Value of Arterialized Capillary Blood Gas Analysis in Lower Respiratory Tract Infection in Childhood

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Doig, W. B. (1971). *Archives of Disease in Childhood*, **46**, 243. **Value of arterialized capillary blood gas analysis in lower respiratory tract infection in childhood.** Blood gas analysis on arterialized capillary blood in 70 young infants yielded satisfactory information about oxygen therapy. Inspired oxygen concentrations above 40% are often required to raise the capillary Po_2 of hypoxic infants above 70 mmHg. Oxygen concentrations above 40% are difficult to achieve and maintain in presently available oxygen tents, though not in modern incubators, or oxygen chairs. A raised PCO_2 has frequently been found in infants with severe respiratory infections, but oxygen therapy has not resulted in CO_2 narcosis in these acute emergencies.

Acute infections of the lower respiratory tract (LRTI) such as acute bronchiolitis and bronchopneumonia constitute a common problem in infancy. They vary widely in degree of severity, but nursing in a humid and oxygen enriched atmosphere is often indicated. Since the degree of hypoxia endured by these infants may be greater than that suggested by the clinical assessment of cyanosis and respiratory difficulty, it is desirable to be able to monitor oxygen therapy by measuring blood gases, relating Po_2 level to the ambient oxygen concentration. Only by so doing can it be certain that oxygen is required and is being given in adequate concentration. Unfortunately the technical problems have all too often resulted in the dyspnoeic infant whose oxygen tension is unknown being nursed in a tent where the oxygen concentration is also unknown. In the neonatal period the accessibility of the umbilical arteries means that arterial Po_2 levels can be measured with relative ease; in older children and adults arterial blood may be obtained by arterial puncture or by the insertion of an indwelling catheter. In infancy, however, arterial sampling is more difficult. Arterialized capillary blood obtained after suitable preparation of the capillary bed is an alternative to arterial puncture, and we here describe our experience with this technique in 70 infants.

Material and Methods

Seventy infants with ages ranging from 17 to 133 days admitted to hospital with acute LRTI of varying severity were studied. Samples for blood gas analysis were obtained on admission in 66 instances while the infants were breathing air; in 4 cases oxygen was already being given at the time of sampling. In 26 cases both arterial and capillary samples were obtained at the initial examination while the infants were breathing air. Capillary samples were taken from the heel; the chosen site was prepared by rubbing for 4 minutes with thurfyl nicotinate (Trafuril). While waiting for the heel to flush arterial sampling was attempted. The radial artery was preferred and samples were withdrawn into heparinized syringes by direct stab. Capillary samples were then obtained by incising the prepared heel with a Sterolet; blood was collected into 100 μl heparinized glass capillary tubes (Radiometer type D.551) and the ends promptly sealed with plasticine. Thurfyl nicotinate preparation in this way was found to yield a very satisfactory free flow of blood. All measurements were made within 15 minutes of sampling. Po_2 measurements were made with the Radiometer oxygen microelectrode; pH, PCO_2 , standard bicarbonate, and base excess were measured by the Astrup method.

Capillary Po_2 was determined in a control group of 50 babies not suffering from a condition likely to cause hypoxia: the opportunity to obtain samples was taken when blood was required for other investigations (e.g. Hb, WBC, serum calcium etc.). Thurfyl nicotinate preparation was used.

According to the initial results and the degree of hypoxia, patients were nursed in air alone, air with

humidity or in humidity with oxygen enrichment using incubators (Vickers Medical) or Isolette (Air-Shields), small croupettes (Air-Shields), Humidaire tents (Vickers Medical), or oxygen chairs (Gomez *et al.*, 1968). Oxygen enrichment was monitored hourly using a paramagnetic oxygen analyser (Mira). Repeat analyses were obtained from capillary samples as described. When infants were nursed in tents the heel could be withdrawn beneath the canopy without disturbing the infant's atmosphere; if an incubator were used, a port-hole was sealed with a sheet of polythene 30 minutes before sampling, at which time a small hole was made in the sheeting through which the heel was withdrawn: in this way the atmosphere in the incubator was maintained. If an oxygen chair was used, samples were obtained with no disturbance to the infant's environment. Nursing care of the infants requires opening of all apparatus from time to time, but handling was kept to a minimum to avoid loss of oxygen concentration. No sample in this series was taken unless the infant had been in his environment undisturbed for at least 30 minutes.

