Continuous Po_2 and Pco_2 Monitoring in the Neonate

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The technique for measuring Po_2 transcutaneously ($tcPo_2$) is now well accepted in routine intensive care of the newborn while Pco_2 ($tcPco_2$) is just being introduced. It is an appropriate time to determine the potential value of both electrodes and what problems remain to be solved with the $tcPco_2$ electrode.

$tcPco_2$

Although we reported the first successful attempts to measure Pco_2 transcutaneously on adults in 1973 (1), the technique has not reached widespread clinical use. There are obviously still problems to obtain a predictable and dependable relationship between $tcPco_2$ and $Paco_2$. Problems are both technical and physiological. Hopefully these can be overcome in the future.

From the physiological point of view it is important to stress that the clinically interesting range for Pco_2 is much smaller than for Po_2. So, in principle, the accuracy and reproducibility of the technique has to be better than with transcutaneous Po_2. Furthermore, because the Co_2 molecule reacts with water and carbonic acid is formed slowly dissociating into H^+ and HCo_3^-, the electrode cannot respond as rapidly as the Po_2 nor can small or rapid changes in Pco_2 be detected.

On the other hand there are some theoretical advantages for transcutaneous Pco_2 compared to Po_2. The skin Pco_2 electrode does not consume Co_2 as does the O_2 electrode so that changes in skin permeability and skin thickness should not affect correlation between arterial and transcutaneous Pco_2. Initial results are consistent with this expectation. In addition, the essential criteria for the validity of transcutaneous Po_2 - sufficient blood flow beneath the electrode - seems to be less critical with $tcPco_2$. Hansen and Tooley (2) reported that even a severe fall in mean blood pressure to as low as 20 Torr did not affect the correlation. The method also appears to be particularly suited for physiologic studies of respiratory control in infants.

$tcPo_2$

The value of continuously monitoring Po_2 has been clearly demonstrated by Yamanouchi in the reduction of RLF (3). In two nearly identical groups of immature infants, birthweights between 650-1500 g and treated between 1974-1977, the incidence of RLF was significantly lower when these infants were monitored transcutaneously. This study confirmed those of others that periods of hypoxaemia or hyperoxaemia can only be prevented when a continuous oxygen monitoring technique is used in infants with cardio-respiratory problems.

Prior to the use of continuous oxygen monitoring physicians felt safe with arterial Po_2 values in an acceptable range obtained under ideal conditions every 1-2 hours, when monitoring an infant with cardiorespiratory difficulties. We now know that this confidence in intermittent sampling was unjustified (Fig. 1). Arterial Po_2 can vary from minute to minute to an extent never believed before even in newborns and premature infants with normal cardiopulmonary function.

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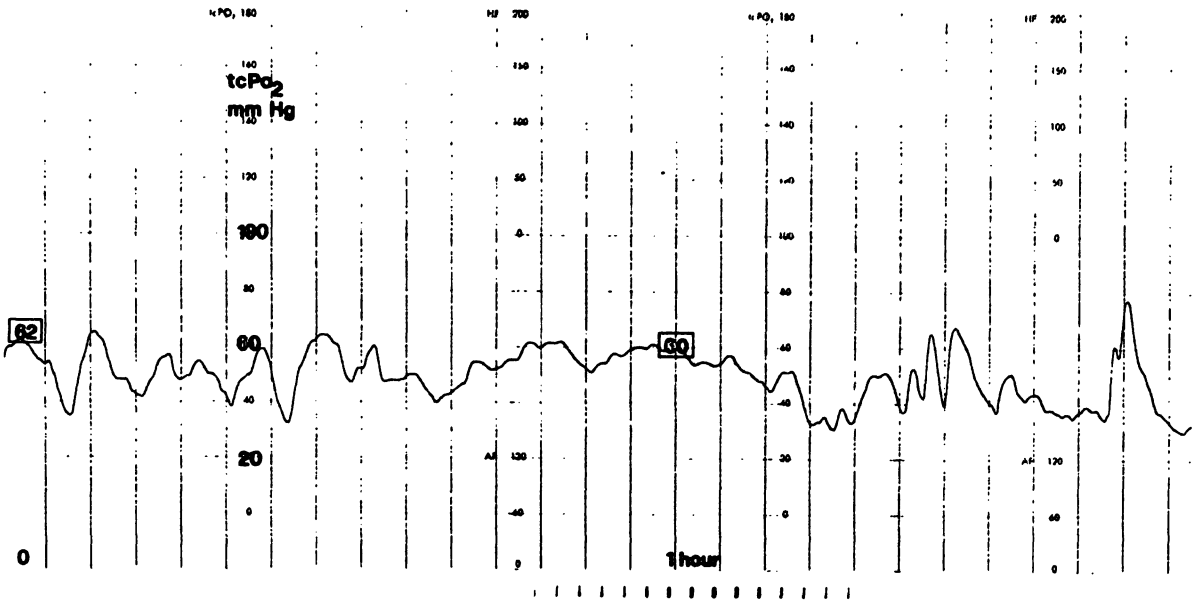

Fig. 1 Excerpt from continuous registration of transcutaneous Po_2 in a low birthweight infant (1620 g) demonstrating the great variability of Po_2 and the information missed when blood samples are taken - even under ideal conditions - every hours; [62] , [60] mm Hg

Because the $tcPo_2$ is measured continuously and non-invasively, without painful arterial blood sampling which can influence the type of breathing, these variations are real.

