Short reports

Pulse oximetry in preterm infants

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SUMMARY One hundred and twenty five measurements of arterial oxygen saturation ($StcO_2$) obtained with a transcutaneous pulse oximeter were compared with direct arterial oxygen tension (Pao_2) in 13 preterm infants with predominantly fetal haemoglobin. $StcO_2$ of 86–92% corresponded to Pao_2 of 5–13 kPa. $StcO_2$ above 92%, however, was sometimes associated with Pao_2 above 13 kPa.

Non-invasive techniques for monitoring blood gas tensions in neonates have been used over the past two decades, but some transcutaneous sensors of arterial oxygen tension have been found unreliable clinically.¹ Recent skin sensors for continuous monitoring of arterial oxygen saturation ($StcO_2$) based on pulse oximetry have been evaluated in patients with predominantly adult haemoglobin and found to be easy to use, to be accurate, and to have no risk to the patient.² Little is known about the performance of the pulse oximeter in preterm infants with predominantly fetal haemoglobin.

As oxygen treatment of preterm infants has been regulated by arterial oxygen tension rather than saturation in the past it is important for clinicians to have data comparing results using the pulse oximeter with arterial PO_2 . This study compared $StcO_2$ and Pao_2 in preterm infants less than 48 hours old who had not received any adult blood.

Patients and methods

Preterm infants admitted to the neonatal intensive care unit were included if they were less than 48 hours old and had not had any blood transfusions, thus ensuring over 70% fetal haemoglobin concentration,³ and they had an umbilical artery oxygen electrode in the thoracic aorta at the level between the sixth and ninth thoracic vertebrae as part of their management.³

For each data recording session the umbilical artery electrode was calibrated using an umbilical

arterial blood sample in a Radiometer ABL-2 blood gas analyser.

Gestational age, birth weight, postnatal age, haemoglobin concentration, arterial blood pH, skin temperature, blood pressure, pulse rate, arterial carbon dioxide tension ($Paco_2$), and clinical state of each neonate were recorded. The ear-lobe clip pulse oximeter sensor was then placed on the hand. Paired measurements of $StcO_2$ and Pao_2 were made with a Ohmeda Biox 3700 pulse oximeter and an umbilical arterial oxygen electrode (Biomedical Sensors, High Wycombe, England), respectively, with a minimum of 30 seconds' stabilisation for each reading. The calibration of the umbilical artery electrode was rechecked at the end of the measurements on each neonate. The total blood sampled for each baby was less than 2 ml.

Results

Thirteen neonates were studied and 125 paired measurements of $StcO_2$ and Pao_2 made. All the neonates were normotensive (mean arterial pressure > 30 mm Hg), and they had heart rates of 130–160/minute and a $Paco_2$ of 3.17–8.07 kPa (mean 6.12 kPa). Eight neonates were ventilated for hyaline membrane disease, five were receiving oxygen by headbox, and none of them had jaundice at the time of the study. Their mean oxygen requirement was 0.37 (range 0.24–0.60), and hence right to left ductal shunting was considered unimportant.

The oximeter sensor applied to an oedematous, bruised hand of one neonate who had had a breech delivery gave a poor quality signal. Movement of the arm carrying the oximeter sensor caused destabilisation of the oximeter reading. The table summarises the clinical details on the 13 neonates. The figure shows the 125 paired measurements. Mean (2SD) curves drawn in the figure were fitted with a MINITAB computer program.

$StcO_2$ of 86–92% corresponded to a range of Pao_2 of 5.0–13.0 kPa. $StcO_2$ of 93%, however, corresponded to a Pao_2 of from 8.5 to over 14.0 kPa, and

Table Clinical data on the 13 preterm infants studied

	Mean	Range
Gestational age (weeks)	29	26–32
Birth weight (g)	1324	610–2360
Postnatal age (h)	26.17	8.25–47.0
Arterial blood pH	7.304	7.167–7.440
Haemoglobin concentration (g/l)	150	113–192
Skin temperature (°C)	36.9	36.4–37.0
Duration of recording per infant (minutes)	53.69	35.0–88.0

Figure Comparison of 125 paired measurements of transcutaneous arterial oxygen saturation (StcaO₂) and arterial oxygen tension (PaO₂). The fitted mean curve $\pm 2SD$ is shown.

therefore an StcaO₂ of over 92% could be associated with hyperoxia. StcaO₂ of 94–96% was associated with a PaO₂ of well over 13 kPa.

Discussion

Sick neonates have such rapidly and widely fluctuating PaO₂ that intermittent blood gas measurements are a poor reflection of the changes. An indwelling umbilical artery oxygen electrode, though clinically useful for continuous monitoring of PaO₂ in a sick baby, requires special techniques of insertion, and

umbilical artery catheterisation in itself is associated with complications.^{3,5} Transcutaneous sensors have been reported not only to be unreliable if the baby is hypotensive or severely acidotic or anaemic, or when vasodilators are being given—all of which are common in sick preterm neonates—but also to cause burns.¹

The pulse oximeter is safe and easy to use and does not require calibration.^{1,2} The IL-282 co-oximeter has been shown to overestimate carboxyhaemoglobin concentrations, thus underestimating oxyhaemoglobin concentration in the presence of fetal haemoglobin.⁶ This has not been evaluated in pulse oximeters, which use different absorption spectra of light wavelengths, and this could be a source of error in the present study. Our study showed that in preterm infants with predominantly fetal haemoglobin StcaO₂ of 86–92% corresponds to a PaO₂ of 5.0–13.0 kPa, and an StcaO₂ of greater than 92% may be associated with hyperoxia and should be checked with in vitro blood gas analysis. Oedema, bruising, and movement at the site of the oximeter sensor can result in inaccurate oximeter readings.

More evaluation of pulse oximetry in different fetal haemoglobin concentrations, underperfusion, and vasoconstrictor drug treatment is needed before it can be widely used in neonatal intensive care. Pulse oximetry, however, can be used to monitor oxygenation in preterm neonates with predominantly fetal haemoglobin. The pulse oximeter's ability to respond rapidly and to display changes in pulse rate make it useful during resuscitation of newborn babies in the delivery room.

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References

- 1 Peabody JL, Emery JR. Non-invasive monitoring of blood gases in the newborn. *Clin Perinatol* 1985;12:147–60.
- 2 Deckardt R, Steward DJ. Non-invasive arterial haemoglobin oxygen saturation versus transcutaneous oxygen tension monitoring in the preterm infants. *Crit Care Med* 1984;12:935–9.
- 3 Wilkinson AR, Phibbs RH, Gregory GA. Improved accuracy of continuous measurement of arterial oxygen tension in sick newborn infants. *Arch Dis Child* 1979;54:307–10.
- 4 Garby L, Sjolín S, Vuille JC. Studies on erythrokinetics in infancy: II The relative rate of synthesis of haemoglobin F and haemoglobin A during the first months of life. *Acta Paediatr Scand* 1962;51:245–54.
- 5 Kollmeyer KR, Tsang RC. Complications of umbilical oxygen electrodes. *J Pediatr* 1974;84:894–7.
- 6 Ryan CA, Barrington KJ, Vaughan D, Finer NN. Directly measured arterial oxygen saturation in the newborn infant. *J Pediatr* 1986;109:526–9.

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