

Correlation between the foetal acid-base status and the Apgar score*

K. H. LEE†
M.D., M.R.C.O.G.

University of Hong Kong

Summary

The foetal pH values of eighty-eight cases delivered within 30 min after foetal blood sampling were correlated with the 1-min Apgar score. With a pH of 7.20 or above the error of prediction was 1.3%. The error in cases with pH below 7.20 was 54.5%.

Significantly higher pH and lower Δ base deficit were present in the low foetal pH group in vigorous, as opposed to depressed infants, suggesting that infusion acidosis was present in infants with a high Apgar score.

The degree of correlation between the foetal pH and the Apgar score was not significantly influenced by shortening the sampling-delivery interval to 15 min or lengthening it to 3 hr. The most significant factor affecting the degree of correlation in the present study was the setting of the critical pH. If the criterion of the critical pH was taken as 7.13 there would have been no false positive results and the error of prediction in cases delivered within 30 min of foetal blood sampling would be reduced to 1.1%.

THE foetal pH has been regarded as the most valuable parameter for the diagnosis of foetal hypoxia and depressed foetal acid-base values have been shown to be closely correlated with the severity of foetal asphyxia (Saling, 1965; Beard, Morris & Clayton, 1966). Correlation between the foetal pH and the Apgar score by previous workers has not given consistent results (Beard, Morris & Clayton, 1967; Paul, Gare & Whetham, 1967; Haworth, Milic & Adamson, 1968; Hon, Khazin & Paul, 1969; Lumley & Wood, 1969; Galloway, 1970). This has been attributed by Beard (1970) to the fact that many workers have not taken the sampling-delivery interval into consideration. Hon *et al.* (1969) have also shown that big discrepancies between the pH and the Apgar score are due to the time interval between foetal blood sampling and delivery. Beard and his co-workers (Beard *et al.*, 1967) have studied only cases delivered within 30 min after foetal blood sampling and think that an interval of more than 30 min is too long. On the other hand Galloway (1970) has attained

good correlation between pH and score in cases delivered within 3 hr after sampling.

This paper presents the results of a study of the relationship between the foetal pH and the Apgar score at three different sampling-delivery intervals, namely 3 hr, 30 min and 15 min.

Material and methods

Foetal blood sampling was performed in 307 Chinese patients at the Tsan Yuk Hospital, Hong Kong from January 1969 to March 1970. Fifty-six of these were normal cases, 200 showed clinical signs of foetal distress and the remaining fifty-one were high risk cases. The details of the acid-base status of this series have been reported separately (Lee, 1972b). A total of 206 cases were delivered within 3 hr after the last foetal blood sample was collected. The sampling-delivery interval was within 30 min in eighty-eight cases and within 15 min in forty-six.

The foetal pH values were divided between those above and below 7.20. The Apgar scores taken at 1 min after birth were divided between 6 and 7 to differentiate depressed from vigorous infants. The relationship between the foetal pH and the Apgar score was studied in a manner similar to that of Beard and his co-workers (Beard *et al.*, 1967).

Results

Sampling-delivery interval within 30 min

Figure 1 is a scattergram showing the foetal pH of the eighty-eight cases in relation to the Apgar score. The horizontal line divides the pH values above and below 7.20. The vertical line separates the vigorous from the depressed infants.

Group A consisted of seventy-six cases with foetal pH 7.20 or above and Apgar score of 7 or more. Group X contained five cases with pH below 7.20 and low Apgar score. These two groups represented correct predictions of the condition of the infant from the pH of the foetal blood sample. They comprised eighty-one of the eighty-eight cases or 92.1%.

Group B contained only one case with normal pH but low score. Group Y was made up of six cases with low pH but vigorous infants. These seven cases were the erroneous predictions giving an error of 7.9%.

* The material in this paper has been taken from an M.D. Thesis submitted to the University of Hong Kong.

† Present address: Tsan Yuk Hospital, Hospital Road, Hong Kong.

