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# Tachypnoea is a good predictor of hypoxia in acutely ill infants under 2 months

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## Abstract

**Objective**—To evaluate the respiratory rate as an indicator of hypoxia in infants < 2 months of age.

**Setting**—Pediatric emergency unit of an urban teaching hospital.

**Subjects**—200 infants < 2 months, with symptom(s) of any acute illness.

**Methods**—Respiratory rate (by observation method), and oxygen saturation ( $\text{SaO}_2$ ) by means of a pulse oximeter were recorded at admission. Infants were categorised by presence or absence of hypoxia ( $\text{SaO}_2 \leq 90\%$ ).

**Results**—The respiratory rate was  $\geq 50/\text{min}$  in 120 (60%),  $\geq 60/\text{min}$  in 101 (50.5%), and  $\geq 70/\text{min}$  in 58 (29%) infants. Hypoxia ( $\text{SaO}_2 \leq 90\%$ ) was seen in 77 (38.5%) infants. Respiratory rate and  $\text{SaO}_2$  showed a significant negative correlation ( $r = -0.39$ ). Respiratory rate  $\geq 60/\text{min}$  predicted hypoxia with 80% sensitivity and 68% specificity.

**Conclusion**—These results indicate that a respiratory rate  $> 60/\text{min}$  is a good predictor of hypoxia in infants under 2 months of age brought to the emergency service of an urban hospital for any symptom(s) of acute illness.

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Keywords: tachypnoea; hypoxia; respiratory rate; oxygen saturation; acutely ill infants

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Rapid breathing is an important clinical manifestation of many illnesses in young infants.<sup>1</sup>

Often it is the only sign of illness in this age group. At a primary health care facility or a crowded paediatric emergency room, respiratory rate counted for one complete minute has been found to be useful in assessing the severity of respiratory infection in infants under 2 months.<sup>2,3</sup> A respiratory rate of  $\geq 60$  breaths/min is used as a predictor of pneumonia in the case management guidelines of the World Health Organisation's acute respiratory infection control programmes globally.<sup>4</sup> However, very little data on the usefulness of respiratory rate as an indicator of hypoxia and risk of mortality in illnesses other than pneumonia are available.<sup>5</sup> In a prospective study, we have evaluated the respiratory rate as an indicator of hypoxia in infants less than 2 months of age attending a paediatric emergency service.

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## Material and methods

### STUDY POPULATION

Two hundred infants under 2 months of age who were brought with symptom(s) of any acute illness to the paediatric emergency service

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of Nehru Hospital, Postgraduate Institute of Medical Education and Research, Chandigarh were included in the study. One hundred infants each were enrolled during winter (October to February) and summer months (May to September). All the infants came from the urban or periurban areas of Chandigarh; most of them were using the facility as their first medical contact point. Infants less than 24 hours of age, those with major congenital malformations, and those referred after previous hospitalisation or active cardiopulmonary resuscitation were excluded. Informed parental consent was obtained. Our study was approved by the ethics committee of the institute.

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## METHODS

Age, sex, and detailed history were recorded and a complete physical examination was performed at admission by a paediatric resident. The resident also obtained diagnostic laboratory tests, including chest x ray, which were guided by the practice and protocols of the unit and were not influenced by our study. Chest x rays were obtained if an infant had symptom(s) and sign(s) suggestive of respiratory illness and were assessed by an experienced radiologist (SK) in a blinded manner.

The respiratory rate of infants was counted soon after their arrival to the paediatric emergency department. A complete one minute count was recorded using a stop watch and observing the chest and abdominal movement. If a baby started crying during the counting, he/she was consoled or breast fed by the mother and the rate was counted again once the baby was quiet. If the respiratory rate was  $\geq 50/\text{min}$ , the rate was counted again after 30 minutes to confirm the high rate.

Oxygen saturation ( $\text{SaO}_2$ ) was measured at finger or toe with a pulse oximeter (BCI, Waukesha, Wisconsin, USA) using an appropriate sized sensor. Hypoxia was defined as  $\text{SaO}_2 \leq 90\%$ . All the observations were made and recorded by a single observer (VTR) who was unaware of the patient's clinical findings and diagnosis.

