Outcome of very severe birth asphyxia

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Scott, H. (1976). *Archives of Disease in Childhood*, **51**, 712. **Outcome of very severe birth asphyxia.** The aim of this study was to establish the outcome of very severe birth asphyxia in a group of babies intensively resuscitated at birth. 48 infants, born between 1966 and 1971 inclusive, were selected; 15 were apparently still-born and 33 had not established spontaneous respirations by 20 minutes after birth. One-half of them died, but 3 to 7 years later three-quarters of the survivors are apparently normal. Later handicap was associated with factors leading to prolonged partial intrapartum asphyxia, while acute periods of more complete asphyxia were not necessarily harmful.

The prognosis for those infants who survive apparent stillbirth or very severe birth asphyxia is difficult to judge from isolated case reports suggesting a successful outcome on the one hand (Lord, Powell, and Roberts, 1953; Holmes and Payne, 1955; Bullough, 1958), and from retrospective series of children with cerebral palsy on the other (Evans, 1948; Churchill and Colfelt, 1963). Yet for those involved in delivery room resuscitation, and no less for the children and their families, it is an important question. In an attempt to answer it survivors of the most profound respiratory and circulatory depression at birth, presumably those in terminal apnoea (Gupta and Tizard, 1967), were re-examined and given psychometric testing.

Patients and methods

Selection. The children were born at Hammersmith Hospital between 1966 and 1971 inclusive. They were all intensively resuscitated and were included in the study on one of two criteria. (1) Apparent stillbirth, with no outward sign of life and an inaudible apex during the first minute after birth, that is an Apgar score of zero. (2) Failure to establish spontaneous breathing within 20 minutes of birth. These babies all had Apgar scores of 1 and 2 at one minute. The time limit of 20 minutes was an arbitrary one to exclude those with respiratory depression secondary to maternal sedation but with essentially good circulatory status at birth, and to exclude certain infants born by caesarean section with fair or good neurological and circulatory status, who after an initial gasp and cry may develop secondary apnoea. Thus a total of 48 infants was studied, 15 of them apparently stillborn and 33 with

spontaneous respirations delayed beyond 20 minutes after birth. The absence of an audible heart beat in the stillborn group was confirmed by the resident in charge in all but one infant. This child, who was given cardiac massage by the attending midwife, was resuscitated but later died. 9 of the 15 infants in this group would also have been selected for the second group, the remaining 6 achieving spontaneous respiration before 20 minutes. During the period of study there were 12 389 live births.

The resuscitation technique used by the resident doctors was standard throughout. If the apex beat was inaudible or very slow, external cardiac massage was started at once while the pharynx was aspirated. Endotracheal intubation was performed as soon as possible, mostly within 1-3 minutes of birth, and the infant ventilated with 40% oxygen. If intubation was delayed attempts were made to inflate the lungs via a tightly fitting face mask. The majority of babies were given alkali in the form of 8.4% sodium bicarbonate, or occasionally THAM, via an umbilical venous catheter before the onset of spontaneous breathing.

Perinatal data. Details of the mothers' pregnancy, labour, and delivery were taken from the maternal notes. Those conditions of the mother which might be associated with impaired placental perfusion such as pre-eclamptic toxæmia, hypertension, severe maternal illness, or heart disease, accidental haemorrhage and prolonged labour were grouped as 'prolonged stress'. Those mothers who produced small-for-dates infants, defined as those below the 10th centile using the birth-weight standards of the British Perinatal Mortality Survey, were also included in this group. Events during labour or delivery leading to sudden, possibly complete interruption of placental flow such as prolapsed cord, breech delivery, or other malpresentation were regarded as 'acute stress'. No sophisticated fetal

monitoring was being undertaken during these years and fetal distress was defined as fetal heart rates >160 /min or <100 /min on more than one occasion; and the presence of meconium in the liquor in vertex presentations.