When an infant is stabbed he cries and may breathhold long enough to cause an abrupt fall in Po_2 level. Indeed in obtaining samples, whether arterial or capillary, a colour change in the blood was often visible during the course of the sampling. Some infants who were not cyanosed and only mildly dyspnoeic when undisturbed became obviously cyanosed on sampling, so that the resultant Po_2 was clearly not truly representative.

Where oxygen therapy was indicated, 35–40% was in most cases adequate. In severe hypoxia over 50% oxygen had to be given for satisfactory relief. Such high levels are obtained quite readily in oxygen chairs (Gomez *et al.*, 1968) and incubators, but even with high oxygen flow rates were difficult to maintain in tents despite manufacturer's claims.

Results

The Po_2 range in the 50 controls was 62–99 mmHg (Fig. 1); 38 infants had Po_2 's of 70 mmHg or greater. A level of less than 70 mmHg in an infant with LRTI was taken as indicating the probable need for oxygen therapy.

Po_2 levels in the 26 patients with LRTI in whom both arterial and capillary samples were obtained are compared in the Table. In 15 instances the arterial level was greater than the capillary, the greatest difference being 18 mmHg, but in 10 instances the capillary level exceeded the arterial, the greatest difference being 13 mmHg; in only one instance were the two identical. These samples were obtained at the same session though not simultaneously. No attempt is made here to compare arterial and capillary Po_2 levels statistically, but the differences probably reflect the difficulty in obtaining a resting state in this age group.

In 66 of the 70 patients the initial capillary

FIG. 1.—Histogram showing the range of Po_2 in arterialized capillary blood samples from 50 normal infants.

TABLE
Initial Arterial and Capillary Po_2 levels in 26 Infants with Lower Respiratory Tract Infection

Arterial Po_2 (mmHg)	Capillary Po_2 (mmHg)	Arterial-Capillary Difference*
82	64	+18
66	52	+14
62	57	+5
89	77	+12
44	53	-9
71	62	+9
84	67	+17
76	67	+9
52	46	+6
63	55	+8
75	72	+3
68	64	+4
57	58	-1
80	87	-7
60	73	-13
71	65	+6
78	81	-3
77	72	+5
70	74	-4
72	68	+4
60	72	-12
78	79	-1
59	59	0
72	75	-3
69	74	-5
64	63	+1

*The + sign indicates an arterial level higher than capillary; the - sign the reverse.

Po_2 level was obtained with the infant breathing air (Fig. 2). The range was 22–87 mmHg and in 42 cases was less than 70 mmHg. 36 of these 42 cases were at once nursed in oxygen. The initial oxygen concentration for the 40 infants so treated ranged from 30–60% and the corresponding Po_2

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FIG. 2.—Histogram showing the range of P_{O_2} in arterialized capillary blood samples in 66 cases of lower respiratory tract infection (breathing air).

levels were 47–118 mmHg. 27 infants were in an adequate concentration (P_{O_2} 70 mmHg or more) but 13 still had a P_{O_2} of less than 70 mmHg. In 2 cases an increase of oxygen to a level still less than 60% was adequate, but in 11 cases a concentration greater than 60% was required to maintain a P_{O_2} of greater than 70 mmHg and 2 infants required oxygen for 12 days or more.

