FOETAL DISTRESS AND NEONATAL ASPHYXIA

BY

URSULA M. LISTER, M.D., F.R.C.S.(Ed.), M.R.C.O.G.

AND

M. F. G. BUCHANAN, M.B., M.R.C.P.(Ed.), D.C.H.

From the Departments of Obstetrics and Gynaecology and Paediatrics, University of Leeds

PART I

WITH improvements in maternal obstetric management, it is possible to turn increasingly to the care of the child, especially throughout labour and in the immediate postnatal period, when the child is at greatest risk. Though the signs considered to indicate foetal distress have been recognized for many years, it is, however, also necessary to assess the urgency and the severity of the threat to the child's life, for, although the majority of babies recover quickly at birth, any tendency to foetal asphyxia is evidence that the margin of safety has been reduced.

It is the purpose of this investigation to determine the incidence and evaluate the significance of the various classical signs of foetal distress, to correlate the occurrence of these signs with the incidence of foetal asphyxia at birth, and to consider whether it is desirable to take into account minor deviations from normal.

MATERIAL AND METHODS

Consecutive cases of women in labour were taken for the investigation. Records were made by medical and nursing staff of the foetal heart rate and rhythm at hourly intervals during the first stage of labour, and at 15-minute intervals throughout the second stage. The presence of meconium was noted, and careful observations were made concerning the maternal condition and the type of uterine contractions. A small number of cases were discarded where records of the mother or the baby were inadequate, and those in which the foetal heart was lost before the onset of labour.

The report is based upon observations made on 1,000 patients delivered at the Maternity Hospital at Leeds. These deliveries resulted in 1,005 live births; there were 17 twins, and 12 babies were stillborn.

Foetal distress and significant changes in foetal heart rate were noted in 29·9 per cent of all cases, an incidence of foetal distress considerably higher than that recorded by the majority of other workers. It is probable that the stringent interpretation of the terms foetal distress and asphyxia employed in the present investigation accounts for this difference.

The literature contains few attempts at a precise definition of neonatal asphyxia. Experience in the present investigation showed that the newly-born infant's colour, cry and muscle tone were too dependent on variable subjective opinion to be of value. It was found that the first gasp often occurred within moments of birth in infants who by other criteria were severely asphyxiated. The majority of healthy babies born at term, and whose delivery was uncomplicated, commenced to breathe regularly within one minute of birth, and for the purpose of this investigation, therefore, the fact that breathing had or had not started within one minute of birth was accepted as a reliable criterion of normal behaviour or asphyxia. Using this definition, asphyxia was noticed in 24·4 per cent of those babies born alive.

I. RISE IN FOETAL HEART RATE

In his classic description of foetal distress, von Winckel (1903) attached significance to a rise in foetal heart rate to 160 per minute. It was felt that changes in foetal heart rate from a level that had been sustained for some time, but were of lesser degree, were also significant, and that a rise of 20 or more, even though the rate did not

exceed 160 per minute, should be considered evidence of foetal distress. In order to secure this base line in foetal heart rate, records were begun early in labour, and at a time when the strength of uterine contractions and the intact membranes had minimal effect on the foetus. This ensured that any decrease or increase in foetal heart rate occurring before a critical level was reached did not pass unnoticed. (Table I.)

(*a*) A rise in foetal heart rate alone to 160 per minute or more occurred less frequently than in association with other manifestations of distress, and only in 21 cases was it the sole finding. Asphyxia was present in 7 (35·0 per cent) of the babies who survived, and 1 was stillborn. In a further 26 cases additional signs of distress were noted, and of these 13 babies showed asphyxia, and 1 was stillborn, making the incidence of asphyxia at birth in the whole group of 45 babies who lived to be 44·4 per cent. Breathing was delayed to 5 minutes in 8 babies, an incidence of severe asphyxia of 22 per cent.

