THE VALIDITY OF CLINICAL CRITERIA IN PREDICTING PNEUMONIA AMONG CHILDREN UNDER FIVE YEARS OF AGE

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مقدمة : يعتبر مرض الرئة من الأمراض الشائعة والخطرة التي تصيب الأطفال مما يجعل التشخيص الدقيق والعلاج المناسب مهمين لمنع المضاعفات الخطيرة والمميتة لهذا المرض.

هدف الدراسة : هدفت الدراسة إلى تقييم صلاحية الأعراض والعلامات السريرية في تشخيص ذات الرئة لدى الأطفال دون سن الخامسة من العمر .

نتائج الدراسة : تم جمع عينة مكونة من 103 طفل تراوحت أعمارهم بين 4 أيام و59 شهر من المراجعين لشعبة العيادة الخارجية وشعبة الطوارئ في مستشفى الخنساء التعليمي في مدينة الموصل . وكانت العينة من الأطفال الذين لديهم أعراض سريرية تنفسية وأجري فحص أشعة الصدر لهم ، بعد ذلك تم تقييم كل حالة وتسجيل الأعراض والمعلومات السريرية ، استخدمت دلائل الفحص الشعاعي لوجود ذات الرئة كمرجع قياسي لفحص التشخيص وحسب الحساسية والخصوصية والقيم التوقعية الموجبة والسالبة وكذلك نسب الاحتمالات الموجبة والسالبة لكل علامة من المعلومات السريرية التشخصية .

نتائج الدراسة : تم تشخيص ذات الرئة حسب الفحص الشعاعي لدى 70طفلاً (9، 68%) أظهرت الدراسة أن حرارة الجسم المساوية لثمان وثلاثين درجة مئوية فأكثر كانت أفضل دليل تشخيص مفرد لذات الرئة ، حيث كانت حساسية هذه العلامة 1, 67% والخصوصية 8, 75% وكذلك كان عدم وجود العلامات الثلاثة وهي توسع فتحتي الأنف وانجذاب جدار الصدر إلى الداخل والقرقعة قد استبعد ذات الرئة بصورة مؤثرة وكانت حساسية ربط هذه العلامات معاً 98% وكذلك كان اكتشاف درجة حرارة الجسم لثمان وثلاثين درجة مئوية فأكثر والفباع معاً بصورة متلازمة كافياً لتأكيد وجود المرض :

اعتماداً على نتائج هذه الدراسة يمكن الاستنتاج أن استخدام المعلومات السريرية بصورة مترابطة يمكن أن يزيد من كفاءة الأطباء في تشخيص ذات الرئة .

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Background: Pneumonia is a major cause of morbidity and mortality, especially among infant and young children. Early diagnosis and treatment is essential to reduce the risk. To achieve this, physicians require high quality diagnostic indicators. The aim of the present study is to assess the validity of clinical symptoms and signs in predicting pneumonia among children below the age of 5 years.

Patients and Methods: This is a case series study for a sample of 103 children aged 4 days-59 months who were admitted to Al-Khanssa Teaching Hospital, Mosul, Iraq, suffering from respiratory symptoms and for whom a chest x-ray was requested. Sensitivity, specificity, predictive values and likelihood ratios were estimated for each clinical criterion.

Results: Pneumonia was diagnosed on radiological bases in about 70% of the patients. All symptoms had high sensitivity with very low specificity. The best positive predictive values for symptoms were for fast and difficult breathing. However, the signs of Crackle, Tachypnoea, nasal flarring and chest indrawing yielded the best sensitivity estimates. Moreover, a body temperature of ≥38 ℃ was the best single predictor of pneumonia with a sensitivity of 67% and specificity of 75.8%. The absence of the 3 signs (nasal flaring, chest indrawing and crackles) ruled out pneumonia effectively. The sensitivity of this combination of signs was 98.6%. Detecting a body temperature ≥38 ℃ and grunting simultaneously was adequate to confirm the disease.