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## STATISTICAL ANALYSIS

The  $\chi^2$  test was done to find the usefulness of a respiratory rate  $\geq 40/\text{min}$ ,  $\geq 50/\text{min}$ ,  $\geq 60/\text{min}$ ,  $\geq 70/\text{min}$ , and  $\geq 80/\text{min}$  as an indicator of hypoxia. Later, sensitivity, specificity, and predictive values were calculated for various respiratory rate cut off points.

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## Results

The mean age of the study infants was 28 days. The final diagnoses established with the help of clinical and laboratory data in these infants

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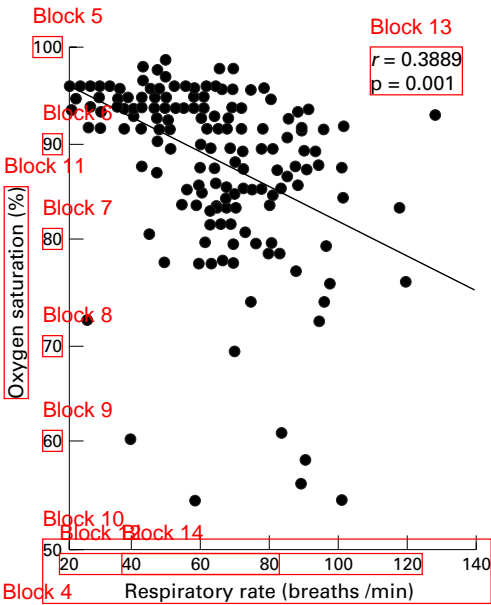


Figure 1 Scatter diagram showing the correlation between the respiratory rate and oxygen saturation.

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were as follows: pneumonia, 68 (34%); septicaemia (suspected and culture positive), 24 (12%); meningitis, 27 (13.5%); congenital heart disease, 12 (6%); congestive cardiac failure, seven; birth asphyxia, 16 (8%); hypocalcaemic seizures, six (3%); bronchiolitis, four (2%); acute gastroenteritis, five (2.5%); upper respiratory infection, five (2.5%); neonatal jaundice, seven (3.5%); and miscellaneous, 29 (14.5%). Ten infants had more than one primary diagnosis—for example, congenital heart disease with congestive heart failure or pneumonia with pneumothorax.

Of the 200 infants, 77 (38.5%) had hypoxia ( $\text{SaO}_2 \leq 90\%$ ). The respiratory rate was  $\geq 40/\text{min}$  in 152 (76%),  $\geq 50/\text{min}$  in 120 (60%), and  $\geq 60/\text{min}$  in 101 (50.5%) infants. A significant negative correlation was seen between the respiratory rate and  $\text{SaO}_2$  ( $r = -0.39$ ;  $p < 0.001$ ; fig 1). The proportion of infants having a respiratory rate  $\geq 50/\text{min}$ ,  $\geq 60/\text{min}$ , and  $\geq 70/\text{min}$  was significantly higher in infants with hypoxia compared with those with  $\text{SaO}_2 > 90\%$  ( $p < 0.001$ ; table 1). A respiratory rate  $\geq 60/\text{min}$  had the best balance of sensitivity and specificity for hypoxia (table 1). A respiratory rate  $\geq 70/\text{min}$  was 17% more specific but 30% less sensitive than a respiratory rate  $\geq 60/\text{min}$  (table 1).

Thirty two (16%) of the 200 study infants died; 72% of these infants had a respiratory rate  $\geq 60/\text{min}$  at initial evaluation, whereas

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Table 2 Sensitivity and specificity of respiratory rate  $\geq 60/\text{min}$  and presence of hypoxia to predict the outcome of 200 acutely ill infants less than 2 months old

	Outcome		Sensitivity (%)	Specificity (%)
	Died	Survived		
Respiratory rate $\geq 60$ (n = 101)	23	78*	72	54
Hypoxia (n = 77)	9	90		
Oxygen saturation $< 90\%$ (n = 77)	17	60	53	64
Hypoxia and $\text{SaO}_2 < 90\%$ (n = 23)	15	108		

\* $p < 0.05$ ;  $\chi^2$  test.