(*b*) When the rise was 20 or more, but not exceeding 160, from a previously sustained rate, asphyxia was demonstrated in 7 (30·4 per cent) of 23 babies born alive. Meconium was passed in an additional 6 cases, of which 3 babies showed asphyxia at birth and there was 1 stillbirth. It would seem that a rise of 20 per minute in foetal heart rate is significant.

II. Fall in Foetal Heart Rate

A fall in foetal heart rate below 100 per minute has been regarded as indicative of foetal distress, but in this investigation the effect on the foetus of a fall in heart rate of 20 from a previously sustained level has also been examined. (Table II.)

(*a*) In 19 cases there was a fall in foetal heart rate below 100 per minute as the one sign of distress, and 4 of these babies (21 per cent) showed asphyxia at birth. A fall in foetal heart rate was accompanied by additional signs of foetal distress in a further 46 cases, the onset of regular respiration being delayed in 26 (41·9 per cent) of the whole series, and 3 babies in this last group were stillborn.

(*b*) The 68 cases in which the fall in foetal heart rate was 20 or more from a maintained level, but not below 100, gave an incidence of asphyxia of 22 cases (32·3 per cent). In an additional 12 patients, in whom meconium was passed and a fall in foetal heart rate of 20 noted, 4 babies showed evidence of asphyxia.

Table I

Relation Between Rise in Foetal Heart Rate and Asphyxia at Birth

	No. of Cases	Asphyxia	Asphyxia (Per cent)
Rise to 160+	20+1 SB.	7	
Rise to 160 and other F.H. changes	16	7	44·4
Rise to 160 and Meconium	9+1 SB.	6	
Rise of 20 plus Meconium	5+1 SB.	3	—
Rise of 20 per minute	23	7	30·4

Table II

Relation Between Fall in Foetal Heart Rate and Neonatal Asphyxia

	No. of Cases	Asphyxia	Asphyxia (Per cent)
Fall below 100	19	4	
Fall below 100 and other changes	27	12	41·9
Fall below 100 and Meconium	16+3 SB.	10	
Fall of 20 and Meconium	12	4	—
Fall of 20	68	22	32·3

III. Fluctuations and Irregularities of Foetal Heart Rate

The term fluctuation has been applied to the slow variations in foetal heart rate with gradual rise and fall over a range of 25 beats or more, whereas finer irregularities, missed beats and alterations in rate with uterine contractions are grouped as irregularities.

Table III
Association of Fluctuating Foetal Heart Rate and Asphyxia

	No. of Cases	Asphyxia	Asphyxia (Per cent)
Fluctuations only	38	17	44·7
Fluctuations and other signs	56	29	51·8

(*a*) Table III summarizes the association between fluctuations in foetal heart rate and asphyxia at birth. In 38 charts fluctuations alone were noticed, in some cases the range being gross, and of these 17 babies (44·7 per cent) were slow to breathe, 7 taking over 5 minutes before the onset of regular respiration. Fluctuations were often one of multiple signs, and in these 56 cases asphyxia was present at birth in 29 (51·8 per cent).

(*b*) Irregularities of rhythm were noticed in only 1 instance as the sole sign of foetal distress, but it presented as an additional factor in 20 other cases.

IV. Meconium

The passage of meconium as a sign of foetal distress is well recognized, and often it may be the earliest evidence. In practice the warnings of distress were frequently found to be multiple, meconium being accompanied by alterations in both foetal heart rate and rhythm.

Meconium was passed in 35 cases in the absence of any alteration in foetal heart rate, 17 of these babies (50 per cent) were slow in breathing, and there was 1 stillbirth. In an additional 53 cases the passage of meconium was associated with changes in foetal heart rate. Twenty-four (50 per cent) of the 48 babies born alive showed a degree of asphyxia, there were 5 stillbirths and asphyxia was severe in 19 per cent of the whole group of 82 babies.

V. Multiple Signs of Foetal Distress

Multiple signs of foetal distress were present in 96 cases, and of these babies, 5 were stillborn and 45 (46·8 per cent) showed asphyxia at birth.

