malaria in the algorithm from the Integrated Management of Childhood Illness from WHO [16]. Nonetheless such use must be restricted to malaria regions. Where malaria is less common, fever may be more predictive of infection [17]. In an urban middle income easy access setting, history of fever at home and triage temperature $\geq 38^{\circ}\text{C}$ were among the associated findings with pneumonia in wheezing children [18]. Improving the case management algorithm of childhood CAP at resource-limited setting has been challenging. A trial of rapid-acting bronchodilator in children with wheeze and fast breathing has now been recommended before making a diagnosis of CAP [19]. From the results presented herein, it is possible to estimate that presence of fever enhances 2.5 times the chance of children hospitalized with lower respiratory tract disease to have radiographically diagnosed pneumonia. Therefore, the presence of fever on physical examination enhanced the probability of pneumonia among children under 5 years-old with lower respiratory tract disease and may be useful to distinguish children with pneumonia from those with other lower respiratory tract diseases. Children with CAP diagnosed solely based on the detection of

tachypnea may receive antibiotics unnecessarily.

It is necessary to highlight the strengths of this study: first, the whole study was conducted at the same hospital where health care professional had been trained to identify eligible patients; second, the same researcher was in charge of compiling the whole data; third, the use of a strict radiographic criteria used by an experienced pediatric radiologist blinded to clinical information; and fourth, the collection of data in daily practice. Nonetheless, the limitations must be commented on: different observers evaluated the enrolled patients and only one radiologist read the CXR. Therefore, the results may be used for similar situations.

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Contributors: NKK collected the clinical data and drafted the manuscript; CAA read the chest X-rays, filled the radiographic forms, took part in the interpretation of the results and critically the manuscript; M-RAC took part in the analysis and revised the manuscript; CMN conceived the research question and designed the study protocol, analyzed the data and revised critically the manuscript. All authors approved the submitted version.

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