Details of the neurological status of the infants during their stay in the neonatal unit were ascertained from notes made by the neonatal residents at the time. No systematic neurological examination was carried out by one person. The abnormalities noted were essentially gross, and their continued presence confirmed by several members of the neonatal team. They included excessive irritability or lethargy, hyper- or hypotonia, abnormalities or asymmetry of posture, convulsions, absent or incomplete Moro reflex, and in the mature infants inability to suck or turn the head towards diffuse light.

Follow-up. Those surviving the neonatal period were followed in the outpatient clinic. Particular attention was paid to developmental progress, incorporating items of Sheridan's and the Denver Developmental Screening Tests (Sheridan, 1968; Frankenburg and Dodds, 1967). During the last year of this study (1973-1974) all were seen by the author and one other paediatrician, except 2 children who had died while in institutional care, and a further 2 children receiving day care in a cerebral palsy unit. Details of their present status were kindly supplied by the physicians concerned.

Most of the children were examined by one of two clinical psychologists and intelligence quotient (IQ) measured by different tests appropriate to their age at testing, which ranged from $3\frac{1}{2}$ -7 years. The 3 youngest children in the series were only aged between 2-3 years when tested, so that a developmental quotient (DQ) only can be given. The two institutionalized children had been too severely retarded for formal testing.

Results

Mortality. Mortality was high, 25 of the 48 children (52%) dying in the neonatal period. Post-mortem examination was carried out in each case. The deaths were evenly distributed between the two selection groups (Table I). 3 of the 6

necropsy was intrapartum asphyxia (13), and those in whom death was primarily due to other causes such as hyaline membrane disease with little or no evidence of cerebral oedema (12), are shown in relation to gestational age in Fig. 1. 'Prolonged

FIG. 1.—Gestational age in relation to outcome (deaths).

stress' factors of pregnancy and/or labour were present in all asphyxial deaths. 4 had histories of 'acute stress', in addition. 6 of the 13 infants were small-for-dates. A history of massive accidental haemorrhage a few hours before birth occurred in 4 babies. Fetal distress was present in 7 of the asphyxial deaths, it taking the form of persistent bradycardia.

Neurological abnormality. 17 of the 23 survivors had no apparent neurological abnormality, and the remaining 6 have cerebral palsy. 4 have athetoid cerebral palsy; all but the youngest are being managed by day attendance at a special centre, and it is hoped that at least 3 of these will eventually lead reasonably full and independent lives. The other two had spastic quadriplegia, were both microcephalic and severely retarded, and have since died while in residential care. Prolonged stress factors were present for 4 of the 6 children with cerebral palsy, 2 of whom were small-for-dates, but in only 2 of the 17 normal children, one of whom was small-for-dates. On the other hand, 8 of 17 normal children were subjected to acute stress, while this was the case in only one of the handicapped children who was also small-for-dates. Fetal distress was present in 5 of the 6 children subsequently found to have cerebral palsy. They had bradycardia, with a fetal heart rate of <80 /min, in 3 lasting between 27 and 45 minutes before birth. Fetal distress was also present in 7 normal children, but only one of these was noted to have similar bradycardia present for 10 minutes before birth. These details for survivors and asphyxiated deaths are shown in Table II.

TABLE I

Severe birth asphyxia, 1966-1971

	Total	Survived
Apparent stillbirth (Apgar 0 at 1 minute)	15	7
Spontaneous respirations delayed <20 min	33	16
Total	48	23

apparently stillborn infants who achieved spontaneous respiration within 20 minutes of birth died. Those infants in whom the diagnosis at

TABLE II

Ante- and intrapartum factors in relation to outcome

	Normal (n=17)	Cerebral palsy (n=6)	Death from asphyxia (n=13)
Acute stress	8	1	4
Prolonged stress	2	4	13
Persistent fetal bradycardia	1	5	6

The majority of the survivors (20/23) had abnormal signs as already defined in the first days or weeks of life, which lasted for varying periods. These are correlated with later neurological outcome in Table III. None of those who were later

TABLE III

Early neurological abnormality and later outcome

	Normal (n=17)	Cerebral palsy (n=6)
Duration of neurological abnormality after birth		
Nil	3	0
<2 w	9	0
2-6 w	5	0
Persisting	0	6
Neonatal convulsions		
One only	3	0
> one	4	4

found to have cerebral palsy were *at any stage* thought to be neurologically normal. The relation of gestational age to neurological sequelae is also shown in Fig. 2.

