Original Article

Bacterial pneumonia score to identify bacterial pneumonia

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Abstract

Background Pneumonia is caused by either bacterial or viral etiologies, with similar symptoms in children. The bacterial pneumonia score (BPS) is a clinical assessment comprised of several investigations: age, assessment of axillary temperature, absolute neutrophil count, band neutrophil percentage, and interpretation of radiological examination. The score will use to differentiate the etiology of pneumonia.

Objective To determine the sensitivity, specificity, positive predictive value, and negative predictive value of BPS in identifying bacterial pneumonia in children.

Methods This diagnostic study was performed at Dr. M. Djamil Hospital, Padang, West Sumatera where subjects were selected by consecutive sampling. Fifty-seven patients were diagnosed with pneumonia. Three patients suffered from ventricular septal defects, 8 patients refused to provide blood specimens and 3 patients' chest X-rays could not be interpreted, hence, 43 subjects were included in the study. Chest X-rays were interpreted by a pediatric pulmonology consultant. Leukocyte and differential counts were performed by a clinical pathology consultant. Subjects' BPS scores were compared to multiplex PCR examinations of blood specimens, as the gold standard.

Result Of 43 subjects, 27 (62.79%) were male. Subjects' mean age was 29.3 (SD 21.5) months. Twenty (46.51%) subjects had good nutritional status, 4 (9.31%) subjects had axillary temperature $\geq$ 39⁰C, and 22 (51.16%) subjects had absolute neutrophil counts $\geq$ 8.000/mm³. Bacterial pneumonia score (BPS) had 69% sensitivity, 60% specificity, 42% positive predictive value, and 81% negative predictive value.

Conclusion In this study, BPS has low sensitivity and specificity for identifying bacterial pneumonia. **[Paediatr Indones. 2015;55:79-82.].**

Keywords: *pneumonia, hospitalized, bacterial pneumonia score, PCR*

Pneumonia is a worldwide health problem because its mortality rate is high in both developing and developed countries.[1] The *World Health Organization* (WHO) in 2005 estimated mortality rate caused by pneumonia in toddlers around the world to be 19% or 1.6 to 2.2 million. Of these, 70% were in developing countries, especially Africa and South East Asia.[2] In Indonesia, the 2007 *Basic Health Research* (*Riskesdas*) reported pneumonia to be the second leading cause of mortality in toddlers (15.5%), following diarrhea (25.2%).[3]

Bacteria and viruses are the organisms that commonly cause pneumonia in children.[2,4,5] Distinguishing bacterial from viral pneumonia may help in decisions on the use of antibiotics. Clinical symptoms are almost the same between these etiologies, causing difficulty in distinguishing between the two. Microbiological examinations have been used to differentiate between these etiologies, including blood cultures and immunofluorescent examinations, such as reverse transcription-polymerase chain reaction (RT-PCR). Bacterial cultures take 24-48 hours and PCR is not

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always available, so the decision on initial treatment is always based on clinical symptoms, laboratory and radiologic data, although there is no clinical algorithm to clearly distinguish the cause of pneumonia.[5]

We wanted to assess the usefulness of the bacterial pneumonia score (BPS) for predicting bacterial infection as the cause of pneumonia in children. The BPS is based on clinical assessments and was developed in Argentina, consisting of axillary temperature measurements, age, absolute neutrophil count, band neutrophil percentage, as well as the interpretation of radiological examinations.[5] The use of this score is expected to reduce the unnecessary use of antibiotics, the incidence of antibiotic resistance, and health care costs.

This study was conducted to evaluate the sensitivity, specificity and predictive values of BPS to identify bacterial or non-bacterial bronchopneumonia. Our analysis included the use of a 2x2 table.