Conclusions: The study suggests that using clinical criteria in combination could improve physicians' prediction of pneumonia among children.

Key Words: Validity, Pneumonia, Epidemiology

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INTRODUCTION

Pneumonia is widely recognized as a major cause of morbidity and mortality.[1] It accounts for approximately 3.5 million deaths among children under 5 years of age annually in developing countries. The number of cases of pneumonia reported in the Ninevah governorate, Iraq in 1999 exceeded 30,000. More than 9% of those children were admitted to hospitals.[2]

Pneumonia in infants and young children may present with only nonspecific complaints such as fever, cough and poor feeding. Clinical examination may reveal more specific pulmonary findings such as tachypnoea, nasal flaring, grunting, chest indrawing, cyanosis, abnormal breath sounds and adventitious breath sounds. The definite final diagnosis of pneumonia requires the isolation of the causative agent. Chest x-ray, however, is more readily obtained in primary care practice and is usually considered as a practical reference standard for pneumonia.[3]

The World Health Organization has advocated an intervention programme to minimize mortality from pneumonia. This program includes guidelines for proper case management in primary care settings. They are based on simple and well-qualified clinical criteria for the diagnosis of pneumonia.[1] Different studies were conducted to estimate the validity of clinical features in the identification of pneumonia.[4-10] Clinical judgment has been used as a reference standard for the assessment of the quality of symptoms and signs of pneumonia by many investigators.[4,7-10] Most studies have concluded that tachypnoea is a valid indicator of pneumonia.[4,8] Others have found that the presence of fever >38.5 °C or respiratory rate >60/min, were the most accurate signs for severe lower respiratory infections, but it was impossible to discriminate these infections with chest indrawing.[11]

In the daily practice, physicians require high quality diagnostic indicators (high sensitivity, specificity and predictive values, and appropriate likelihood ratios) to differentiate pneumonia from other lower respiratory infections like bronchitis and bronchiolitis. This would help the clinician to avoid additional tests like radiography or blood culture, eliminate the misuse of antibiotics, and limit the unnecessary hospitalization of patients.

The aim of the present study is to determine the validity of the clinical criteria in diagnosing pneumonia, confirmed by chest x – ray, among children under 5 years of age.

PATIENTS AND METHODS

The study consisted of a sample of 103 children who were admitted to Al-Khansaa hospital in Mosul during a three-month period starting from the 1st of December 1999. After parental permission, patients were eligible for enrolment in the study if they were younger than 5 years of age, presented with respiratory symptoms for which a chest x–ray was ordered independently by the treating physicians. Patients with a history of congenital heart disease, foreign body inhalation, poisoning and preterm newborns were excluded.

A questionnaire form was prepared and filled for every patient. The information included in this form consisted of age, sex, case history and related physical examinations. The necessary information was taken by direct interview of the patient's parents or relatives. The case history was obtained by asking about the presence or absence of symptoms such as cough, difficult breathing, fast breathing, noisy breathing, fever and poor feeding. The child was then examined for drowsiness, central cyanosis and nasal flaring. Grunting and stridor were determined by listening carefully when the patient was calm. Respiratory rate was counted for 1 minute by observing the respiratory movements while the child was awake and quiet. The indrawing of the chest was observed when the child's chest was bare. The patient's body temperature was recorded by adding 0.5 C^o to auxiliary temperature. The heart rate was measured by auscultation for 30 seconds. Diminished breath sounds, wheezes (ronchi) and crackles (crepitations) were determined by auscultation of the front, back, and sides of the patient's chest.

A precise definition for each symptom and sign was used throughout the study. Tachypnoea and tachycardia were defined, respectively, as a respiratory rate or heart rate, above the upper limits of normal rates for age.[3]

The final conclusion of the presence of pneumonia was based on chest radiograph findings as ascertained by the hospital radiologist. All reports of lobar or bronchopneumonia were considered as pneumonia cases for the purpose of the present study.

