

Factors Influencing the pH Value of Foetal Scalp Blood with Special Reference to Caput Succedaneum

H. ODENDAAL

SUMMARY

Foetal pH estimations are most helpful in evaluating the intra-uterine condition of the foetus. False abnormal and false normal values, however, are caused by certain conditions of which caput succedaneum is one.

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Foetal loss and neonatal death rate are still challenges to obstetricians. Several techniques have been developed to estimate the foetal well-being *in utero*—the pH determination of the foetal blood being one of these. The technique has been described by Saling¹ and Morris and Beard.^{2,3} Several reports showed the reliability of this technique in predicting the Apgar score of the foetus.⁴⁻¹³

There are, however, cases where the foetus is observed to be acidotic shortly before delivery, but is nevertheless born in a vigorous condition. On the other hand, there are conditions where the foetus is only minimally acidotic, but is severely depressed at birth. Bowe *et al.*¹⁴ called these false normal, false abnormal values. They reported an incidence of 10,4% false normals, and 7,6% false abnormal. Hon *et al.*¹⁵ reported that 20,1% of samples with a greater pH than 7,20 were associated with an Apgar score of 1-6 at one minute. With a foetal pH of 7,20 or less, 57,7% of samples were associated with an Apgar score of 7-10 at one minute.

Beard *et al.*¹⁶ found that when the pH was more than 7,25, 92% of babies had an Apgar score of 7 or more. When the pH was less than 7,16, 80% of babies had an Apgar score of 6 or less.

Several factors may lead to these false normal and false abnormal values.

FALSE NORMAL VALUES (NORMAL pH WITH A LOW APGAR SCORE)

Maternal Sedation

Medication or anaesthesia given to the mother accounts for more false normal values than any other cause. Heavy

sedation of the mother, especially in cases of pre-eclamptic toxemia, causes depression of the baby without causing any foetal acidosis.

Infection

Bowe *et al.*¹⁴ reported 2 cases of maternal or foetal infection where the foetal acid-base status was completely normal. One of these resulted in a neonatal death. When the foetus is in an infected environment, it is advisable to hasten the delivery as much as possible.

Airway Obstruction

This may be caused by obstructive congenital abnormalities of the tracheobronchial tree, aspiration pneumonia as a result of prolonged rupture of the membranes, or obstruction of the trachea by a mucus or meconium plug. It is often seen that the foetus starts crying as soon as this plug is removed.

Mechanical Trauma

Different factors such as a difficult forceps delivery, intracranial haemorrhage, delay in delivery of the after-coming head during breech delivery, impaction of the shoulders and precipitate labour may play a role. In these cases the intra-uterine foetal pH is most probably normal, but a low Apgar is caused by delay in the second stage. The same is seen in cases of intracranial haemorrhage.

Prematurity

Depression will only be seen in the smaller infant where hypotonia due to developmental immaturity exists or where pulmonary ventilation may be prevented by the low lung compliance or soft chest wall.

Delayed Recovery of the Central Nervous System

With severe asphyxia the foetal central nervous system depression closely follows the increased foetal acidosis, but the nervous system may still be depressed after the foetal pH has returned to normal values.

Department of Obstetrics and Gynaecology, Tygerberg Hospital and University of Stellenbosch, Tiervlei, CP

H. ODENDAAL, F.C.O.G. (S.A.), M.MED. (O. AND G.), M.R.C.O.G.

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Delay in Delivery

The sooner the foetus is delivered after the pH estimation the better the correlation between the Apgar score and the pH values will be. Foetal distress could occur after the last normal pH value. An example of this is a low-lying umbilical cord.

Technical Faults

Under normal conditions the standard deviation of the pH measuring system should not be greater than 0,005 units. Causes of inaccuracies could be associated with the liquid junction, the reference electrode or the electrode glass. Another source of error is contamination of the electrode glass from blood proteins. If the apparatus is used too infrequently, dissolution of the electrode glass or drying out of the liquid reservoir may occur.²⁷ When the foetal blood is stored for long periods in the polyethylene tubes, carbon dioxide may diffuse through the capillary wall with a resultant abnormal pH.

