Assessment

Individualised limits for SpO₂ were no better than fixed limits for detecting hypoxia or hyperoxia in sick infants

Gupta R, Yoxall CW, Subedhar N, et al. *Individualised pulse oximetry limits in neonatal intensive care*. *Arch Dis Child Fetal Neonatal Ed* 1999 Nov;81:F194–6.

QUESTION: Are individualised limits for arterial oxyhaemoglobin saturation (SpO₂) assessed by pulse oximetry as accurate as fixed limits for detecting hypoxia and hyperoxia in sick newborn infants?

Design

Comparison of sensitivities and specificities of individualised and fixed SpO₂ limits for detecting hypoxia or hyperoxia.

Setting

A neonatal intensive care unit in Liverpool, UK.

Patients

95 infants (68% boys, median gestational age 28 weeks, median birth weight 1165 g) who required arterial lines. Infants with structural congenital cardiac lesions were excluded.

Description of tests and diagnostic standard

Simultaneous measurements of SpO₂ and partial pressure of oxygen in arterial blood (PaO₂) (diagnostic standard) taken over a 3 year period. For each infant, ≥2 sets of measurements were required, taken ≤6 hours apart. For each pair of measurements, sensitivity and specificity of fixed SpO₂ limits for detecting hypoxia (PaO₂ <6 kPa) and hyperoxia (PaO₂ >10 kPa) were calculated. Individualised SpO₂ limits were calculated retrospectively using a standard equation for the shape of the oxygen-haemoglobin dissociation curve; these limits were then applied to the next pair of measurements in that infant.

*Test properties of SpO₂ for detection of hypoxia in sick infants**

Lower limit for SpO ₂	Sensitivity	Specificity	+LR*	–LR*
88%	0.33	0.77	1.43	0.87
89%	0.41	0.67	1.24	0.88
90%	0.55	0.65	1.57	0.69
91%	0.72	0.56	1.64	0.50
92%	0.80	0.49	1.57	0.41
93%	0.84	0.39	1.38	0.41
94%	0.89	0.33	1.33	0.33
Individualised	0.68	0.46	1.26	0.69

*Test properties of SpO₂ for detection of hyperoxia in sick infants**

Upper limit for SpO ₂	Sensitivity	Specificity	+LR*	–LR*
94%	1.00	0.27	1.37	0
95%	1.00	0.40	1.67	0
96%	0.80	0.59	1.95	0.34
97%	0.42	0.92	5.25	0.63
98%	0.11	0.86	0.79	1.03
Individualised	0.75	0.64	2.08	0.39

*Positive/negative LR (likelihood ratios) calculated from data in article.

Main outcome measures

Sensitivity and specificity of individualised and fixed limits of SpO₂ for detecting hypoxia and hyperoxia.

Main results

A total of 692 simultaneous measurements of SpO₂ and PaO₂ were taken. Individualised SpO₂ lower limits for hypoxia had similar test properties (sensitivities and specificities) to a fixed lower limit of 91% and individualised upper limits for hyperoxia were similar to a fixed upper limit of 96% (table).

Conclusion

When monitoring arterial oxyhaemoglobin saturation by pulse oximetry, individualised limits were no better than fixed limits for detecting hypoxia or hyperoxia in sick infants.

Source of funding: no external funding.

For correspondence: Dr N J Shaw, Neonatal Intensive Care Unit, Liverpool Women's Hospital, Crown Street, Liverpool L8 7SS, UK. Fax +44 (0)151 702 4082.

COMMENTARY

In premature and sick newborn infants, hypoxia is associated with organ damage and pulmonary hypertension and hyperoxia is associated with retinopathy of prematurity.¹ It is important, therefore, to have an accurate measure for monitoring arterial oxygen levels so that appropriate levels can be maintained and adverse events prevented. Pulse oximetry is the standard for monitoring SpO₂ in newborns.² Gupta *et al* examined whether fixed SpO₂ limits for identifying hypoxia and hyperoxia were as good as individualised limits derived from previous readings for a given infant. The derivation of these individualised limits was based on a complex formula that accounted for the oxygen-haemoglobin curve.

The study results indicate that the sensitivities and specificities of individualised limits were similar to those of fixed limits. Sensitivity and specificity values can, however, be misleading when used as a basis for clinical decision making because they restrict us to only 2 levels of results (positive and negative).³ In this study, many different levels (limits) were assessed, and therefore, it may be more informative to consider likelihood ratios (LRs), which tell us how much the probability of hypoxia (or hyperoxia) changes from baseline when the test is positive (positive LR) or negative (negative LR). Positive LR >2 and negative LR <0.1 should be considered in clinical decision making. As we can see from the LR calculated from the data in this study, neither fixed nor individualised lower limits for detecting hypoxia had positive LR >2 or negative LR <0.1, and fixed and individualised limits had similar LR for SpO₂ limits of 89% (positive LR) and 90% (negative LR). For hyperoxia, a fixed upper limit of 97% and individualised limits both had positive LR >2, whereas fixed limits of 94% and 95% had negative LR <0.1. Given this, it does not appear that the additional work required to establish individualised SpO₂ limits resulted in better accuracy for identification of hypoxia or hyperoxia.

Nevertheless, the results of this study will be useful to nurses working in NICUs in determining optimal upper and lower limits for setting alarms. When determining these limits, clinicians should also be aware that hypothermia, cardiac anomalies, partial pressure of carbon dioxide, pH, and haemoglobin levels can affect the accuracy of pulse oximetry.⁴

Jennifer Medves, RN, PhD
School of Nursing, Queen's University
Kingston, Ontario, Canada

- 1 Hay WW Jr, Brockway JM, Eyzaguirre M. *Pediatrics* 1989;83:717–22.
- 2 Grieve SH, McIntosh N, Laing IA. *Crit Care Med* 1997;25:2051–4.
- 3 Sackett DL, Straus S. *Evidence-Based Medicine* 1998 May/June;3:68–70.
- 4 Brockway J, Hay WW Jr. *J Pediatr* 1998;133:63–6.