The Chi–squared test with Yate's continuity correction was used for statistical analysis of association between discrete variables. Continuous data were compared by using t test. P values <0.05 were considered significant.

Sensitivity and specificity, positive and negative predictive values, and positive and negative likelihood ratios were estimated for each

clinical criterion. Moreover, and in an attempt to improve the performance characteristics of clinical criteria in the diagnosis of pneumonia, two combinations of clinical findings were chosen according to the degree of their association after analysis of the results. The 1st model was done simaltaneously and the 2nd serially.

RESULTS

A successful tracing was obtained for all the 103 patients. Their ages ranged from 4 days to 59 months. Table 1 summarizes the age and sex distribution of the study sample. Three quarters of the patients were less than 1 year old and about two thirds of the patients were males. Male to female ratio was 1.64:1.

Table 1: *Age and sex distribution of the study population*

Sex	Age Group (month)			Total No. (%)
	<1 No. (%)	1 - <12 No. (%)	12 - <60 No. (%)	
Male	9 (8.7)	41 (39.8)	14 (13.5)	64 (62.0)
Female	2 (2.0)	25 (24.3)	12 (11.7)	39 (38.0)
Total	**11 (10.7)**	**66 (64.1)**	**26 (25.2)**	**103 (100)**

Table 2: *The association of the studied symptoms and signs with pneumonia proved by chest radiography*

Symptom and Signs	Pneumonia		p-value*
	Present (n=70) No. (%)	Absent (n=33) No. (%)	
Symptom:			
Cough	65 (92.9)	32 (97.0)	NS
Difficult breathing	65 (92.9)	27 (81.8)	NS
Fast breathing	58 (82.9)	23 (69.6)	NS
Noisy breathing	60 (85.7)	27 (81.8)	NS
Fever	55 (78.6)	25 (75.8)	NS
Poor feeding	62 (88.6)	28 (84.9)	NS
Signs:			
Temperature >38°C	47 (67.1)	8 (24.2)	<0.0005
Tachypnoea	60 (85.7)	17 (51.5)	<0.0005
Tachycardia	35 (50.0)	10 (30.3)	NS
Drowsiness	41 (58.6)	11 (33.3)	<0.05
Cyanosis	10 (14.3)	3 (9.1)	NS
Grunting	54 (77.1)	12 (36.4)	<0.0005
Stridor	1 (1.4)	3 (9.1)	NS
Nasal flaring	60 (85.7)	17 (51.5)	<0.0005
Chest indrawing	59 (84.3)	18 (54.6)	<0.005
Diministed breath	6 (8.6)	2 (6.1)	NS
Bronchial breath	5 (7.1)	1 (3.0)	NS
Wheezes	43 (61.4)	22 (66.7)	NS
Crackles	66 (94.3)	24 (72.7)	<0.01

*X2 test was used. NS=Not significant

Table 2 shows that pneumonia was diagnosed on radiological bases in 70 (68.9 %) patients. The table also reveals that none of the individual symptoms evaluated was significantly associated with pneumonia. Significant associations were observed, however, for the signs of temperature ≥38 °C, tachypnoea, grunting, nasal flaring, chest indrawing, crackles and drowsiness.

Table 3 demonstrates the sensitivity, specificity, predictive values and likelihood ratios of each symptom in the diagnosis of pneumonia. All symptoms had high sensitivity with very low specificity. The best positive predictive values of the symptoms were those of fast breathing and difficult breathing; which also showed the best positive likelihood ratios. None of the ratios, however, revealed an accepted 95% confidence limits.

The sensitivity, specificity, predictive values and likelihood ratios of the signs are shown in Table 4. Crackles, tachypnea, nasal flaring, and chest indrawing yielded the best sensitivity estimates. but their specificity were low. Bronchial breath sounds, diminished breath sounds, cyanosis and stridor were signs among which the highest specificity was observed. Body temperature >38C° as a sign had the highest positive predictive value (85.5%) and positive likelihood ratio (2.77); with adequate sensitivity (67.1 %) and specificity (75.8%) at the same time. The absence of this sign decreased the negative likelihood ratio adequately (0.43). Bronchial breath sounds and grunting also had high positive likelihood ratio. The negative likelihood ratio for crackles, tachypnoea, and nasal flaring were the lowest among all the studied signs.