Methods

The study was conducted in the Child Health Department and Clinical Pathology Laboratory of Dr. M. Djamil Padang Hospital, and the Biomedical Laboratory of the Faculty of Medicine, University of Andalas, West Sumatera, from July 2012 until March 2013. The study population was patients hospitalized with pneumonia based on the WHO criteria.[6]

Subjects were selected by non-probability sampling with a consecutive technique, so that all patients diagnosed with pneumonia and fulfilled the inclusion criteria were included in the study. The inclusion criteria were children aged 2 months - 14 years whose parents provided informed consent, and diagnosed with severe pneumonia based on the hosptial criteria. We obtained subjects' blood specimens for routine examinations of peripheral blood (hemoglobin level, leukocyte, and differential counts) and PCR, as well as radiological examinations (chest x-ray, in an anteroposterior position). We excluded patients with other severe diseases, such as congenital heart diseases, pertussis, malnutrition, leukemia, immunological deficiency, or nosocomial pneumonia (those whose pneumonia started during hospitalization).

The required minimum sample size was calculated based on a formula for diagnostic study, in which the specificity (P) was 0.89 (based on previous study),[6] α was 0.05 (Zα = 1.96), and d was 0.1. Taking into account a 10% possibility of dropping out, the minimum number of required subjects was 42. This study was apporved by the Research Ethics Committee of the Faculty of Medicine, University of Andalas. Parents of patients were given an explanation of the purpose, objectives, and benefits of the study. All subjects' parents provided informed consent.

We collected the following data on 43 subjects: age, gender, weight, length/height, nutritional and clinical symptoms such as body temperature, respiratory rate per minute, as well as presence of chest wall retractions, and crackles on auscultation. Chest X-rays were taken of subjects in an anteroposterior position and read by a pediatric pulmonology consultant. Children who received antipyretic medication before the study had their body temperature measured 8 hours after the last time of antipyretic administration.

Blood specimens (up to 3 mL) were taken from the cubital vein area with aseptic and antiseptic techniques. The BPS was calculated based on the method of Glazen and Khamapirad.[7] Variables analyzed consisted of axillary temperature, age, absolute neutrophil count and band neutrophil percentage, as well as the results of chest X-ray results. Subjects with total scores $\geq$ 4 were considered to have bacterial pneumonia and those with scores <4 were considered to have non-bacterial pneumonia.[7]

The DNA isolation was performed directly on blood using Purelink Genomic DNA purification (*Invitrogen*®). Lysis buffer was mixed with 200 uL of blood so that the next isolated cell was inserted into spin column which causes the DNA attached to the membrane. The DNA was then removed using elution buffer.

DNA amplification was performed with universal primers for bacterial l 16S rRNA, namely F: 5'-CAG-CAGCCGCGCTAATAC-3' and R: 5'-CCGTCAAT-TCCTTTGAGTTT-3'. Stages of PCR consisted of an initial denaturation 95°C for 10 min, followed by 45 cycles of amplification consisting of denaturation at 94°C, annealing at 62°C, and extension at 72°C for each cycle, 1 minute for each stage. Amplification was performed with dream green Taq PCR master mix (*Fermentas*®). Amplification products were identified with 1% agarose gel electrophoresis and viewed on a gel apparatus dock.

Severe pneumonia diagnosis was made based on

our hospital criteria: fever, cough, shortness of breath (based on age according to WHO),[7] respiratory distress (or nasal flaring and grunting and/or suprasternal/intercostal/subcostal retractions), and smooth wet loud rales on chest auscultation. Fever was considered to be present for temperatures $> 37.5\ ^{0}C$ following 5 minutes of thermometer insertion in the axillae.

Results

During the study period, 57 children were hospitalized with a diagnosis of bronchopneumonia. Three children suffered non-cyanotic congenital heart disease (ventricular septal defects); 8 children refused to provide blood specimens; and 3 children had X-ray results which could not be analyzed. Hence, the number of subjects totaled 43, selected by consecutive sampling. Analyses were performed using a 2 x 2 table. The characteristics of subjects are shown in **Table 1**.

There were different incidences of pneumonia, by BPS and PCR assessments. By BPS assessment,

Table 1. Characteristics of subjects

Characteristics	(N=43)	
	n	%
Age		
≤9 months	21	48.84
>9 months	22	51.16
Gender		
Male	27	62.79
Female	16	37.21
Nutritional status		
Well-nourished	20	46.51
Undernourished	23	53.49
Axillary temperature		
≥39^{0}C	4	9.31
<39^{0}C	39	90.69
Absolute neutrophils		
≥8,000/mm^{3}	22	51.16
<8,000/mm^{3}	21	48.84
Band neutrophil percentage		
≥5%	4	9.31
<5%	39	90.69

bacterial pneumonia incidence was not much different from that of non-bacterial pneumonia (21 vs. 22 subjects, respectively), while PCR assessment, the incidences were (13 vs. 30 subjects, respectively).