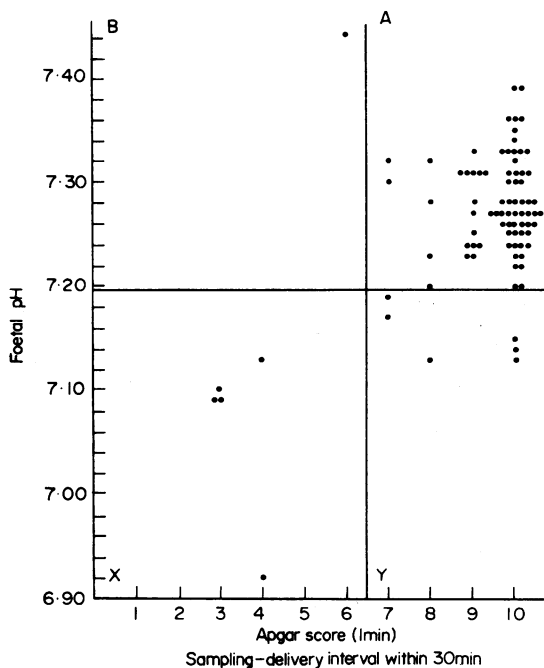


FIG. 1. Distribution of pH values relative to Apgar score in eighty-eight cases delivered within 30 min after foetal blood sampling.

The mean acid-base values for each of the groups A, X and Y are shown in Table 1. The mean foetal pH in group A was 7.28 and the mean maternal pH 7.38. These values showed no significant difference from those found during normal labour in Chinese women as reported separately (Lee, 1972a).

The mean foetal pH in group X was 7.07. This, and the values of pH_{qu40}, P_{CO₂}, standard bicarbonate, base deficit and Δ base deficit were all significantly different from those in group A ($P < 0.001$). The mean maternal pH in group X was 7.36 which showed no significant difference from that in group A.

Cases in group Y had a mean foetal pH of 7.15 which was significantly lower than that in group A ($P < 0.001$). Comparison between groups X and Y showed that the acidosis in group X was more severe. The mean foetal pH, pH_{qu40} and standard bicarbonate were significantly lower in group X and the mean base deficit and Δ base deficit were signifi-

cantly higher. All the cases in group Y had a foetal pH of above 7.13 whereas it was below 7.13 in all the cases in group X. Furthermore, the Δ base deficit in group X was more than 4 mEq/l in all cases whereas in group Y it was less than 4 mEq/l in three of the five cases.

In the seventy-seven cases with pH above 7.20, the Apgar score was 7 or more in seventy-six (98.7%). Only one infant (1.3%) was depressed at birth. Of the other eleven cases with foetal pH less than 7.20, five (45.5%) were depressed and six (54.5%) recorded a score of 7 or more. The difference in the incidence of neonatal asphyxia between the group with high pH and that with low pH was highly significant ($P < 0.001$).

Sampling-delivery interval within 15 min

Figure 2 shows the relationship between the foetal pH and Apgar score in the forty-six cases delivered within 15 min after foetal blood sampling. The error in prediction was 8.7% (four cases) which was not lower than that in cases with sampling-delivery interval within 30 min.

Sampling-delivery interval within 3 hr

The distribution of the pH relative to the Apgar score in these 206 cases is shown in Fig. 3. The nineteen cases of erroneous predictions (groups B and Y) constituted an error of 9.2%, which was not significantly different from the error in cases delivered within $\frac{1}{2}$ hr of sampling. Among the cases with pH higher than 7.20 nine of the 192 infants were depressed at birth (4.7%). Of the fifteen infants with pH lower than 7.20, ten (66.7%) had Apgar scores of 7 and above.

Discussion

Considering the cases delivered within 30 min after foetal blood sampling, the error in prediction in the present series was 7.9%, which was lower than that of 18% reported by *Bowe et al.* (1970). Further study of the results showed that when the foetal pH was 7.20 or more, 98.7% of the infants were vigorous at birth. On the other hand, among the cases with foetal pH less than 7.20 only 45.5% were depressed at birth. Thus, the incidence of false negative results was only 1.3% while that of false positive results was 54.5%.