Table 5 shows the quality of two chosen models based on a combination of signs. The absence of the three signs in the first model (nasal flaring, chest indrawing, and crackles) in parallel, lowered the negative likelihood ratio to 0.08 and increased the negative predictive value to 85.7 %. The presence of any of these three signs had a positive likelihood ratio of 1.21 and a positive predictive value of 71.9 %. This model also showed a very high sensitivity (98.6 %). Seven patients in the study sample did not have any of the three signs and only 1 of them had pneumonia. The presence of >38C° body temperature and grunting in the second model in serial evaluation increased the positive likelihood ratio to 4.84 and the positive predictive value to 91.1%. The absence of any of these 2 signs had a negative likelihood ratio of 0.47 and a negative predictive value of 50%. This model also showed a high specificity (87.9%). The number of patients who had these 2 signs simultaneously were 45 and only 4 of these patients did not have pneumonia.

Table 3: *The sensitivity, specificity, predictive values and likelihood ratios of the studied symptoms*

Symptom	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	LR+	LR-
Cough	92.9	3.0	67.0	16.7	0.96	2.37
Difficult breathing	92.9	18.2	70.7	54.5	1.14	0.40
Fast breathing	82.9	30.3	71.6	45.5	1.19	0.57
Noisy breathing	85.7	18.2	69.0	37.5	1.05	0.79
Fever	78.6	24.2	68.9	34.8	1.04	0.88
Convulsion	1.4	97.0	50.0	31.7	0.47	1.02
Poor feeding	88.6	15.2	68.9	38.5	1.04	0.75

Table 4: *The sensitivity, specificity, predictive values and likelihood ratios of the studied signs*

Symptom	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	LR+	LR-
Temperature >38ºC	67.1	75.8	85.5	52.1	2.77*	0.43*
Tachypnoea	85.7	48.5	77.9	61.5	1.66*	0.29*
Tachycardia	50.0	69.7	77.8	39.7	1.65*	0.72*
Drowsiness	58.6	66.7	78.8	43.1	1.76*	0.62
Cyanosis	14.3	90.9	76.9	33.3	1.57	0.94
Grunting	77.1	63.6	81.8	56.8	2.12*	0.36*
Stridor	1.4	90.9	25.0	30.3	0.15	1.08
Nasal flaring	85.7	48.5	77.9	61.5	1.66*	0.29*
Chest indrawing	84.3	45.5	76.6	57.7	1.55*	0.35*
Diministed breath sounds	8.6	93.9	75.0	32.6	1.41	0.97
Bronchial breath sounds	7.1	97.0	83.3	33.0	2.37	0.96
Wheezes	61.4	33.3	66.2	28.9	0.92	1.16
Crackles	94.3	27.3	73.3	69.2	1.36*	0.21*

*Significant LR's according to the 95% confidence interval

Table 5: *The performance characteristics of combinations of signs in the diagnosis of pneumonia (Model I and II)*

Characteristics	Combination of signs	
	Nasal flaring, chest indrawing, or crackles (Model I – parallel testing)	Temperature >38ºC and Grunting (Model II-serial testing)
Pneumonia:		
Present (n=70) %	98.6	58.6
Absent (n=33) %	81.8	12.1
p-value (X^2 test)	<0.01	<0.0005
Sensitivity %	98.6	58.6
Specificity %	18.2	87.9
PPV %	71.9	91.1
NPV %	85.7	50.0
LR+ (95% confidence intervals)	1.21 (1.15 – 1.27)	4.84 (4.07 – 5.76)
LR- (95% confidence intervals)	0.08 (0.04 – 0.15)	0.47 (0.41 – 0.51)

