

In children aged 2-59 months with pneumonia, which clinical signs best predict hypoxaemia?

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The World Health Organization has produced guidelines for the management of common illnesses in hospitals with limited resources. This series reviews the scientific evidence behind WHO's recommendations. The WHO guidelines, and more reviews are available at: http://www.who.int/child-adolescent-health/publications/CHILD_HEALTH/PB.htm

This review addresses the question: *In children aged 2-59 months with pneumonia, which clinical signs best predict hypoxaemia?*

The **WHO Pocketbook of Hospital Care for Children** recommends that very severe pneumonia is defined as cough or difficulty breathing and at least one of: cyanosis, severe respiratory distress, inability to drink or vomiting everything or lethargy/unconsciousness/convulsions and that severe pneumonia is defined as cough or difficulty breathing plus one of: lower chest indrawing, nasal flaring, grunting.

Introduction:

A plausible gold standard for the presence of severe disease in LRTI is the presence of hypoxaemia. Hypoxemia is a clear indication for inpatient care because children are likely to benefit from supportive care, especially oxygen administration. Treatment guidelines [1, 2] recommend that in the child with pneumonia admitted for inpatient care, pulse oximetry- a noninvasive estimate of arterial oxygenation- should be used to guide oxygen therapy. In developing countries, however, facilities such as pulse oximetry for the early detection of hypoxaemia are lacking and oxygen is in short supply. As an alternative, recent studies [3-5] have suggested a range of respiratory and non-respiratory signs that predict hypoxaemia thus

guiding referral for or administration of oxygen therapy.

Methodology

The clinical search strategy used was that of Haynes et al "Clinical Queries" in PubMed. The search strategy employed was as follows: Hypoxaemia AND predict* AND clinical signs. Both broad and narrow searches were conducted. Filters for diagnosis were employed. One hundred and twenty five articles were found.

Articles were excluded if they did not answer the clinical question. This left 12 studies all of which were from developing countries. One study was excluded because it assessed hypoxaemia in acute respiratory and non-respiratory illnesses.[6] Among the eleven studies selected for inclusion, one was an extensive review of the data and findings of the seven studies conducted prior to the date of the review. Two studies have been conducted since this review.

Results

Systematic review

Published studies evaluating the value of clinical signs in predicting hypoxaemia in children with acute lower respiratory infection were reviewed in 2001[7]. The prevalence of hypoxaemia, determined by pulse oximetry, ranged from 31% to 72%, depending on the definition of hypoxaemia used. Different cut-off values were used to define hypoxaemia at the study sites located at varying altitudes (Table 1). The review presented the sensitivity and specificity of clinical signs associated with hypoxaemia as discussed by various studies. [3-5, 8-10] These signs included very fast breathing, cyanosis, grunting, nasal flaring, chest retractions, head nodding and auscultatory signs as well as general depression

of the child, inability to feed and lethargy. The reported value of the various signs as indicators of the need for oxygen therapy is presented below, followed by more recent studies that have postdated the review.

Use of clinical signs as indicators of oxygen therapy

Central cyanosis- Clinical interpretation of this sign can be difficult. Blueish discolouration of the nail beds or lips represents peripheral cyanosis and is not always a reliable indicator of central cyanosis. In areas where moderate and severe anaemia (Hb < 7g/dl) are common and/or in highly pigmented races there are particular difficulties in using cyanosis as a clinical sign. Observers also often disagree over whether the sign is present or not and the usefulness of the sign may vary with the age of the child.

Despite these problems in the majority of studies cyanosis remains very useful. It appears to have a higher specificity than other signs – that is it the number of times oxygen would be given on the basis of this sign when it might not be needed are proportionately few. However using just this sign to guide treatment often more oxygen would be given to children without hypoxia than with hypoxia. In addition central cyanosis has poor sensitivity. That is, of all children who really have hypoxaemia, central cyanosis detects only a small proportion of them (between 9 – 42%).

Inability to drink / poor general status defined to include severe lethargy, prostration or sometimes coma.

The recent studies that have assessed the usefulness of this group of signs show mixed results. For an inability to drink in most studies the sensitivity was low (<50%) but better than that for cyanosis. However, in two of the four studies this was at the cost of low specificity, suggesting that many children might be identified as hypoxaemic who are not, potentially wasting oxygen. Where the general status was very poor with children being comatose sensitivity was somewhat improved (49% – 68%) but specificity was poor in two of the three studies (<80%). [3, 10]

Severe chest indrawing
Perhaps because chest indrawing is a key sign in the diagnosis and classification of pneumonia in children it has not convincingly been demonstrated that it is helpful beyond this in the detection of hypoxaemia.

Over 70 breaths/minute (in children 2 months up to 5 years old)

Errors in counting respiratory rates are likely to increase as the rates increase. Under study conditions very high respiratory rates have shown variable performance as indicators of hypoxaemia and possibly some variability with age with higher specificity and lower sensitivity as age increases above 12 months[3]. In one study[9] at high altitude sensitivity was very low (<20%) although specificity was 100%. Overall it would seem sensitivity is modest (4 – 57%) and specificity good (70% - 100%) for a threshold of > 70bpm while reducing the threshold to > 60 bpm predictably increases sensitivity and reduces specificity limiting the usefulness of very high respiratory rate thresholds.