TABLE 1. Mean acid-base values of groups A, X and Y

| | pH | pH _{qu40} | P _{CO₂} (mmHg) | Standard bicarb. (mEq/l) | Base deficit (mEq/l) | Δ base deficit (mEq/l) | Maternal pH |
|---------|------|--------------------|---------------------------------------|--------------------------------|----------------------------|-------------------------------------|----------------|
| Group A | 7.28 | 7.33 | 49.9 | 20.5 | 4.7 | 0.1 | 7.38 |
| Group X | 7.07 | 7.13 | 69.3 | 12.7 | 16.9 | 10.1 | 7.36 |
| Group Y | 7.15 | 7.22 | 54.6 | 15.8 | 11.1 | 4.5 | 7.35 |

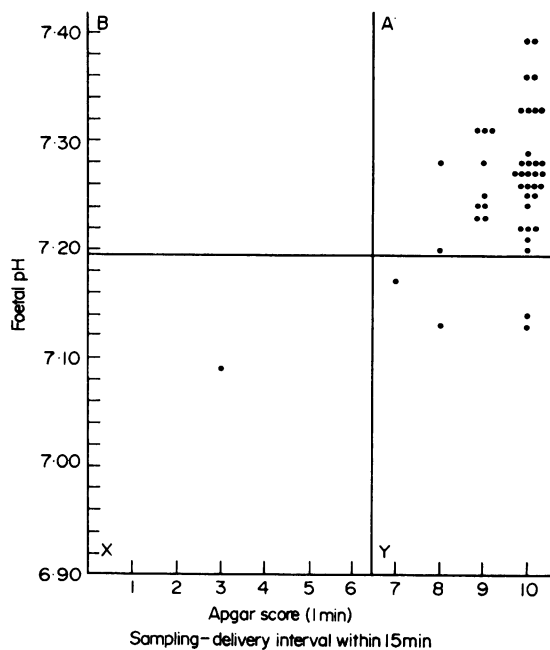


FIG. 2. Distribution of pH values relative to Apgar score in forty-six cases delivered within 15 min after foetal blood sampling.

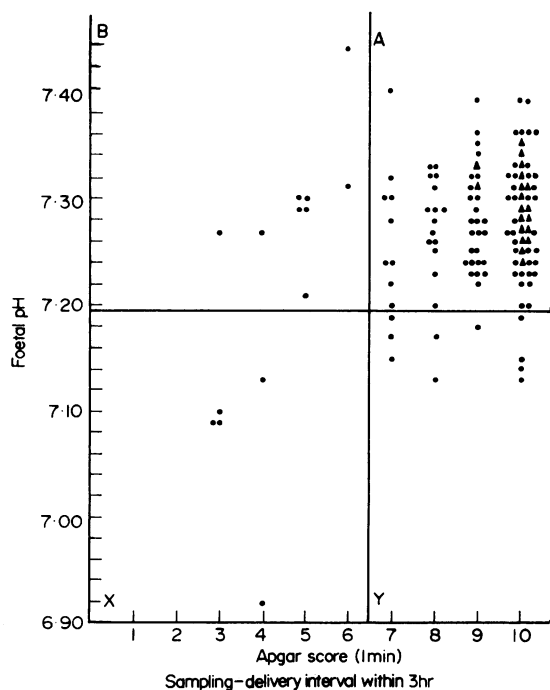


FIG. 3. Distribution of pH values relative to Apgar score in 206 cases delivered within 3 hr after foetal blood sampling. ▲ represents five points.

Other investigators have also encountered more false positive than false negative results and reported incidences have varied from 5 to 45% (Kubli, 1966; Paul, Gare & Whetham, 1967; Wood *et al.*, 1967). False negative results, that is normal pH and low score, are less acceptable. Beard (1970) suggested that the reason for the high incidences of false positive results obtained by some workers was that the sampling-delivery interval had not been taken into consideration.