FIG. 2.—Gestational age in relation to outcome (survivors).

Intelligence or developmental quotient. The distribution of IQ and DQ scores is shown in Fig. 3. The results have been plotted on one histogram, despite the fact that different tests have been used,

FIG. 3.—Severe birth asphyxia and later intelligence.

because of the small numbers involved. Social class distribution of the group was not normal, and most (judged according to the Registrar General's classification by father's occupation) were from social classes IV and V. Only one child had a significant discrepancy between verbal and performance IQ when tested at 3 years 9 months. One child fell in the borderline educationally subnormal range, with an IQ of 78 at 5 years. He was a West Indian boy from a particularly underprivileged social background. He attends a normal school which reports favourably on his progress, and for this reason has been included in the normal group. Details of school performances were sought from the parents of the older children, and no learning difficulties were reported, but no routine investigations were made to confirm this with school staff.

An appendix containing details of the 23 survivors may be obtained from the author.

Discussion

The scoring system devised by the late Virginia Apgar has been widely used to quantitate the severity of birth asphyxia (Apgar, 1953). It has been shown that the lower the score at birth the higher the neonatal mortality (Apgar and James, 1962; Drage, Kennedy, and Schwarz, 1964; Langrehr and Dollman, 1971; Randow and Blume, 1971), and the higher the incidence of neurological sequelae (Drage *et al.*, 1966; Drage, Berendes and Fisher, 1969). However, only those infants with a zero score at birth can be said with certainty to be in terminal apnoea as many infants with low scores of 1-3, commonly equated with severe asphyxia, have a higher score within 3-5 minutes of birth without intensive resuscitation. As others have pointed out, the duration of a low score after birth

must be taken into account when assessing the severity of asphyxia, and gives a better guide to later morbidity (Fraser and Wilks, 1959; Auld *et al.*, 1961; Drage *et al.*, 1964, 1966). Thus, although the method of selection used in this study may have excluded many infants in terminal apnoea who responded to resuscitative measures in less than 20 minutes, it ensures that only the most severely asphyxiated have been included. Although the numbers are relatively small, it is nevertheless one of the largest consecutive series of very severely asphyxiated infants so far reported, the only comparable one being from Newcastle (Neligan, Prudham, and Steiner, 1974; Steiner and Neligan 1975).

The results show that not unexpectedly the mortality was high, and just over one-half of the children died in the neonatal period. One-quarter of the survivors were shown to have cerebral palsy, and in 2 of these 6 children the handicap was severe, making independent existence impossible. The IQs or DQs of 3 of the other 4 children, and of the nonhandicapped children were normal taking their social background into account, and the latter were all leading normal lives.

Nearly one-fifth of infants with birth asphyxia, not necessarily of the severity described here, have fits starting towards the end of the first 24 hours of life (Thorn, 1969), and these and other abnormal neurological signs have been correlated with eventual outcome by a number of authors (Prechtl, 1965; Amiel-Tison, 1969; Keen & Lee, 1973; Brown *et al.*, 1974). In this series, of the 11 infants who had fits, 7 later appeared normal. However, 3 had only a single fit, one had two, and the remaining 3 children multiple fits. 4 of the 6 children with cerebral palsy all had multiple fits. Only 3 of the 23 survivors had no detectable neurological abnormality in the neonatal period. Most of the children who later proved normal had signs which disappeared by 2 weeks; but 5 were recognized to have some neurological abnormality for up to 6 weeks. None of the 6 handicapped children ever lost their abnormal signs.

