Predictive Value of Respiratory Rate Thresholds in Pneumonia among Preschool Children

BN Tagbo*, AC Ude**, BC Ibe+

Summary

Tagbo BN, Ude AC, Ibe BC. **Predictive Value of Respiratory Rate Thresholds in Pneumonia among Preschool Children in Enugu, Nigeria.** *Nigerian Journal of Paediatrics* 2002; **29**: 108. A study was carried out to determine the predictive value of respiratory rate in the clinical diagnosis of pneumonia in 101 children with respiratory symptoms of <28 days duration. Clinical, demographic and anthropometric variables were obtained at presentation while confirmation of the diagnosis was by a chest x-ray in each subject. Fifty-two of the subjects had radiological pneumonia; 42(80 percent) of them were less than three years old including 22 (42 percent) less than one year. The male to female ratio was 1.3:1. Of the 52 children with pneumonia, 38 (73 percent) had respiratory rate $\geq$50/minute, while 43 (83 percent) had respiratory rate $\geq$40/min. When all age groups are considered, subjects with pneumonia had significantly higher respiratory rates. Respiratory rate was found to be least reliable as an indicator of pneumonia in children aged 2-11 months in whom the widest variation of respiratory rate was identified. For children aged 12-35 months, a respiratory rate of $\geq$50/min was a good predictor of pneumonia while a respiratory rate of $\geq$35/min was highly sensitive in children $\geq$36 months old. The current data suggest that the age specific respiratory rate cut off recommended by WHO programme for the control of acute respiratory infections need to be reviewed.

Key Words: Predictive value, Respiratory rate, Pneumonia, Pre-school children.

Introduction

PNEUMONIA is one of the severe forms of acute respiratory infections (ARI),[1,2] and it is often difficult clinically to differentiate it from other forms of ARI because they present with similar symptoms and signs. In developing countries, bacterial pathogens account for the majority of the pneumonia.[3,4] The WHO control of ARI programme stresses improved and early case management to prevent deaths from pneumonia principally by treating children with suspected pneumonia with antimicrobial drugs.[5,6] The prediction of pneumonia by the rural health worker is based on the history and observation of simple clinical signs. One of such simple and early clinical sign is increased respiratory rate (RR). Although several workers have studied RR in pneumonia, there are conflicting reports. This study therefore, aimed at investigating the sensitivity, specificity and predictive value of RR in the case management of pneumonia in children and comparing the results with the current WHO recommendations.

University of Nigeria Teaching Hospital, Enugu

Institute of Child Health
*Assistant Chief Research Fellow/Consultant
  Paediatrician

Department of Radiology
**Senior Lecturer

Department of Paediatrics
+ Professor
Correspondence: BN Tagbo

Patients and Methods

The study was carried out at the University of Nigeria Teaching Hospital (UNTH), Enugu, between November 1996 and February 1997. All children presenting at the outpatients department and children's emergency room aged between two months and five years with complaints of cough and difficult breathing of less than four weeks duration were recruited into the study. Informed consent was obtained from the parents/care givers. The

following were excluded from the study: children aged less than two months or older than five years, children whose complaints had lasted for more than four weeks, children with measles, tuberculosis, cardiac failure and severe malnutrition. Ethical approval was obtained from the UNTH Ethical Committee. Data was collected using a study protocol and the responders were the parents or care givers. Demographic, clinical and anthropometric variables were obtained at presentation and respiratory rate was counted for one full minute by the observation method while the child was either asleep or awake and quiet. Each child underwent chest radiography, and films were read by an experienced radiologist (ACU).

Results

A total of 101 children were enrolled into the study. Of these 101 children, 52 (51.5 percent) had radiological evidence of pneumonia. Twenty-two (42 percent) of these 52 children were under one year of age, while 20 children (38 percent) were aged between one and three years. Therefore a total of 80 percent of children with pneumonia were under three years of age. The mean (±SD) RR was 59±16.1 breaths/minute for children with pneumonia and this was significantly faster (p<0.025; Table I) than the corresponding mean of 52±15.5 breaths/minute in those without pneumonia.