VI. No Evidence of Foetal Distress

No foetal heart changes and no meconium were found in 701 patients with an incidence of neonatal asphyxia of 17·7 per cent, and severe asphyxia of 5·1 per cent. In the 5 instances in which sudden cessation of the foetal heart occurred, it was felt that more frequent scrutiny might have produced a warning, though seldom in time for effective treatment.

Table IV
Comparison of the Various Signs of Foetal Distress With the Incidence of Neonatal Asphyxia

	No. of Cases	Asphyxia (Per cent)
Rise to 160 (all cases)	45	44·4
Fall to 100 (all cases)	62	41·9
Meconium (all cases)	82	50·0
Fluctuations (all cases) ..	94	48·8
Rise of 20	23	30·4
Fall of 20	68	32·4
No sign of foetal distress ..	701	17·7

PART II

The second part of this paper consists of an analysis of various obstetric factors and their relationship to foetal distress and asphyxia of the child at birth.

I. Maternal Age

The influence of maternal age on foetal distress and neonatal asphyxia is linked to a

Table I
The Influence of Maternal Age on the Incidence of Foetal Distress and Neonatal Asphyxia

Maternal Age	Under 25 Years	25–34 Years	Over 35 Years
No. of Cases	371	505	112
Foetal distress (per cent) ..	30·5	27·6	29·2
Asphyxia (per cent) ..	20·8	23·2	32·2

considerable extent with parity, the majority of patients under 25 years of age being primiparae.

In this series, the incidence of foetal distress was not affected by maternal age, but asphyxia at birth was encountered more frequently in infants born to mothers of 35 years or more. Twenty-nine patients who were over 35 years of age were pregnant for the first time, and in this group of elderly primiparae there were 12 cases (41 per cent) of foetal distress and 11 cases (38 per cent) of asphyxia at birth. Although these figures are small, they show an increase in both factors.

II. Parity

Foetal distress and neonatal asphyxia were both more frequent in first pregnancies, but in succeeding pregnancies after the seventh asphyxia again became noticeable, its incidence equalling that in the first pregnancy.

Table II
Incidence of Foetal Distress and Asphyxia at Birth in Primiparae and Multiparae

	Para-1	Para-2 or More
No. of cases	687	313
Foetal distress (per cent) ..	33	23·3
Asphyxia (per cent)	25·6	20·8

III. Maturity

(a) *Prematurity*

There were 108 infants who weighed 5½ pounds or less at birth. The incidence of foetal distress, and more particularly asphyxia of the child at birth, bore a close relation to the birth weight.

Table III
Relationship of Foetal Distress and Asphyxia to Birth Weight in Premature Infants

	Under 3½ Pounds (16 Infants)	3½–4½ Pounds (30 Infants)	4½–5½ Pounds (62 Infants)
Foetal distress	7 (44 per cent)	8 (27 per cent)	16 (26 per cent)
Asphyxia ..	11 (69 per cent)	15 (50 per cent)	20 (32 per cent)

(b) *Postmaturity*

In 112 cases delivery occurred 14 days or more after the expected date of confinement. The weights of the children so born varied between 4 pounds 14 ounces and 11 pounds 13 ounces, the average being 7 pounds 12 ounces.

Table IV
The Incidence of Foetal Distress and Asphyxia at Birth in Premature, Mature and Postmature Infants

	Cases	Foetal Distress (Per cent)	Asphyxia (Per cent)
Premature ..	108	28·7	42·6
Mature ..	785	28·5	20·1
Postmature ..	112	39·3	30·4

Foetal distress was more frequently encountered in the postmature than in the premature group, but though the incidence of asphyxia was significantly raised when compared with the rate for mature babies, it did not reach the level found in the premature group. The greater part of this increase is probably related to the higher proportion of deliveries under general anaesthesia amongst postmature infants.