It has been suggested that less mature fetuses withstand lack of oxygen better than the mature (Mott, 1961). All but one of the severely asphyxiated infants in this study who were less than 32 weeks' gestation died of complications of their immaturity such as hyaline membrane disease and intraventricular haemorrhage, the sole survivor appearing normal. All but one of the survivors of 32-37 weeks' gestation were normal while 5 of the 14 mature infants (>37 weeks' gestation) had cerebral palsy.

Many of the studies of birth asphyxia in older animals have been concerned with acute total asphyxia of the fetus directly after birth (see reviews by Dawes, 1967; Windle, 1969), but it is now recognized that this is not an accurate model for most cases of human birth asphyxia. In a series of publications Myers and colleagues, working with Rhesus monkeys, have furthered the concept of two patterns of perinatal brain damage (Myers, 1972; Adamsons and Myers, 1973; Brann and Myers, 1975). Prolonged partial asphyxia in the monkey fetus, however caused, leads to brain swelling, sometimes with areas of softening in the paracentral and posterior parietal-preoccipital junctional areas, and frequently to damage of the basal ganglia. In contrast, episodes of acute total asphyxia have in the past been shown to cause lesions of the brain stem alone, without hemisphere involvement or brain swelling. Thus partial and total asphyxia seem to produce different effects on the brain. The situation for the human fetus is most commonly that of partial asphyxia. Myers believes that fetal partial asphyxia from any cause, independent of fetal circulatory collapse or head compression, is the primary event which 'sets in motion a vicious cycle of brain swelling leading to stasis of blood flow and, finally to cerebral necrosis' (Brann and Myers, 1975). Most of the human infants with marked brain swelling presumably die, or are severely handicapped. However, the involvement of the basal ganglia in the animal model is important since athetoid cerebral palsy was the most commonly diagnosed form of handicap in this study, and has previously been described as a not uncommon occurrence after severe birth asphyxia (Churchill and Colfelt, 1963; Griffiths and Barrett, 1967).

Assuming that hypoxia after birth is minimized by prompt and adequate resuscitation, later neurological sequelae in the human must be related to ante- and intrapartum asphyxia. The many obstetrical factors which may cause this are relatively well known (Larks and Larks, 1972). We have in this study unfortunately little objective evidence of partial intrauterine asphyxia since no form of sophisticated fetal monitoring was being undertaken. However, there is subjective evidence in that those conditions which might lead to prolonged partial intrapartum asphyxia occurred more commonly in those who were later found to be neurologically abnormal. As might be expected, the rather crude measure of persistent fetal bradycardia was a particularly ominous sign. During the period 1961-70 a comparable series of actively resuscitated children has been followed in New-

castle. 2 of 6 'stillbirths' were severely handicapped (Steiner and Neligan, 1975); and 30% of 30 children in whom respirations were not established for 20 minutes after birth, 7 of whom also had cardiac arrest, were also handicapped though not always severely (Neligan *et al.*, 1974). Steiner and Neligan suggest there must be serious concern about the likelihood of permanent brain damage if respiration is not established within 30 minutes of the return of the heart beat. In this study if those attaining spontaneous respirations 30 minutes and less after birth are compared with those breathing spontaneously after 30 minutes, then 2 of 12 children, and 4 of 11 respectively are handicapped. Perhaps a combination of the results of these two surveys, i.e. a high incidence of handicap occurring when there is evidence of prolonged partial intra-partum asphyxia together with failure to establish respiration by 30 minutes of age, may act as a guide to clinicians in the labour ward

During the time this work was carried out I was holding a Percy J. Neate fellowship from the Worshipful Company of Clothworkers, to whom I am greatly indebted for support. I also thank Mrs. Barbara Spode and Mrs. Diane Lukeman who carried out the psychometric testing, and Dr. Pamela Davies who suggested the study, for their help

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