On further classification according to age groups, there was no significant difference between the mean RRs for the two diagnostic categories in the age group 2-11 months. However, significant differences in mean RRs were observed in the other age groups (Table II).

Table III shows that RRs of ≥30/minute, ≥40/minute, and ≥50/minute had high sensitivities but poor specificities. However, only RR of ≥50/minute had fairly good predictive values. Respiratory rate analyzed for different age groups are shown in Table IV. For children aged 2-11 months, RRs of ≥40/min and ≥50/min had high sensitivities (96 percent and 78 percent, respectively); however, their specificities were low (0 percent and 28 percent, respectively). All the respiratory rate cutoffs in the age groups had poor predictive values. In the 12-23 month age group, RR of ≥50/minute had a better combination of sensitivity, specificity and predictive values than RR of ≥40/min. This was also the case for the 24-35 months age group. However, in children aged ≥36 months, RR of ≥35/min had higher predictive values than that of ≥40/min, ≥50/min, and ≥60/min. The receiver-operator characteristic curves (Fig. 1) show that a RR of ≥50/min best predicts pneumonia in children aged 12-35 months, while RR ≥35/min is better in children ≥36 months old. However, no RR cutoff value was good enough in predicting pneumonia in infants aged, 2-11 months.
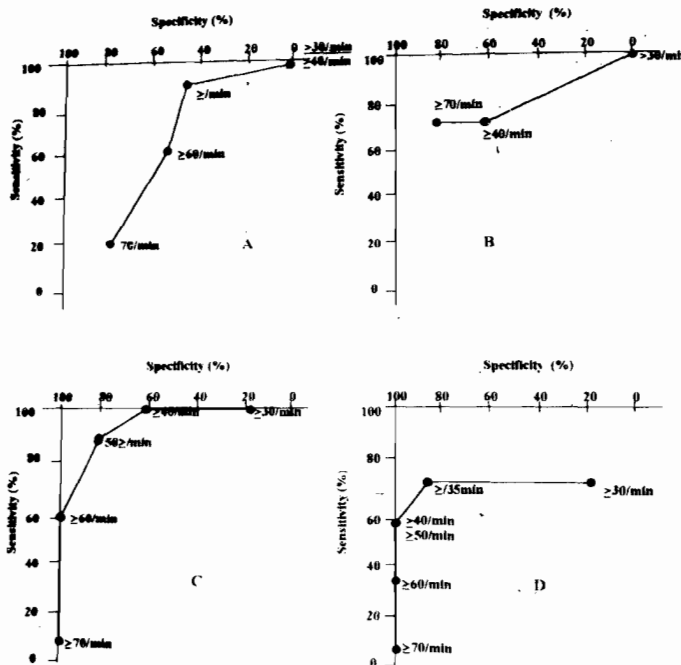

Fig 1. Receiver-operator characteristic (ROC) curves showing the sensitivity and specificity of respiratory rates as a predictor of pneumonia in different age groups, A:2 – 11 months; B:12 – 23 months; C: 24 – 35 months; and D: ≥36 months.

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Table I

Mean (SD) Respiratory Rate and Temperature of Children with/without Pneumonia

Clinical Variable	Mean (SD)		Z Value	P Value
	Pneumonia	No Pneumonia		
RR (breaths/min)	59 (16.09)	52 (15.54)	2.2152	0.025
Temperature (°C)	37.8 (0.99)	37.4 (1.11)	1.8613	0.05

Table II

Mean Respiratory Rate of Children with/without Pneumonia at Various Age Groups

Age (mons)	Mean Respiratory Rate/min (SD)		t value	P value
	Pneumonia	No Pneumonia		
2-11	62 (15.35)	58 (10.87)	1.0582	>0.05
12-23	52 (12.03)	39 (5.56)	3.2746	<0.005
24-35	62 (13.06)	39 (9.82)	3.7217	<0.005
≥36	48 (15.28)	33 (2.49)	2.8355	<0.01

Table III

Sensitivity, Specificity, Positive and Negative Predictive Values of various Respiratory Rate Thresholds in 52 Children with Pneumonia

Resp. rate (Breaths/min)	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
30	94	3	23	51
40	83	25	57	54
50	73	55	66	63
60	52	63	55	60