IV. Hypertension, Pre-eclampsia and Eclampsia

In this series of 166 patients there are included 29 cases of hypertension, 135 cases of pre-eclampsia and 2 cases of eclampsia.

Foetal distress was apparent in 30·1 per cent of cases, a figure comparable with that for the whole series, and the incidence of asphyxia at birth, 28·3 per cent, is only slightly higher than 24·4 per cent for all babies. The exclusion of some of the more severe cases at an early stage of pregnancy by the liberal use of Caesarean section may have affected these figures.

V. Ante-partum Haemorrhage

The numbers in this group are small as many cases of severe accidental haemorrhage resulting in immediate foetal death are excluded, as are also major types of placenta praevia necessitating Caesarean section. In the 26 cases that remain, foetal distress was noticed in 12 (46·1

per cent), and of the babies 9 (34·6 per cent) showed asphyxia, both figures being greater than those for the series as a whole.

VI. Influence of Labour

(a) *Normal Labour*

Patients delivered within 24 hours of the onset of labour, whether primiparae or multiparae, were considered to have had a normal labour, with the exception of a few patients in whom the second stage was unduly rapid.

In this group of 812 patients the incidence of foetal distress was 28 per cent and of asphyxia at birth 22·4 per cent.

(b) *Long Labour*

With increasing length of labour the incidence of both foetal distress and asphyxia at birth mounts steadily.

Table V

The Incidence of Foetal Distress and Asphyxia at Birth in Normal and Prolonged Labour

Duration of Labour	No. of Cases	Foetal Distress (Per cent)	Asphyxia (Per cent)
Under 24 hours ..	812	28	22·4
24–47 hours ..	129	38	27
Over 48 hours ..	34	55·9	53

(c) *Prolonged Rupture of Membranes*

In 88 cases membranes were ruptured for longer than 24 hours. This was frequently performed as a surgical induction of labour because of some factor which in itself might adversely affect the child. The incidence of both foetal distress (34·4 per cent) and asphyxia at birth (36·3 per cent) was raised.

(d) *Precipitate Labour*

The influence of very rapid labour on the frequency of asphyxia at birth was considered with special reference to the speed with which the second stage of labour was accomplished. For this purpose a labour in which the second stage lasted 5 minutes or less was considered to be precipitate. (Table VI.)

The numbers are small, but an extension of the definition to include cases in which the second stage lasted 10 minutes or less showed that the incidence of asphyxia was similar to that for the series as a whole.

Table VI

The Incidence of Foetal Distress and Neonatal Asphyxia in Long Labour, Precipitate Labour and Normal Labour

	No. of Cases	Foetal Distress (Per cent)	Asphyxia (Per cent)
Long labour	163	41·7	32
Precipitate labour ..	13	—	46
Normal labour ..	812	28	22·4

VII. Pitocin and Morphia

(*a*) Pitocin was used to induce or expedite labour in 46 cases either by slow transfusion or by intermittent injection of 2 units. Foetal distress occurred in 14 instances (30·4 per cent) and 18 of the 43 liveborn infants (41·8 per cent) showed asphyxia at birth. The 3 stillbirths were associated in 2 instances with accidental haemorrhage, and in 1 with intracranial haemorrhage, but these cases are difficult to assess as in so many multiple adverse factors were present.

(*b*) Morphia was administered to the mother within the last 4 hours of labour in only 30 cases. Asphyxia was noticed in 14 babies (46·4 per cent), and, in a considerable number of these, delay in breathing was followed by evidence of respiratory depression without other signs of disease. N-Allyl-Normorphine was not in use in the early part of this investigation.

VIII. The Maternal State

During the progress of the study it became apparent that a deteriorating maternal condition was often reflected in the foetus. Such deterioration is not readily measured, but a rise in the maternal pulse to 110 beats per minute or more was taken as an indication of maternal distress brought about by several causes including prolonged labour, heart failure and severe pre-eclampsia. In some instances these causes led to immediate operative delivery, but in others analgesics, intravenous fluids and oxygen not only improved the maternal state but appeared to lessen the signs of foetal distress.

