Correspondence

Relationship of transcutaneous PO_2 to arterial PO_2

To the Editor:

We read with interest the refresher course summary by R.L. Knill which appeared in the 1985 Annual Meeting Supplement of the Journal.[1]

We feel many of the readers of Dr. Knill's article may be left with the wrong impression regarding transcutaneous PO_2 ($PtcO_2$). He states that $PtcO_2$ does not "consistently follow the PaO_2 trends." This statement is referenced by only one article which was authored by Dr. Knill.[2] This previous article compared 44 arterial blood samples to $PtcO_2$ values in 20 patients under anaesthesia while the inspired oxygen was reduced to produce an end tidal oxygen of 6.5 per cent.

We recently reviewed the $PtcO_2$ literature and found a great deal of work has resulted in the opposite conclusion.[3–9] We compared 1,073 arterial blood samples to $PtcO_2$ from 106 patients.[9]

We agree that $PtcO_2$ is not PaO_2 but that should be obvious: $PtcO_2$ is the PO_2 from heated skin and PaO_2 is from an arterial blood sample. A more meaningful question is which PO_2 is more useful for patient care. Inspired PO_2 and mixed venous PO_2 are not equal to PaO_2 but that does not mean they are wrong or not useful. $PtcO_2$ is a new PO_2 variable which reflects peripheral tissue PO_2 continuously and noninvasively. We and others have conducted experiments and clinical studies to investigate the response of $PtcO_2$ when the factors in oxygen delivery are varied (i.e., arterial content and cardiac output).[9–12] We have also examined the effect of blood pressure versus blood flow on $PtcO_2$.[13] $PtcO_2$ follow changes in blood flow (cardiac output) and not necessarily blood pressure. Finally, we compared $PtcO_2$ to an internal organ PO_2 (liver surface PO_2) to demonstrate whether the heated skin PO_2 ($PtcO_2$) responds differently than central organ PO_2.[14] $PtcO_2$ followed liver PO_2 during variations of PaO_2, cardiac output and blood pressure.

We fell $PtcO_2$ is a more useful variable to monitor than O_2 saturation during anaesthesia because it detects decreasing PaO_2 or cardiac output both of which affect tissue oxygenation.[15]

Kevin K. Tremper, PH D, MD
Stuart Anderson, MD
Steven J. Barker, PH D, MD
Department of Anesthesiology
University of California – Irvine
Medical Center
101 City Drive South
Orange, California 92668

REFERENCES

1 *Knill RL.* Evaluation of arterial oxygenation during anaesthesia. Can Anaesth Soc J 1985; 32: S16–S19
2 *Knill RL, Clement JL, Kieraszewicz HT, Dodgson BG.* Assessment of two noninvasive monitors of arterial oxygenation in anesthetized man. Anesth Analg 1982; 61: 582–6.
3 *Tremper KK.* Transcutaneous PO_2 measurement. Can Anaesth Soc J 1984; 31: 664–77.
4 *Rafferty TD, Marrero O, Nardi D et al.* Transcutaneous PO_2 as a trend indicator of arterial PO_2 in normal anesthetized adults. Anesth Analg 1982; 61: 252–5.
5 *Harnik E, Kulczycki L, Games MN.* Transcutaneous oxygen monitoring during bronchoscopy and washout for cystic fibrosis. Anesth Analg 1983; 62: 375–62.
6 *Johnson R, Swift D, Murawchick S.* Oxygenation of peripheral tissues in young and elderly patients during spinal anesthesia. Anesthesiology 1984; 61, A226.
7 *Maneksha FR, Bella J, Zawin M, Poppers PJ.* Intraoperative hypoxia and hypotension caused by gastrographin induced hypovolemia. Anesthesiology 1984; 61: 454–6.
8 *Chubra-Smith NM, Grant RP, Jenkins LC.* Transcutaneous oxygen monitoring during endobronchial thoracic anesthesia (abstract). Anesth Analg 1985; 64: 200.
9 *Tremper KK, Shoemaker WC.* Transcutaneous oxygen monitoring of critically ill adults, with and without low flow shock. Crit Care Med 1981; 9: 706–9.
10 *Parzinger G.* Der transkutane PO_2 im hypo- und

normovolamischen schock in beziehung gesetzt zum kontinuierlich gemessenen art. und ven. PO_2, pH-werten und kardiozirkulatorischen parametern. Medical Doctoral Thesis at Ludwig-Maximilians Universitat, Munich, West Germany, 1977.

11 *Tremper KK, Waxman K, Shoemaker WC.* Effects of hypoxia and shock on transcutaneous PO_2 values in dogs. Crit Care Med 1979; 7: 526–31.

