

Astrup studies in the newborn

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Introduction

BLOOD GAS ANALYSIS is important in the diagnosis and management of acid-base problems. The pH value indicates whether the patient is acidotic or alkalotic. The pCO₂ value gives an idea of whether it is mainly a respiratory or metabolic type of acid-base imbalance. The base-excess value enables a fairly accurate calculation of the bicarbonate required to correct metabolic acidosis using the equation, viz: body weight in kg x 0.3 x base-excess = HCO₃ mEq/L required. In the very young infants, the blood gas values can be estimated by the micro-Astrup technique using arteriased capillary blood from the heel. This study is an attempt to establish the normal values of pH, pCO₂ and base excess of neonates using the existing facilities of the Clinical Diagnostic Laboratory of the University Hospital, Kuala Lumpur.

Materials and Method

Arteriased capillary blood was obtained from heel prick of ten normal, unselected babies, of age half to three days old, and of birth weights more than 2.3 kg.

The heel was warmed by immersion in warm water till it looked pink. It was then held with the investigator's thumb pressing slightly anterior to the baby's heel and the rest of the fingers of the same hand grasping the baby's leg just above the ankle joint. After drying the heel with cotton wool, it was then stabbed with a lancet to a depth of about 5 mm.

Blood flowed out freely and this was collected in a heparinised capillary tube, (Code NW/100/CT. Exogen Limited Glasgow). The tube was held in a slightly slanting position with the lower end dipped into the drop of blood, and the upper end closed with the index finger of the other hand of the investigator which was intermittently released to allow the tube to be completely filled by capillarity. In this way, five tubes of the blood were collected. Each tube was then sealed at one end with plasticine. A metal mixer was put into the capillary tube via the other end which was then sealed with plasticine. After this, the tube was held horizontally and the metal mixer moved to and fro with a magnet. The five tubes of blood collected were sent to the laboratory for estimation by the technician using the micro-Astrup technique.

At times, blood flowed from the heel slowly. This needed slight pressure on the heel with the investigator's thumb to squeeze out the blood, or rubbing the heel repeatedly with dry cotton, or another stab wound on the heel concerned.

Results

The results obtained by the writer are shown in **Table 1**. The average values obtained for pH, pCO₂ and base excess are 7.36, 34.9 mm Hg and -4.8 mEq/L respectively. A comparison with values obtained by other investigators is shown in **Table 2**.

Discussion

The acid base status of an individual is best assessed on arterial blood using the Astrup method. This, however, is not feasible, especially in paediatric patients. Fortunately, arterialised capillary blood provides a good approximation for practical purposes. Gandy et al (1964) obtained good correlation between arterial and arterialised capillary blood pH and pCO₂ in healthy newborn over three hours of age. In newborn less than three hours old, correlation was not so good especially in regard to pCO₂. The discrepancy was greater in infants with impaired cardiopulmonary function. The correlation for base excess, however, was good throughout. Malan et al (1966), using arterialised capillary blood, obtained results which compared very favourably with those of Reardon et al (1960) using arterial blood in normal full-term neonates of age even less than three hours. Ann Bannister (1966), in a study of 13 neonates with respiratory distress, found good correlation between arterial and capillary values for pH throughout; pCO₂ correlation was poor. In the case of base excess values, correlation was good provided blood was obtained from an oedema-free site.

The practical aim in the technique of micro-Astrup study is to collect anaerobically blood which is as arterialised as possible, and send it without delay to the laboratory for estimation. Considerable errors, which will invalidate the results, can occur in the collection and final estimation of the blood. Since it is often the doctor who is responsible for the blood collection, this is the area where attention to details is of utmost importance in this discussion.