The maternal pulse rose to 110 or more in 73 patients with signs of foetal distress in 37 (50·6 per cent). There were 3 stillbirths, 2 with preceding evidence of foetal distress and 1 without warning, and 53 per cent of the 70 liveborn infants showed asphyxia at birth.

IX. Operative Delivery

Foetal distress is often the indication for speeding delivery by Caesarean section, or, after full dilatation of the cervix, by the application of forceps, but the operative delivery or the anaesthetic may in itself contribute to the asphyxia of the newborn child.

Table VII

The Incidence of Foetal Distress and Asphyxia at Birth in Relation to Operative Delivery

	No. of Cases	Foetal Distress (Per cent)	Asphyxia (Per cent)
Forceps (local analgesia) ..	22	50	31
Caesarean section (general anaesthesia)	36	52·7	47·1
Forceps (general anaesthesia)	105	51·4	66·7

Delivery was by forceps or Caesarean section in 163 cases. In slightly over half the cases there was already evidence of foetal distress, but, where it was possible to deliver by low forceps with local infiltration of the perineum, the incidence of asphyxia was only slightly raised (to 31 per cent). If there was no foetal distress preceding the application of forceps under local analgesia, no increase in neonatal asphyxia was found.

Table VIII

Influence of Foetal Distress in Labour on Asphyxia in Babies Born by Operative Delivery

	Incidence of Asphyxia (Per cent)	
	No. Preceding Foetal Distress	Born After Foetal Distress
Forceps (local analgesia) ..	18·1	45·4
Caesarean section (general anaesthesia)	35·3	57·0
Forceps (general anaesthesia)	62·7	66·6

Tables VII and VIII confirm the opinion that general anaesthesia is a factor in producing neonatal asphyxia.

The incidence of foetal distress in breech presentations was low (22·7 per cent), perhaps because meconium was accepted as a normal feature, but asphyxia at birth was present in 77·2 per cent of babies.

X. Placenta and Cord Complications

(*a*) A number of placental abnormalities were discovered, and the conditions that were considered likely to affect the child in labour included small placentae weighing under 1 pound, circumvallate placentae, infarction involving one-quarter or more of the placenta, and retro-placental blood clot.

There were 70 such cases, foetal distress was encountered in 38·5 per cent and there were 6 stillbirths. Of the children born alive 43·7 per cent showed asphyxia at birth and 2 died later.

(*b*) In 24 cases there were cord complications, including true and occult prolapse of the cord, a short cord, a true knot and the cord tightly round the neck (17 cases). There were 12 instances of foetal distress and 12 of asphyxia at birth.

XI. Stillbirths and Neonatal Deaths

(*a*) In the 12 cases of foetal death in labour, 5 occurred without warning. These 5 stillbirths were associated with prolonged labour; the cord was round the neck in 1 case, pre-eclampsia and placental infarction in another, 2 patients were postmature, and the fifth had no associated factor.

Of the remaining 7 stillbirths in which signs of foetal distress had been noticed, meconium was present in all but one. Contributing conditions included prolonged labour (2 cases), antepartum haemorrhage (2 cases), eclampsia and postmaturity (1 case of each), and in 1 no cause could be found.

(*b*) There were 23 deaths in the first 12 days of life: foetal distress had been noticed in 13 instances, and 20 (87 per cent) of the babies showed asphyxia at birth. Death was due to intracranial haemorrhage (5 cases), respiratory failure in the first 36 hours including atelectasis

and hyaline membrane (10 cases), congenital abnormalities (5 cases), 2 cases of infection and 1 of haemolytic disease.