12 *Rowe MI, Weinberg G.* Transcutaneous oxygen monitoring in shock and resuscitation. J Ped Surg 1979; 14: 773–8.

13 *Tremper KK, Waxman KS, Applebaum RA et al.* Transcutaneous PO_2 monitoring during sodium nitroprusside infusion. Crit Care Med 1985; 13: 65–7.

14 *Tremper KK, Hufstedler SM, Zaccari J et al.* Transcutaneous and liver surface PO_2 during normotensive shock in dogs. Anesth Analg 1985; 64: 294.

15 *Barker SJ, Tremper KK.* Transcutaneous oxygen tension: a physiological variable for monitoring oxygenation. J Clin Monitoring 1985; 1: 130–4.

REPLY

The specific issue addressed in the Refresher Course was the potential value of various monitors in detecting hypoxaemia during clinical anaesthesia. It is clear that the transcutaneous oxygen tension ($PtcO_2$) does not reflect absolute PaO_2, being anywhere from 30 to 130 per cent of PaO_2 values. Notwithstanding this marked variability, it has been suggested that $PtcO_2$ might be useful in detecting hypoxaemia by indicating PaO_2 trends. In a limited study of anaesthetized adults, we observed that the $PtcO_2$ did not consistently follow PaO_2 changes. From a larger study of patients and a review of the literature, Dr. Tremper has apparently reached the opposite conclusion.

Dr. Tremper's assessment appears to have been based upon significant correlation coefficients between $PtcO_2$ and PaO_2 values at normal and high PaO_2 levels. Ours was based upon the lack of reliability and the very long response times of $PtcO_2$ in following induced reductions of PaO_2. The different conclusions appear related in the first place to differences in data analysis, and specifically to the use of the correlation coefficient in assessing consistency of trend detection. For example, in Figure 2 of Dr. Tremper's original report[1] it appears that PaO_2 values measured every 15 minutes during the course of an anaesthetic increased or decreased ten different times. Since the $PtcO_2$ correlated significantly with these PaO_2 values, it was concluded that the $PtcO_2$ "trended with the PaO_2 values." However, the data presented in the Figure show clearly that with five of the ten changes in PaO_2, the $PtcO_2$ moved in the opposite direction. These inappropriate shifts of $PtcO_2$ cannot all be accounted for by changes in cardiovascular variables. Thus, a direct analysis of Dr. Tremper's data as well as our own, reveals that the $PtcO_2$ does not consistently follow PaO_2 trends. Furthermore, this analysis points out the danger of inferring consistency of $PtcO_2$ performance on the basis of correlation coefficients alone.

Before one accepts the $PtcO_2$ as an indicator of peripheral tissue oxygenation, it is important to remember that it is not a physiological oxygen tension but one which is induced artificially at the surface of the skin, and that it is critically dependent upon and influenced by the factors used to induce it. These include (1) local heating of the skin which vasodilates the circulation and shifts the oxyhaemoglobin dissociation curve to the right (thereby artificially increasing blood PO_2) and (2) the addition of a considerable resistance to oxygen diffusion at the surface of the skin (thereby artificially increasing PO_2 values in the skin). Any $PtcO_2$ value represents a complicated and variable interaction between the effects of these inducing factors and the effects of the principal physiological influences on $PtcO_2$, i.e., the PaO_2, the cutaneous oxygen consumption and the rate of local cutaneous perfusion which is in itself affected by PaO_2. Hence, the varying and unpredictable relationships between $PtcO_2$ and PaO_2. It seems to me that if $PtcO_2$ is to become a meaningful indicator of tissue oxygenation and/or a reliable index of change of PaO_2 or perfusion, some method will have to be found to control or independently assess the influence of the added variables.

For the moment, modern ear oximeters are far more direct, accurate, rapidly responsive and reliable detectors of hypoxaemia in anaesthetized adults.

R.L. Knill, MD, FRCPC
Department of Anaesthesia
University of Western Ontario
London, Ontario

REFERENCE

1 *Tremper KK, Shoemaker WC.* Transcutaneous oxygen monitoring of critically ill adults, with and without low flow shock. Crit Care Med 1981; 9: 706–9.

Recurrence of bronchial asthma after adrenalectomy for phaeochromocytoma

To the Editor:

Although it is well known that plasma epinephrine plays an important role in the relaxation of bronchial smooth muscles,[1–3] there has been only one case report of asthmatic attacks recurring after removal of a phaeochromocytoma in an asthmatic.[4] We wish to report such an episode which occurred