$\text{SaO}_2 \leq 90\%$  was recorded in only 53% of the infants who died ( $p < 0.05$ ; table 2).

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Discussion

The detection and effective management of hypoxia is an important aspect of the clinical management of acutely ill infants. Published data on the subject are not clear about whether there is a reliable correlation between the respiratory rate and the presence of hypoxia in very young infants with acute symptoms. Using a pulse oximeter,<sup>6</sup> which has been accepted for the detection of hypoxia,<sup>7–10</sup> we found that a respiratory rate  $\geq 60$  was a sensitive and reasonably specific predictor of hypoxia in acutely ill infants brought to the paediatric emergency service of an urban health facility in a tropical developing country. Although a respiratory rate  $\geq 70/\text{min}$  was marginally more specific, it was remarkably less sensitive than a respiratory rate  $\geq 60/\text{min}$ . Moreover, a significant negative correlation was seen between the respiratory rate and  $\text{SaO}_2$ .

Studies looking for simple clinical signs and the respiratory rate as predictors of hypoxia in infants less than 2 months are scarce. Almost all the published studies that have evaluated the respiratory rate as a predictor of hypoxia were conducted on children with acute lower respiratory infection between 2 months and 5 years of age.<sup>7–12</sup> Some of these were conducted at high altitude and found a high respiratory rate to be a useful predictor of hypoxia,<sup>8 10 12</sup> whereas others did not.<sup>7 11 13</sup> Onyango and colleagues<sup>10</sup> did include 45 infants less than 2 months of age in their study, but did not find any significant relation between the presence of hypoxia and a respiratory rate  $\geq 70/\text{min}$ . Our study therefore provides useful information on the subject.

Our findings might help in the selection of sick infants for oxygen treatment in a busy emergency room, especially in urban hospitals without an oximeter and where oxygen is not freely available. The World Health Organisation has made recommendations for oxygen treatment of patients with acute lower respiratory infection in places with free or limited availability of oxygen based on specific respiratory signs such as chest indrawing, grunting, cyanosis, etc. However, oxygen might be required by infants who have sepsis, heart failure, meningitis, shock, and other conditions, but who do not have the above mentioned respiratory signs. A respiratory rate  $\geq 60$  might be a useful indicator in such patients.

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Table 1 Sensitivity, specificity, and predictive values of a respiratory rate (RR)  $\geq 40/\text{min}$ ,  $\geq 50/\text{min}$ ,  $\geq 60/\text{min}$ ,  $\geq 70/\text{min}$ , and  $\geq 80/\text{min}$  for hypoxia in 200 acutely ill infants

RR (breaths/min)	Hypoxia		Predictive value (%)	
	Present (n = 77)	Absent (n = 13)	Sensitivity (%)	Specificity (%)
$\geq 40$ (n = 152)	74	78	96	37
$\geq 50$ (n = 120)	70	50*	91	59
$\geq 60$ (n = 101)	62	39*	80.5	68
$\geq 70$ (n = 58)	39	19*	51	85
$\geq 80$ (n = 25)	17	8	22	99

\* $p < 0.001$ .

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In a large series of 1007 babies under 6 months, 709 of whom were brought to hospital for assessment of an acute illness and 298 were normal babies seen at home, the respiratory rate did not show any correlation with illness severity.<sup>5</sup> However, the mean respiratory rate of awake babies in this study was 61 breaths/min both at hospital and at home. It is possible that such high normal respiratory rates were because of the short counting time (only 15 seconds), the lack of reconfirmation of high respiratory rates by a second count, and stimulation of the child caused by placing of a hand or stethoscope on the chest for counting the respiratory rate. These fallacies related to counting were eliminated in our study by counting the respiratory rate for a full one minute by observation and not touching the chest/abdomen, and a repeat count after 30 minutes if the initial respiratory rate was  $\geq 50$ /min.