The technique of $tcPo_2$ has been useful for routine screening purposes in the early neonatal period. This enabled us to describe on the basis of more than 2000 newborns what is physiological and normal in newborn infants with their special post partum circulatory status. On the basis of this experience $tcPo_2$ fluctuations up to 30 mm Hg due to alternating periods of deeper and shallower breathing have to be considered to be physiological. Only when the child is sleeping - and especially when in so called quiet sleep - does $tcPo_2$ show minimal variations. Because Po_2 is so variable even in healthy infants one has to describe a normal range and not one normal value for a given situation.

Fig. 2 shows the histograms from 2000 healthy and quiet newborn infants. The anterior histogram (black) indicates the minimal and the posterior histogram (open) maximal values for $tcPo_2$ at rest during the first day of life.

This figure demonstrates that there is not one normal value for Po_2 for a healthy newborn infant at rest. Although the possible range is large it is apparent that a minimum value of less than 60 mm Hg at rest occurs in less than 1% of cases.

During crying in the first day and week of life Po_2 usually falls, sometimes to hypoxaemic levels. A possible explanation is that the intrathoracic pressure increase, measured during crying (4), results in R → L shunting through fetal circulatory passages. Consequently blood samples taken during crying cannot be used for evaluation of cardiorespiratory

functions. The fact that Po_2 decreases during crying provides an explanation for the great variation in data that has been reported to be normal for Po_2 in the first hours and days of life.

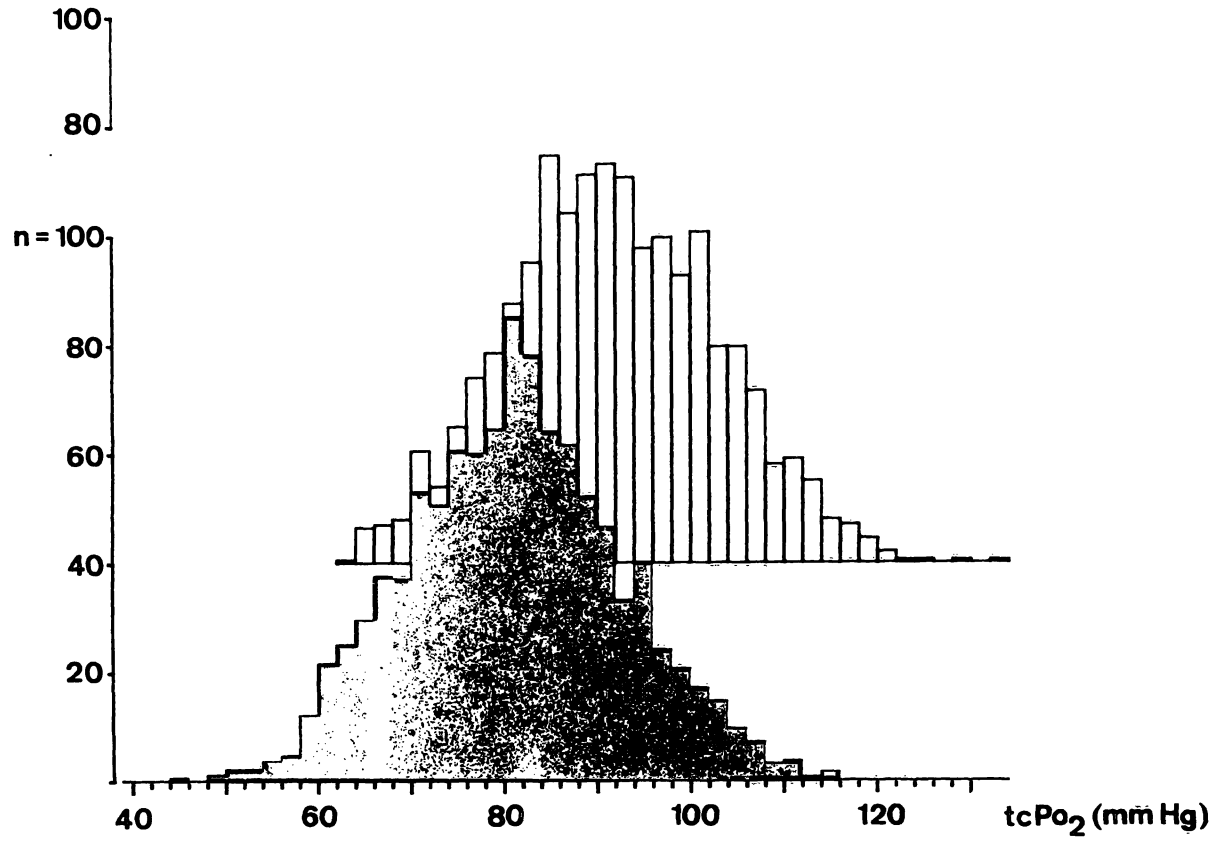

Fig. 2 Histograms of minimal (black) and maximal (open) $tcPo_2$ values in quiet phases of healthy newborn infants (n = 2051)

The most widespread use of $tcPo_2$ monitoring has been in the diagnosis, clinical management and clinical research of infants and children suffering cardio-pulmonary disease. Systematic continuous studies of the $tcPo_2$ pattern of these infants have shown that the normal fluctuations described in healthy newborns are dramatically accentuated in the sick term and preterm infant (reviewed in (5)). $tcPo_2$ has allowed the identification of causative factors linked to the marked swings in Po_2 of these infants.

Continuous $tcPo_2$ has changed and improved our knowledge about what is physiological and what is normal, and also what is iatrogenic and therefore preventable. Experience with continuous blood gas monitoring did tell us that the small safe range of blood gases in neonates should only be monitored continuously.

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