Table 2 summarizes the results of three recent studies together with the present one in which foetal blood samples were collected within 30 min before delivery. In all these studies a foetal pH below 7.20 was considered abnormal and an Apgar score of less than 7 as evidence of a depressed infant. With normal foetal pH the infant was vigorous at birth in 87-98% of cases. However, a low foetal pH did not correlate so well with the condition of the infant at birth as a normal pH. The incidences of false positive result in Table 2 ranged from 45 to 70%. Beard *et al.* (1967) found twenty-five false positive cases out of a total of sixty acidotic foetuses and noted that the mean pH of this group was not as low as among the low Apgar score infants and that maternal acidosis was more common. They concluded that transient hypoxia and infusion acidosis were the major causes of false positive results.

Comparison between depressed and vigorous infants among those with low pH (group X and group Y) in the present series gave support to the view of Beard. The mean foetal pH of 7.07 among the depressed infants was significantly lower than that of 7.15 in cases with vigorous infants ($P < 0.05$). Furthermore, the Δ base deficit was significantly smaller in the infants with a high score indicating that a proportion of the acidotic foetuses in group Y were associated with a more pronounced maternal acidosis. Beard (1970) considers a Δ base deficit of less than 4 mEq/l as indicating infusion acidosis and a Δ base deficit of more than 4 mEq/l as meaning hypoxic acidosis. In the present cases, the Δ base deficit in group X was more than 4 mEq/l in all cases whereas in group Y it was less than 4 mEq/l in three out of five cases.

Saling (1966) considers that the pH_{qu40} provides a more meaningful index of the condition of the foetus. On the other hand other workers have suggested that the level of metabolic acidosis has little advantage over the actual pH in prediction of the condition of infant (Beard *et al.*, 1967; Hon *et al.*, 1969; Khazin, Hon & Quilligan, 1969). The results in the present study did show that the metabolic component gave a better prediction. Among the cases with pH below 7.20 (groups X and Y), those in group X with depressed infants all had a pH_{qu40} of below 7.20 and a standard bicarbonate of less than 15

TABLE 2. Distribution of Apgar scores relative to the pH of foetal blood samples collected within 30 min before delivery

| Author | No. of cases | Foetal pH \geq 7.20 | | Foetal pH $<$ 7.20 | |
|----------------------------|--------------|-----------------------|---------|--------------------|----------|
| | | Apgar score | | Apgar score | |
| | | 7-10 | 1-6 | 7-10 | 1-6 |
| Beard <i>et al.</i> (1967) | 176 | 101(87%) | 15(13%) | 25(42%) | 35(58%) |
| Kubli (1968) | 77 | 53(90%) | 6(10%) | 10(55%) | 8(45%) |
| Bowe <i>et al.</i> (1970) | 355 | 232(88%) | 34(12%) | 27(30%) | 62(70%) |
| Present series | 88 | 76(98.7%) | 1(1.3%) | 6(54.5%) | 5(45.5%) |

mEq/l whereas for cases in group Y with vigorous infants, the pH_{qu40} was over 7.20 and standard bicarbonate more than 15 mEq/l except in one case. The differences in the mean pH_{qu40} and standard bicarbonate between group X and group Y were in fact statistically significant ($P < 0.05$).

Some workers regard any foetal pH of less than 7.25 as abnormal. Lumley and co-workers (Lumley, McKinnon & Wood, 1971) consider pH 7.25 as the lower limit of normal. Bretscher & Saling (1967) consider pH values between 7.20 and 7.24 as 'pre-acidosis'. In the present series of eighty-eight cases delivered within 30 min after sampling there were seventeen with foetal pH within this range and all the seventeen infants were delivered with an Apgar score of 7 or more. These results tended to agree with those of Galloway (1970).

In fact the present study indicated that the high incidence of false positive results could be attributed to the setting of the critical pH at too high a level—7.20. The cases in group Y had pH higher than 7.13 while the pH was below 7.13 in all the cases in group X (Fig. 1). If the critical pH level had been set at 7.13 the false positive results would have been completely eliminated, and the error of prediction in cases delivered within 30 min of sampling would be reduced from 7.9 to 1.1%.

The error in prediction was not significantly influenced by the sampling-delivery interval whether it was 15 min, 30 min or 3 hr (Fig. 2). Had the critical pH been set at 7.13 there would have been no false positive results and the error of prediction in cases delivered within 3 hr of sampling would be reduced from 9.2 to 4.4% (Fig. 3).