By studying patients who were brought to hospital for assessment of illness we might have been looking at a population skewed in favour of serious illness. Nonetheless, our investigation has met the objective to evaluate the respiratory rate as an indicator of hypoxia in the infants who are brought to a health care facility and by implication were considered unwell by their parents. We do acknowledge that the sensitivity and specificity of the respiratory rate as an indicator of hypoxia might not be same in a community setting, but our findings should be helpful in planning a community based study on the subject. In a large longitudinal study, we found that the mean respiratory rate of healthy Indian infants under 2 months of age counted by the observation method is 42–43 breaths/min, and less than 9% of these infants had a respiratory rate  $\geq 60$ /min.<sup>14</sup>

We conclude that acutely ill infants under 2 months of age presenting at an urban paediatric emergency service with a respiratory rate  $\geq 60$ /min should be considered hypoxic and treated with oxygen if the facility to measure  $\text{SaO}_2$  is not available. More data might be needed before recommending the application of these findings at the primary health care level and in remote places in developing countries.

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## Block 4

## Commentary

In a hospital in the industrialised world, endowed with specialist medical and nursing staff and sophisticated monitoring equipment, information is integrated from a number of sources in reaching a diagnosis and implementing a management plan. The situation is quite different in many parts of the developing world where rural health care workers take responsibility for much acute illness in childhood, relying on simple clinical observations without access to radiography, oximetry or the luxury of a functioning telephone with which to contact a more senior colleague. In these circumstances, simple algorithms are required. With minor qualifications, in the absence of respiratory symptoms, fever becomes malaria and in the presence of respiratory symptoms, tachypnoea becomes pneumonia.

These two papers address a topic with a long and controversial history: the significance of tachypnoea. This is a beguilingly simple physical sign but, as both papers point out, to obtain a reliable estimate of respiratory rate, a carefully standardised procedure should be followed. Although one may criticise certain aspects of the methodology of both studies, their conclusions that tachypnoea in the first 2 months of life is under some circumstances a surrogate for hypoxaemia and that tachypnoea is a moderately specific and sensitive sign of pneumonia, are both important. But how should these imprecise associations be translated into practical guidelines for action? The WHO management guidelines for acute respiratory infections in children use tachypnoea as a critical guide to management. These two studies might usefully contribute to minor revisions to some of its recommendations.

For instance, the observations by Palafox and colleagues that tachypnoea was not a reliable feature of “pneumonia” (that is, radiological changes in a child with respiratory symptoms) when symptoms had been present for less than 3 days, would be a useful cautionary message to those who might feel that the absence of tachypnoea inevitably meant the absence of pneumonia. Others, including Singhi *et al.*<sup>1</sup> have pointed out that clinical features other than tachypnoea, such as “difficult breathing” or indrawing reported by the child’s mother, may be equally useful. The implication is that tachypnoea alone is insufficiently robust.

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The study reported by Rejesh and colleagues will need to be taken a stage further before it can contribute to a modification of the WHO recommendations. The sensitivity and specificity of tachypnoea as an indicator of hypoxaemia and the cause of hypoxaemia itself may be quite different in infants with and without lower respiratory tract illness. Simply equating tachypnoea with the need for oxygen treatment (the conclusion of the paper) leads to too great an oversimplification of the process of clinical reasoning. Management guidelines for very young infants are still needed, in view of doubts that tachypnoea is a reliable sign either of pneumonia or of hypoxaemia in that age group in the developing world.<sup>2,3</sup> It will also be important to know, given the scarcity of oxygen supplies in many hospitals in the developing world, whether treating mild degrees of hypoxaemia is beneficial in very young children with pneumonia.

## Block 1

These papers should serve as a reminder that, even in an age of sophisticated technological medicine, much of what we do as health professionals is based on simple clinical observation. Re-examination of the assumptions that surround these building blocks of clinical medicine is always salutary. Conclusions derived from research in sophisticated Western hospitals cannot be applied directly to the practice of medicine in the developing world.

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