Discussion

Consecutive cases of patients in labour have been reviewed in an attempt to assess the significance of the recognized signs of foetal distress, so that guidance in the management of labour and urgency of delivery might be gained. Neonatal asphyxia is not often defined, but it was found that regular respiration was usually established within 1 minute of birth, and this formed a reliable indication of the child's state.

A rise in foetal heart rate to 160 or a fall below 100 beats per minute were seen to be of equal significance, and a fluctuating rhythm, though often associated with other signs of foetal distress, indicated an increase in the threat to the child. These findings do not quite bear out FitzGerald and McFarlane's (1955) statement that a rise in rate is more serious than a fall, and they are at variance with the general view expressed by the Editor of *Obstetrical and Gynecological Survey* (1955) that a fall in foetal heart rate is of greater significance. Moreover, Lund's (1940, 1943) statement that transient tachycardia is present in 17·6 per cent of cases and bears no relation to asphyxia at birth, could not be supported.

Whatever the signs of foetal distress may be, the risk to the child of asphyxia at birth was found to be considerably increased, and of all the single factors the passage of meconium gave the worst prognosis for the child. This is in agreement with FitzGerald and McFarlane's results, yet it is widely held that if the foetal heart is of normal rate and rhythm, the passage of meconium is inconsequential (*Obstetrical and Gynecological Survey*, 1955).

The serious significance of the major foetal heart changes is well recognized, but if these are awaited the opportunity for active intervention may already have been lost. For this reason the lesser deviations in foetal heart rate from a sustained level must also be considered in determining treatment, as they too carry a significant increase in the incidence of asphyxia at birth.

There are many factors which can be shown to have a direct bearing on foetal distress in labour, and asphyxia of the child at birth. FitzGerald and McFarlane could find no significant difference in the incidence of foetal distress in the various age groups, but contrary statements are made that the stillbirth and neonatal death rates rise in direct relation to increasing age. In the present series, age appeared to affect the issue only in so far as it could be associated with parity. Thus primiparity was linked with the highest incidence of foetal distress and asphyxia, the neonatal asphyxia again becoming prominent after the seventh child.

Foetal distress and particularly the state of the child at birth bore close relation to the weight, those babies under 4½ pounds showing significant variations in these two factors. Again in the postmature infant there was an increase in the incidence of foetal distress and asphyxia, findings that confirm earlier statements by McKiddie (1949) and Clayton (1953).

As might be expected, both long labour and prolonged rupture of membranes affected the child's condition not only *in utero* but also at birth, but sometimes maternal exhaustion from such diverse conditions as severe pre-eclampsia or a heart lesion was reflected in the alterations in foetal heart rate, and treatment directed to improve the maternal state resulted also in improvement in the foetus.

Operative delivery became necessary for a variety of reasons including foetal distress, and the results underline the significance of the general anaesthetic in its effect on the foetus. Where it was possible to deliver by forceps under local infiltration of the perineum, the risk of asphyxia was not increased, yet inevitably a general anaesthetic must be given for the more difficult deliveries, and in two-thirds of these cases asphyxia at birth can be expected to occur.

In the whole series 35 children died in the neonatal period or were stillborn. Perhaps by meticulous observation of the lesser variations in foetal heart rate and by earlier intervention, some of these lives might have been saved.

We would like to thank Professor Claye and Professor Craig for their assistance in the preparation of this paper.

References

Clayton, S. G. (1953): *Proc. R. Soc. Med.*, **46**, 91.

FitzGerald, T. B., and McFarlane, C. N. (1955): *Brit. med. J.*, **2**, 358.

Lund, C. J. (1940): *Amer. J. Obstet. Gynec.*, **40**, 946.

Lund, C. J. (1943): *Amer. J. Obstet. Gynec.*, **45**, 636.

McKiddie, J. M. (1949): *J. Obstet. Gynaec. Brit. Emp.*, **56**, 386.

Obstetrical and Gynecological Survey (1955), **10**, 856.

von Winckel, F. (1903): *Handbuch der Geburtshülfe*. Bergmann, Wiesbaden.