Most infants had a degree of hypercarbia: in air the initial P_{CO_2} levels ranged from 30–100 mmHg, and 38 infants had levels of 45 mmHg or more. During oxygen therapy the highest rise in P_{CO_2} over the initial value obtained after admission, was 15 mmHg and the highest recorded level was 105

mmHg. By discharge the P_{CO_2} in all cases was normal (<38 mmHg). Assisted ventilation was not employed in any infant in this series. There were no deaths.

Illustrative Case Reports

Case 1 (Fig. 3). On admission this 2-month-old infant had signs of severe acute bronchiolitis and was in oxygen when first examined. In an initial oxygen concentration of 30% her P_{O_2} was obviously not satisfactory being only 47 mmHg, and increasing the concentration to 46% had little effect (P_{O_2} —45 mmHg). To obtain a satisfactory P_{O_2} she had to be nursed in a concentration of oxygen of 60% or higher for 10 days and at a somewhat lower concentration for a further 2 days before she maintained a P_{O_2} above 70 mmHg in air alone. 17 samples were obtained from her, 7 during the first 48 hours during which time the required environmental oxygen concentration progressively increased.

Case 2 (Fig 4). Admitted aged 2½ months with moderately severe acute bronchiolitis. On admission he was put straight into oxygen-enriched air and his initial P_{O_2} of 118 mmHg indicated that the environmental concentration of 40% was adequate. After 48 hours he was nursed in air, but as his P_{O_2} fell to 56 mmHg and his clinical condition deteriorated oxygen was restarted. On day 5 he was again nursed in air and was clinically much improved: during sampling however he breatheld and his P_{O_2} of 55 mmHg was clearly not truly representative of his resting state. No further oxygen was given and he continued to improve steadily.

Discussion

Infants with LRTI are often more hypoxic than simple clinical assessment would suggest. In

FIG. 3.—Blood gas findings during oxygen therapy in a 2-month-old infant with severe acute bronchiolitis.

FIG. 4.—Blood gas findings during oxygen therapy in a 2½-month-old infant with acute bronchiolitis.

deciding on the need for, and in monitoring the effect of oxygen therapy, arterial blood sampling is ideally required. While methods of arterial puncture in infants have been described (Shaw, 1968; Bucci *et al.*, 1966), there are undoubted difficulties in this age group and repeated sampling may be particularly difficult. In adults Po₂ values for capillary blood agree closely with those obtained from arterial blood, provided that the site of sampling is adequately prepared (MacIntyre, Norman, and Smith, 1968). In infants the use of thurfyl nicotinate produces a very satisfactory free flow of capillary blood and the heel may be used for repeated sampling during therapy. A major problem in infants lies in their ability to co-operate, so that sampling leads often to breathholding and temporary increase in hypoxia. In this situation Po₂ analysis should be repeated after a short interval if doubt exists as to the true significance of the initial value. Our aim has been to obtain a capillary Po₂ level of 70 mmHg or more. If this was obtained on admission, oxygen therapy was considered unnecessary in the first instance. In some cases subsequent deterioration indicated the need for resampling, and oxygen therapy did sometimes then become necessary.

If the capillary Po₂ on admission was less than 70 mmHg in the absence of breathholding, oxygen was then given. In many of these infants an oxygen concentration of 35–40% was adequate but as has been previously clearly shown (Simpson and Flenley, 1967) some infants require substantially higher concentrations to relieve hypoxia. It is noteworthy also that with the exception of incubators and oxygen chairs which are only suitable for the smallest infants, no tent presently available can reliably and consistently give an atmosphere of much more than 50% oxygen, an observation made by Simpson and Russell in 1967. There remains a need for an improved tent for large infants who require high oxygen concentration in association with high humidity.

Measurement of Po₂ levels in arterialized capillary blood, though less reliable than arterial, allows satisfactory control of oxygen therapy in the young infant when the oxygen concentration in the inspired atmosphere is also monitored. Blood can always be obtained and can be frequently sampled. Oxygen therapy can obviously be more accurately controlled when such measurements are available, and hypoxia more confidently corrected.

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