Comparison of Arterial and Arterialized Capillary Blood in Infants with Respiratory Distress

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Arterial sampling for monitoring blood gases and pH in respiratory distress of the newborn is only practised in a few centres in Britain. For control of acid base balance most paediatricians rely on capillary samples, which do not require experienced medical staff for collection. Micro-equipment for measuring Po_2 in capillary samples is now commercially available. This study was planned to assess the practical value of capillary readings. One previous study in sick newborns has been reported (Gandy *et al.*, 1964), but this was in babies of 2000 g. or more.

Material and Methods

Newborn babies suffering from respiratory distress, in whom umbilical artery catheters were inserted for control of therapy, were studied. Details are given in Table I. The age at sampling ranged from 3 to 95 hours, the majority of samples being taken before 48 hours. Capillary samples were collected from a warmed heel (Siggaard-Andersen *et al.*, 1960). Immediately afterwards arterial blood was withdrawn into a heparinized glass syringe, the first 0.5 ml. blood being discarded to avoid dilution with the heparin-saline solution filling the umbilical artery catheter between sampling. Samples were analysed in duplicate either immediately or within an hour after storage in iced water (Siggaard-Andersen, 1961; Johnstone, 1966). pH, PCO_2 , and base deficit were measured by the method of Siggaard-Andersen *et al.* (1960) and Siggaard-Andersen and Engel (1960), using Radiometer equipment. When a micro-oxygen electrode became available (Radiometer E5044) comparative Po_2 measurements were also made. The t test was applied to assess the significance of arterial-capillary differences.

Results

Results are given in Table II, and in Fig. 1 to 4. There was good correlation between arterial and capillary values for pH measurements throughout.

However, PCO_2 , Po_2 , and base deficit were poorly correlated, the differences being significant. Capillary blood tended to have a higher PCO_2 and a lower Po_2 and base deficit. Age, birthweight, and maturity did not influence these results, but the state of the puncture site was important. Feet that were originally warm and where blood flowed freely after puncture were judged to have a good circulation. The presence of oedema of the foot was graded as slight or marked. PCO_2 correlation was poor whatever the state of the foot, though variation was least with a good peripheral circulation. The presence of oedema was the important factor in giving unreliable capillary base deficit measurements. In the absence of oedema, whatever the state of the peripheral circulation, there was close correlation with arterial readings. The number of Po_2 readings was too small for such further analysis.

TABLE I
Details of Babies Studied.

No. of Readings	Birthweight (g.)	Gestation (wk.)	Diagnosis*
3	1340	33	RDS; twin
3	1360	33	RDS; twin
1	1360	30	RDS
6	1423	32	RDS
4	1720	34	RDS; accidental haemorrhage; CS
3	1790	34	RDS; severe PET; CS
1	1930	?	RDS
4	2360	36	RDS
1	2470	34	RDS; accidental haemorrhage; CS
10	2470	36	RDS; placenta praevia; CS
4	2040	32	Bronchopneumonia at 36 hours
3	3630	37	Choanal atresia; diabetic mother; CS
2	3580	43	Meconium aspiration

* RDS, respiratory distress syndrome; PET, pre-eclamptic toxemia; CS, caesarean section.

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TABLE II
Results

		No. of Observations	Mean Difference*	SD	p
All measurements	pH	45	+0.007	0.039	>0.2
	Pco ₂	45	-8.29 mm. Hg	16.7	<0.005
	Base deficit	45	+1.31 mEq	2.36	<0.001
	Po ₂	12	+6.25 mm. Hg	4.8	<0.001
Good circulation	Pco ₂	15	-5.47 mm. Hg	7.1	<0.01
Poor circulation	Base deficit	15	+0.53 mEq	1.9	>0.3
Slight oedema	Base deficit	12	+0.42 mEq	0.9	>0.1
Slight oedema	Base deficit	8	+2.5 mEq	3.32	>0.05
Marked oedema	Base deficit	10	+2.8 mEq	2.39	<0.005

* '+' indicates that arterial value exceeds capillary value.

FIG. 1.—Comparison between arterial and capillary pH.

FIG. 3.—Comparison between arterial and capillary base deficit. ●, no oedema of foot; ○, oedema of foot.

FIG. 2.—Comparison between arterial and capillary Pco₂.

FIG. 4.—Comparison of arterial and capillary Po₂.

Discussion

This study in newborn babies suffering from respiratory distress has shown that capillary Po_2 and PCO_2 results from a heel prick are unreliable for use as a guide to oxygen therapy or the need for artificial ventilation. The arterial-capillary differences are greater than could arise by chance, and the variation of capillary results is wide. The capillary base deficit is a reliable guide to the correction of metabolic acidosis only in the absence of oedema at the puncture site. As many premature babies, and especially those suffering from respiratory distress, develop oedema, the usefulness of capillary samples in sick newborns is limited.

Studies in adults have shown the importance of careful arterialization of the puncture site for collection of capillary blood (Koch, 1965). Results from correctly warmed sites may be unreliable, especially where the peripheral circulation is poor, though the ear lobe is a more reliable site than the thumb (Koch, 1965, 1968; Laughlin, McDonald, and Bedell, 1964; MacIntyre, Norman, and Smith, 1968; Worth, 1965). Satisfactory pH, PCO_2 , and base deficit readings in normal newborns cannot be obtained from capillary blood at birth. Gandy *et al.* (1964) found good correlation with results from arterial blood after 3 hours, and Koch and Wendel (1967) only after 48 hours of life. In healthy prematures Thomsen (1964) found poor correlation, though the ages of the babies were not stated. Koch and Wendel (1967) found capillary Po_2 unreliable in normal neonates.

Gandy *et al.* (1964) studied 40 sick babies, all weighing 2000 g. or more, of whom 18 had respiratory distress syndrome, the others having suffered severe fetal distress, or having severe cyanotic congenital heart disease. The 46 readings in these 40 babies were analysed together. Correlation between arterial and capillary pH and PCO_2 readings was not as good as in normal newborns, but the differences were still much less than those found in the present study. This may be due to the difference in maturity in the two groups. They found good correlation throughout for base deficit. This contrasts with the present findings, where there was poor correlation for base deficit in the overall figures, though the error was shown to arise from samples from oedematous feet. All these studies in babies have used blood from a heel stab. Desai *et al.* (1967), in older newborns having artificial ventilation for tetanus, used capillary samples from the scalp, and found excellent correlation of Po_2

with temporal artery samples. It is possible that this site might give more reliable results in respiratory distress than the heel.

Summary

Comparison was made of 45 capillary heel prick and arterial samples in 13 newborn babies with respiratory distress. Good correlation was found between arterial and capillary pH. Both capillary PCO_2 and Po_2 were unreliable. Base deficit readings were reliable whatever the state of the peripheral circulation unless there was oedema of the feet.

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