Sensitivity, specificity and predictive values were displayed in the form of 2x2 tables, to compare BPS to PCR, with the latter considered to be the gold standard for distinguishing between bacterial and viral infection in children with bronchopneumonia.

Table 2 shows that of the 43 subjects with bronchopneumonia, 9 subjects had bacterial infections based on both BPS and PCR examinations. Using PCR alone, 13 patients had bacterial pneumonia, the sensitivity of BPS was 69%. This value indicates that BPS is not sensitive for use as a screening tool for patients with bacterial pneumonia.

There were 18 subjects with non-bacterial pneumonia, based on BPS and PCR. For PCR alone, 30 subjects had non-bacterial pneumonia, so the BPS specificity was 60%. This illustrates that BPS was not specific as a tool for patients with non-bacterial pneumonia. The positive predictive and negative predictive values in this study were 42% and 81%, respectively.

Discussion

Subjects ranged in age from 2 months to 10 years, with a mean age of 29.3 (SD 21.5) months. This result was different from that obtained by Kisworini *et al.*, who examined clinical symptoms, laboratory and demographic data as predictors of mortality in children with pneumonia and Beyeng *et al.*, who examined BPS validity as a predictor of pneumonia bacteremia in children. Kisworini *et al.*[8] and Beyeng *et al.*[9] found the average ages of their sample who suffered from pneumonia, to be 16 month and 11 months, respectively. However, Torres *et al.*, who examined the clinical predictors for initial treatment

Table 2. Comparison of BPS and PCR

	PCR		
	Positive	Negative	Total
BPS ≥ 4 (bacterial pneumonia)	9	12	21
BPS < 4 (non-bacterial pneumonia)	4	18	22
	13	30	43

of children with pneumonia, found an average age of 25.3 (SD 16.5) months.[10] In this study, the total sample of men was fewer than the women, i.e., 62.79%. Similarly, Kisworini *et al.* and Beyeng *et al.* each found the total of male patients to be more than the total of girls, by about 55%[8] and 59.4%, respectively.[9] In contrast, Torres FA *et al.* found that only 45% of pneumonia subjects were male.[10] The most common nutritional status of our subjects was undernourished (53.49%). In contrast, Kisworini *et al.*[8] and Beyeng *et al.*[9] found more pneumonia patients in the well-nourished category with 69% and 51.1%, respectively.

Sensitivity, specificity, positive predictive value and negative predictive value were different from those reported by Moreno *et al.*,[5] who examined the development and validation of clinical predictors for distinguishing bacterial and viral pneumonia in children. They found sensitivity to be 100%, specificity 93.9%, positive predictive value 75.9% and negative predictive value 100%. There were several differences between the Moreno *et al.* study and our study. Moreno *et al.* had 175 subjects by consecutive technique, who were pneumonia patients aged 1 month - 5 years. Patients were excluded if they had chronic lung disease, congenital heart disease, ICU admission, recurrent pneumonia, malnutrition, immunological deficiency, nosocomial pneumonia or the use of antibiotics in the 2 weeks prior to the study. In contrast, as the age range of our subjects was wider, 2 months - 14 years, pneumonia could more likely be caused by *Mycoplasma*, which has mild clinical symptoms, with lower axillary temperatures. According to studies by McIntosh,[13] Ostapchuk *et al.*,[12] Stain *et al.*,[13] and Setyoningrum,[14] pneumonia in patients over 5 years of age is mostly caused by mycoplasma group. Our small sample size may also have influenced the results.

In conclusion, BPS has low sensitivity and specificity for identifying bacterial pneumonia. Further study with a larger sample size is needed to better evaluate the usefulness of the bacterial pneumonia score in clinical practice.

Conflict of interest

None declared

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