Resp. = Respiratory

Discussion

In the current study, there was a significant difference between the mean RRs for children with pneumonia and those without pneumonia. This lends support to the fact that RR is increased in pneumonia. The pathological changes that take place in the lungs during pneumonia reduce the lung compliance and impair gaseous exchange, resulting in disturbed ventilation/perfusion relationships which leads to hypoxaemia and stimulation of the J-receptors in the lungs causing a rise in RR.[2] Some workers have contended that RR is not useful in identifying children with pneumonia,[7] while others also insist that RR did not correlate with the presence of a serious lower respiratory tract infection.[8]

The explanation for these differences in finding may be due to the differences in the ages of the children studied; while the former workers studied children under two years of age, the latter studied children six months of age and it is known that RR varies widely in infants.[7,9,10] Besides, serious lower respiratory tract infection may be accompanied by alveolar hypoventilation and respiratory failure in which case, RR may become normal or indeed low.[11] This wide variation in the RRs in infancy probably explains why in the current study, the difference in the means of RRs between children with and without pneumonia in the 2-11 months age group, was not significant. However, for the older age group, there were such significant differences. The exact reason for this wide

Table IV

Accuracy of Various Respiratory Rate Thresholds in Predicting Pneumonia in Children of Different Age Groups

Age (Mons)	Resp. rate (Breaths/min)	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
2-11	30	100	0	44	0
	40	96	0	43	0
	50	78	28	45	62
	60	52	38	40	50
	70	30	76	50	58
12-23	30	91	0	46	0
	40	73	50	57	67
	50	73	100	100	80
	60	46	100	100	67
	70	9	100	100	55
24-35	30	100	20	69	100
	40	100	60	73	10
	50	89	80	89	80
	60	67	100	100	39
	70	11	100	100	39
≥36	30	78	0	70	0
	35	78	67	88	50
	40	56	100	100	43
	50	56	100	100	43
	60	33	100	100	33
	70	11	100	100	27

Resp. = Respiratory

variation in the RRs in infancy is not clear, but may be due to the poor maturation of the central regulatory mechanism of respiration in infants.[12] However, it is well documented that RR decreases with age and body size.[9,10,13] This is the basis for the recommendation by the WHO programme for the control of ARI that age-specific RR cutoff value be used rather than a single value for all age groups.[14] This explains why in the current study, analysis of single RRs for all age groups put together, did not yield good enough predictive values. While a RR of ≥50/min was moderately predictive of pneumonia for all age groups (63 percent positively predictive and 66 percent negatively predictive) with a sensitivity of 75 percent and specificity of 55 percent, RR of ≥40/min was highly sensitive (83 percent) but poorly specific (25 percent). These findings are similar to those reported by Cherian *et al* [15] and Campbell *et al*.[16] This is why in the present study, various RRs were evaluated for each group to find out which one would best predict pneumonia for that age group. The receiver-operator characteristic curves generated from the current data showed that RR alone was not reliable in predicting pneumonia in infants aged 2-11 months probably due to reasons

already discussed. However, a RR of ≥50/min was the best predictor of pneumonia in the 12-35 months age group. The finding of a RR ≥50/min as a good predictor in the 12-23 months age group is similar to those of Shann *et al* [17] and Harari *et al*,[5] but differs from those of other authors,[15, 18] and is indeed, at variance with the current WHO case management recommendations[19] in which a RR of ≥40/min was recognized to be a better indicator of pneumonia in this age group. This is probably because most studies lumped the age group, 1-5 years into one, without further breakdown giving rise to a lower average figure. That a RR of ≥35/min in children aged ≥36 months predicted pneumonia in the present series is consistent with the findings of Singhi *et al* [18] but slightly higher than that of Gupta *et al*[20] who suggested a RR of ≥30/min. Redd *et al*[6] and Cherian *et al* [15] did not find any reliable RR for identifying pneumonia in this older age group probably because analysis was not done for the ≥35/min cut off value.

This study shows that RR alone is not a reliable parameter for predicting pneumonia in infants. We therefore, recommend that the current WHO recommendations on the use of RR to predict

pneumonia be reviewed with a view to excluding infants and further classify the 1-5 year age group into younger and older age groups.

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