Restlessness.

Restlessness does not appear to be a useful predictor of hypoxia in the context of pneumonia or severe ARI although there are few studies examining its value.

Head nodding.

This sign is present if the head nods downwards towards the chest each time the child breathes in as a result of accessory muscle use in breathing.

There are limited data evaluating the usefulness of this sign. In one study [8] sensitivity was low (29%) but specificity high (96%) while in the other [5], from the same site, sensitivity was better (57%) but specificity lower (85%).

Post-review studies

Two post review studies were identified. In India, respiratory rates above age-specific cut-offs were the single most useful sign in predicting hypoxaemia (Sensitivity 82%; Specificity 51%). [11] Cyanosis was much more specific (96%) but if used alone would have failed to detect over 80% of children with hypoxaemia. Chest indrawing and grunting although specific for hypoxaemia were rare signs with very low sensitivity (<20%). The second study from Papua New Guinea correlated clinical findings with different levels of hypoxaemia, <93%, <90%, and <85%. [12] From this study conducted among children with pneumonia at high altitude, cyanosis, head nodding and drowsiness were good predictors of hypoxaemia but lacked sensitivity. The sensitivity of these signs improved slightly as the cut offs for hypoxaemia were lowered; when oxygen saturation of 93%

was used the sensitivities of the three signs ranged from 24% to 74% and increased to 60-90% when the cut off was lowered to 85%. (Table 1)

Discussion

The risk of death from pneumonia increases significantly when hypoxaemia is present. In fact studies have shown that severe hypoxaemia is likely to be on the causal pathway to mortality in children with lower respiratory infections. [13] The compensatory respiratory responses to hypoxaemia or indicators of its consequences (for example altered levels of activity or consciousness) can be used to predict its presence. These associated physical signs include: cyanosis, raised respiratory rate and use of accessory muscles in breathing resulting in head nodding. Apart from these several non respiratory signs present in severely ill children may serve as indicators of severe disease in children with respiratory infection. Examples include altered general mental status of a child.

Summary

Children admitted with severe lower respiratory tract infections should be investigated for hypoxaemia. Pulse oximetry, a non-invasive and accurate method of measuring arterial oxygen saturation, should be used. In centers where pulse oximetry is not available, clinical signs can be used to predict hypoxaemia. No single sign has been found to be a reliable predictor of hypoxaemia. However, a respiratory rate > 60 breaths per minute and altered mental status had good sensitivity and specificity across studies. Combining a sign of severe respiratory distress with a sign of general depression can help predict hypoxaemia with reasonable sensitivity and specificity.

References

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Table 1: Sensitivities and specificities of clinical signs for hypoxaemia.

Study	Laman 2005	Lodha 2004	Usen 1999	Smyth 1998	Weber 1997	Dyke 1995	Lozano 1994	Onyango 1993
Altitude		239 meters	Sea level	1150 meters	Sea level	1600 meters	2640 meters	1670 meters
Hypoxaemia	SpO ₂ <93	SpO ₂ <90	SpO ₂ <90	SpO ₂ <92	SpO ₂ <90	<85%	SpO ₂ <88	SpO ₂ <90
Age	1m-5y	<5 y	2-33 m	1-60m	2-60m	3-36m	7 days-36 m	7 days-36 m
Resp Rate >70/min		82/52(<3m) 54/78(>3-12m)	54/80	57/91			16/100(0-11 m) 4/100(12-36 m)	48/70(<2m) 51/83(3-11 m) 39/80(>12 m)
Resp Rate >60/min	68/77(SpO ₂ <93) 75/69(SpO ₂ <90) 80/78(SpO ₂ <85)	89/24(<3m) 82/52(>3-12m) 54/78(>12m)	81/47	72/67	39/100		40/86(0-11 m) 12/100(12-36m)	76/35(<2m) 86/56(3-11 m) 65/76(>12 m)
Cyanosis	74/93(SpO ₂ <93) 70/75(SpO ₂ <90) 80/71(SpO ₂ <85)	14/96	25/95		39/100	42/84		20/100(<2m) 9/96(3-11 m) -(>12 m)
Grunting		14/93	46/86		15/93	42/89	45/72	48/65(<2m) 64/73(3-11 m) 56/76(>12 m)
Head nodding	24/100(SpO ₂ <93) 30/96(SpO ₂ <90) 60/97(SpO ₂ <85)		57/85		29/96			
Nasal flaring	70/58(SpO ₂ <93) 85/57(SpO ₂ <90) 100/53(SpO ₂ <85)		98/17		71/54	56/84	63/65	
Inability to feed			33/91		16/97		35/60	66/47(<2m) 50/75(3-11 m) 40/71(>12 m)
Unresponsive	68/91(SpO ₂ <93) 85/83(SpO ₂ <90) 90/74(SpO ₂ <85)		49/77		68/100		Lozano 1994	68/50(<2m) 63/67(3-11 m) 56/78(>12 m)
Crepitations		68/68		79/53		90/16		

* Albuterol = Salbutamol