The most significant factor affecting the degree of correlation between the foetal pH and the Apgar score appears to be the setting of the critical pH level. In this series of Chinese patients, the closest correlation would have been achieved with a critical pH of 7.13.

Acknowledgment

I am grateful to Professor Daphne Chun for encouragement in this work and permission to publish these results.

References

- BEARD, R.W. (1970) Foetal blood sampling. *British Journal of Hospital Medicine*, **3**, 523.
- BEARD, R.W., MORRIS, E.D. & CLAYTON, S.G. (1966) Foetal blood sampling in clinical obstetrics. *Journal of Obstetrics and Gynaecology of the British Commonwealth*, **73**, 562.
- BEARD, R.W., MORRIS, E.D. & CLAYTON, S.G. (1967) pH of foetal capillary blood as an indicator of the condition of the foetus. *Journal of Obstetrics and Gynaecology of the British Commonwealth*, **74**, 812.
- BOWE, E.T., BEARD, R.W., FINSTER, M., POPPERS, P.J., ADAMSONS, K. & JAMES, L.S. (1970) Reliability of foetal blood sampling. *American Journal of Obstetrics and Gynaecology*, **107**, 219.
- BRETSCHER, J. & SALING, E. (1967) pH values in the human fetus during labor. *American Journal of Obstetrics and Gynaecology*, **97**, 906.
- GALLOWAY, R.K. (1970) Clinical experience with foetal blood pH measurement in foetal distress. *Journal of Obstetrics and Gynaecology of the British Commonwealth*, **77**, 589.
- HAWORTH, S.G., MILIC, A.B. & ADAMSONS, K. (1968) Biochemical indices of foetal condition. *Clinical Obstetrics and Gynaecology*, **11**, 1182.
- HON, E.H., KHAZIN, A.F. & PAUL, R.H. (1969) Biochemical studies of the foetus. II. Foetal pH and Apgar scores. *Obstetrics and Gynaecology*, **33**, 237.
- KHAZIN, A.F., HON, E.H. & QUILLIGAN, E.J. (1969) Biochemical studies of the foetus. III. Foetal base and Apgar scores. *Obstetrics and Gynaecology*, **34**, 592.
- KUBLI, F. (1966) *Fetale Gefahrenzustände und Ihre Diagnose*. Geog. Thiem, Stuttgart.
- LEE, K.H. (1972a) Acid-Base status of the Chinese foetus during normal labour. *Journal of the Asian Federation of Obstetrics and Gynaecology* (in press).
- LEE, K.H. (1972b) Foetal acid-base status in clinical foetal distress and high risk cases. *Postgraduate Medical Journal* **48**, 91.
- LUMLEY, J., MCKINNON, L. & WOOD, C. (1971) Lack of agreement on normal values for fetal scalp blood. *Journal of Obstetrics and Gynaecology of the British Commonwealth* **78**, 13.
- LUMLEY, J. & WOOD, C. (1969) Foetal acidosis. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, **9**, 145.
- PAUL, W.M., GARE, D.J. & WHETHAM, J.C. (1967) Assessment of fetal scalp sampling in labor. *American Journal of Obstetrics and Gynaecology*, **99**, 745.
- SALING, E. (1965) A New method of safeguarding the life of the foetus before and during labour. *Journal of the International Federation of Gynaecology and Obstetrics*, **3**, 100.
- SALING, E. (1966) *Foetal and Neonatal Hypoxia*. Translated by F. E. Loeffler. Edward Arnold, London.
- WOOD, C., FERGUSON, R., LEETON, J., NEWMAN, W. & WALKER, A. (1967) Fetal heart rate and acid-base status in the assessment of fetal hypoxia. *American Journal of Obstetrics and Gynaecology*, **98**, 62.



Correlation between the foetal acid-base status and the Apgar score

K. H. Lee

Postgrad Med J 1972 48: 405-408
doi: 10.1136/pgmj.48.561.405

Updated information and services can be found at:
<http://pmj.bmj.com/content/48/561/405>

Email alerting service

These include:

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:
<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:
<http://group.bmj.com/subscribe/>