DISCUSSION

The present study suggests that certain clinical criteria could be useful for practising physicians to improve their ability to diagnose pneumonia in children under 5 years of age. Using chest x-ray as a reference standard (gold standard) for the diagnosis of pneumonia in this study is justified because it was available in the study area, was more practical, relatively safer and less invasive than other diagnostic techniques like bronchoscopy or lung puncture.[12] Variability of radiographic appearance of pneumonia and negative chest radiograph findings in-patients with early bacterial pneumonia are not considered as substantial

limitations of chest x-ray. In fact, chest radiograph is used as a dependable diagnostic tool together, with clinical findings for the identification of pneumonia in children.[3,13] The study sample, however, probably represented more severe cases of respiratory infection, as they were more likely to have a chest x-ray. This could explain the relatively high prevalence of pneumonia (69%) in this study as compared to a previous study.[5]

None of the evaluated symptoms showed a significant association nor had appropriate likelihood ratios to rule in or rule out pneumonia. This was similar to the findings of Lozano *et al*.[6] Others found an association with some of the

symptoms.[10,16] This was probably due to the varying methods of sampling or differences in the definition and interpretation of symptoms.

The individual symptoms of cough, difficult breathing, poor feeding, noisy breathing, fast breathing and fever were all sensitive indicators of pneumonia with adequate positive predictive values but their specificity and negative predictive values were low. Similar results had also been reported in other studies.[6] This will reduce the probability of missing the diagnosis. The validity of such symptoms, however, might be affected by the intervening time between the onset of the disease and maternal reporting.[14]

Several individual signs in the present study showed significant association with pneumonia. The most useful single sign was fever>38 °C which was the best predictor of pneumonia with adequate sensitivity and specificity simultaneously. Tachypnoea was also a good indicator of pneumonia. It had a high sensitivity with adequate predictive values and likelihood ratios. These results confirm the findings of previous studies.[4,8,15]

Clinicians typically assess the presence or absence of many clinical findings in order to reach an accurate diagnosis of pneumonia.[8] The use of multiple indicators at the same time in parallel (considering the presence of any criterion as a positive diagnosis) increases the sensitivity and reduces the false negative diagnosis. This would increase the negative predictive value and improve the negative likelihood ratio. Conversely, the use of multiple indicators serially (considering the absence of any indicator as a negative diagnosis) maximizes the specificity and minimizes the false positive diagnosis. In this manner, the positive predictive value and positive likelihood ratio would increase. To achieve this, two models have been tested in this study. This approach has rarely been used in epidemiological evaluation of clinical diagnosis.[15] These combinations were limited to signs which yielded significant association with positive radiological findings of pneumonia. The 1st model combined signs with high sensitivity (crackles, nasal flaring, and chest indrawing) and this combination was found to be very sensitive. The presence of any of these 3 signs as a positive clinical finding had missed the identification of only one of the 70 patients with pneumonia. On the other hand, the concurrent absence of these three signs might rule out pneumonia more effectively than any other single clinical indicator assessed in this study. To increase the specificity of the clinical criteria in the detection of children with pneumonia,

the second model has been used. This combination was restricted to grunting and a temperature of >38C°. The absence of any of these two signs had a high specificity rate (85.7%). In the study sample, patients who were both grunting and had fever as signs had the highest probability of having pneumonia (positive predictive value = 91.1%). Furthermore, children with pneumonia are five times more likely to have these two signs simultaneously than children without pneumonia.

CONCLUSION

The study showed that the best positive predictive values for symptoms were for fast and difficult breathing and the presence of body temperature ≥ 38c°.

The study suggested two models, a combination of clinical criteria, to improve the prediction of diagnosing of pneumonia. These models are simple and less time consuming and easy for physicians to use. This approach will markedly improve the validity of signs and symptoms in predicting pneumonia, rather than the dependence on individual clinical criteria.

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