FALSE ABNORMAL VALUES (LOW FOETAL pH ASSOCIATED WITH A NORMAL APGAR SCORE)

Maternal Acidosis

Several authors mentioned the effect of maternal metabolic acidosis on the acid-base status of the foetus.¹⁷⁻²³ Reduction of the foetal blood pH may be the result of a decreased blood base or increase in the $p\text{CO}_2$, or both. During pregnancy the $p\text{CO}_2$ falls from the non-pregnant value of 40 mmHg to an average of 32 mmHg and is due to increased pulmonary ventilation. This effect starts in the luteal phase of the menstrual cycle and is increased during pregnancy. It is caused by the effect of progesterone on the respiratory centre.

Plasma bicarbonate is also reduced during the luteal phase of the menstrual cycle to compensate for the respiratory alkalosis. The average value is 20,8 mEq/litre at the end of pregnancy.

Maternal metabolic acidosis, although rare in the first stage of labour, may be associated with serious maternal metabolic disorders such as kidney disease or diabetes mellitus. Metabolic acidosis is more pronounced in the late first stage or second stage and is caused by strong muscle contractions involved in the expulsion of the baby. This metabolic acidosis is more pronounced in the primigravida and where long and difficult labour exists. The decrease in the maternal base is then reflected by a fall in the foetal blood pH as the placenta has a permeable effect on the bicarbonate. The result is a low foetal pH.

Lack of nutrition in labour causes ketonuria more rapidly than in the non-pregnant subject. Although there is no causal relationship between the ketosis and acidosis, these abnormalities are frequently associated with each other.

Technical Faults

Again the technique of pH measurement may be defective. The collection of blood in polyethylene tubes, where an excess of heparin is used to soak the cotton thread, may lower the pH.²⁴

Pressure by the Amnioscope

This may lead to a decreased perfusion of the sample area. Anaerobic metabolism with an accumulation of lactic acid takes place, as well as an increase in the carbon dioxide. The end result is a decrease in the pH. When insufficient hyperaemia is obtained, the same effect may be seen.

Caput Succedaneum

This condition is frequently seen in cases of prolonged labour, especially when a mild degree of cephalopelvic disproportion is present. It is also more often seen in Bantu patients where the higher incidence of an anthropoid pelvis leads to more occipitoposterior positions of the foetal head. The stronger uterine contractions together with the prolonged labour due to long rotation of the occiput lead to a higher incidence of caput succedaneum in the Bantu.

Several authors mention that caput formation may lead to stasis which tends to increase the local carbon dioxide concentration and decrease the base. McDonald⁹ mentioned 3 such cases.

Clayton²⁵ suggested that oedema of the scalp will impede the circulation. Gare²⁶ mentioned that the effects of caput oedema or the firm application of the dilating cervix to the foetal head, have not been studied. They believe that these factors may play a role when scalp puncture samples are analysed. Hon and Khazin¹¹ reported that the effect of local conditions of the scalp, such as oedema, caput and vasoconstriction on the quality of the foetal scalp sample, is extremely difficult to determine.

For these reasons it was decided to study the effect of caput succedaneum on the pH value of the foetal scalp blood.

PATIENTS AND METHODS

Only infants with caput succedaneum were included in the trial. Blood was obtained from the area of caput and a 'normal' area of scalp within approximately 5 minutes of delivery. It was attempted to take the two samples simultaneously or, when this was not possible, to take the sample from the 'normal' area first and then from the area of caput.

The same technique as for the intra-uterine sampling was used. The area was first sprayed with ethyl chloride to produce vasoconstriction and then rubbed vigorously with a cotton swab to obtain reactive vasodilatation and hyperaemia. The area was then cleaned with a sterile dry

swab and a thin film of liquid paraffin was smeared over the sample area to obtain a well-formed drop of blood. With a 2-mm-wide guarded blade, two or three 2-mm-deep incisions were made and blood collected with heparinised glass capillary tubes. The pH readings were taken immediately after collection of the samples. The incision areas were sprayed with Polyflex and observed for further bleeding. There were no complications such as haemorrhage, abscesses or haematomas. It was obviously more difficult to obtain sufficient capillary haemorrhage from the caput than from the normal area.