Arterialised capillary blood is obtained after the warming the heel. Gandy et al (1964) warmed the heels in warm water (42 degrees C) for ten minutes. Malan et al (1966) warmed for 15 minutes. The writer's warming technique is less standardised and is insufficient and this probably contributes to the more acidotic values compared with those of other workers. (Table 2). The correlation between arterial blood and capillary blood for unwarmed heels is very poor. Gandy et al (1964) found the difference to be as high as 0.15 for pH and 48 mm Hg for pCO₂. Fischer and Toussaint (1963)'s results which were from unwarmed heels (Table 2) also showed a very acidotic picture. Adequate warming of the heels also promotes free flow of the blood, and thus prevents squeezing of the heel which adds tissue fluid to the blood and also causes venous congestion; furthermore, it enables sufficient blood to be obtained from just one stab of the heel and thus prevents the baby

Table 1. Acid-Base Values of 10 Normal Newborn

Number	Age (day)	pH	pCO ₂ mmHg	Base excess mEq/L
1	3	7.39	31.5	-4.0
2	1	7.31	42.0	-5.0
3	2	7.39	31.5	-5.0
4	3	7.37	39.0	-2.5
5	2	7.35	38.0	-4.2
6	1	7.35	38.0	-4.2
7	½	7.33	36.0	-6.5
8	1	7.37	35.5	-4.0
9	1	7.42	27.0	-5.5
10	½	7.36	30.5	-7.0

Table 2. Neonatal Acid-Base Values reported by various investigators

Author	Weight	Age	pH	pCO ₂ mmHg	Base excess mEq/L
*Reardon et al (1950)	2.4 kg	4-24 hr	7.43	30.0	-2.8
*Fisher and Toussaint (1963)	2.1 kg	24 hr	7.28	35.5	-8.8
*Kildeberg (1964)	Full term	0-7 day	7.40	35.4	-1.9
Malan et al (1966)	Full term	4 hr	7.38	36.7	-2.5
Malan et al (1966)	Full term	24 hr	7.41	34.9	-1.4
Hee (1970)	Full term	½-3 day	7.36	34.9	-4.8

* quoted by Malan et al (1966)

from crying which can cause a decrease in pCO₂, (Heese et al, 1966).

The avoidance of air bubbles in the capillary tube is also very important because air bubbles interfere with the technical process of blood gas estimation on the micro-Astrup equipment. Air bubbles also promote loss of CO₂ from the blood but this is a rather slow process (Siggard-Anderson 1965). In the writer's limited experience, it is found that free-flowing blood from the heel, consequent upon adequate warming of the heel plus rubbing of the heel with a little vaseline before stabbing it, usually enable anaerobic collection of blood in the capillary tube quite easily.

High temperature promotes metabolism which can interfere with the results. Hence the blood collected must be sent to the laboratory as soon as possible. In this study, the estimation was done in less than half an hour. Gandy et al (1964) and Heese et al (1966) were amongst the many investigators who performed the estimation immediately or within one hour after collection during which time the blood specimens were kept in refrigeration. Heese et al (1966) emphasised the need to record the body temperature at the time of the Astrup study to allow for corrections to be made in determining the actual pH of the patient. This latter measurement is extremely important in the paediatric age-group, especially in premature and newborn infants in whom hypothermia occur both easily and rapidly. Temperature corrections for actual pH are made thus: add 0.015 for every one degree C that the patient is below 38 degrees C, and subtracting 0.015 if it is above 38 degrees C.

In the premature newborn, the blood gas values are more variable compared with the full-term newborn in any sample studied. For premature babies of about 24 hours of age, Malan et al (1966) obtained values of pH, pCO₂ and base excess ranging from 7.33 to 7.48, 27.6 to 43.0 mm Hg and -7.4 to 0 mEq/L respectively.

In conclusion, a proper technique of blood collec-

tion can influence significantly the results of neonatal Astrup studies, especially in regard to adequate warming of the heels immediately prior to blood collection.

Summary

A method of collecting blood for pH, pCO₂ and base excess estimation of arterialised capillary blood of ten normal newborn is described. The factors affecting the results were discussed and the need to pay attention to details in blood collection was emphasised.

Acknowledgement

1. Mr. Leng Keng Sai of the Clinical Diagnostic Laboratory, University Hospital, for carrying out the blood gas estimation.
2. Professor A.E. Dugdale of University Hospital for his advice and encouragement; this study was carried out during the writer's internship in his unit.
3. Professor Lau Kam Seng of University Hospital for provision of laboratory facilities.
4. Dr. R. Menon of General Hospital, Kuala Trengganu, for advice in the preparation of this manuscript.

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