RESULTS

A total of 20 babies was studied. Table I shows the pH values of the different areas and the one-minute Apgar score of the foetus.

TABLE I. pH VALUES IN NEONATES WITH CAPUT SUCCEDANEUM

Patient No.	pH caput	pH 'normal' area	Apgar score
1	7,28	7,35	8
2	7,21	7,22	9
3	7,21	7,31	9
4	7,08	7,28	1
5	7,10	7,25	9
6	7,28	7,28	9
7	7,26	7,31	10
8	7,23	7,29	10
9	7,18	7,18	3
10	7,30	7,32	8
11	7,20	7,29	6
12	7,18	7,23	5
13	7,25	7,28	10
14	7,08	7,17	4
15	7,30	7,35	6
16	7,28	7,28	9
17	7,09	7,14	6
18	7,01	7,20	8
19	7,13	7,15	8
20	7,21	7,24	10
AV	7,1895	7,2540	—
SD	0,0829	0,0628	—
SE	0,185	0,140	—

AV — average value; SD — standard deviation; SE — standard error.

The average pH value of the caput area was 7,1895 while the normal areas had an average pH of 7,254 (Table II). The difference between these two values was 0,0645 which is statistically significant (t -value = 2,7718; $P < 0,005$).

As a control group 15 neonates without any caput succedaneum were examined. Most of these were uncomplicated vertex deliveries. A few were delivered by elective Caesarean section. Using the same procedures as in the study group, blood samples were obtained from occiput and lateral sides of the head. These were also immediately

examined. The results are shown in Table III. No statistically significant difference between these values could be demonstrated ($P > 0,5$).

TABLE II. HIGHER INCIDENCE OF FALSE ABNORMAL pH VALUES IN NEONATES WITH CAPUT SUCCEDANEUM

Block	Caput	Normal
1 (low Apgar; high pH)	0	2
2 (high Apgar and pH)	12	14
3 (low Apgar and pH)	4	2
4 (high Apgar; low pH)	4	2

TABLE III.

Patient No.	pH lateral	pH occiput
1	7,345	7,382
2*	7,251	7,241
3	7,320	7,280
4	7,37	7,28
5	7,35	7,29
6	7,120	7,150
7	7,321	7,245
8*	7,386	7,385
9*	7,281	7,282
10	7,281	7,302
11	7,397	7,367
12*	7,396	7,385
13	7,305	7,261
14*	7,382	7,383
15	7,325	7,345
AV	7,322	7,305
SD	0,071	0,069
SE	0,0185	0,0177

* Elective Caesarean section, (t -value = 0,66; $P > 0,5$).

DISCUSSION

Fig. 1 and Table II show that there were 2 false normals in the normal group in comparison with the 4 false normals in the caput group. This shows that the presence of caput may lead to the diagnosis of foetal distress when it does not exist.

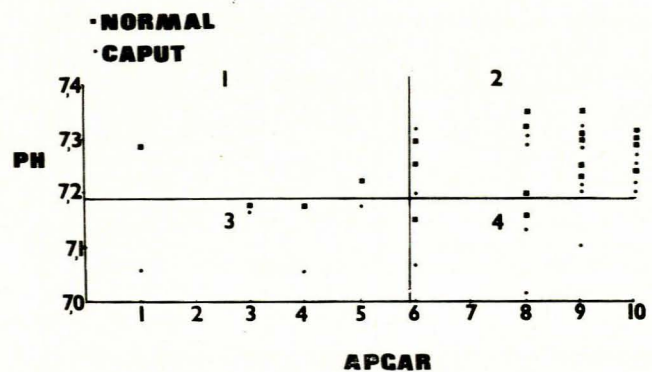


Fig. 1. See text.

It is usually possible to determine the presence of caput during vaginal examination. When a low intra-uterine foetal pH value is obtained in these cases it must be kept in mind that the oedema may cause the acidosis. It would be advisable in these cases not to go entirely by the pH value, but also to evaluate the clinical signs of foetal distress.

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