CEREBRAL PALSID TWINS

BY

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Various studies on the prevalence of twins in the cerebral palsied population have shown that twins are more likely than single born children to be affected by cerebral palsy (Asher and Schonell, 1950; Skatvedt, 1958; Hansen, 1960). Berg and Kirman (1960) showed that the proportion of twins among mental defectives exceeded that in the general population. The stillbirth and neonatal mortality rates for twins are three times higher than those for single births (Yerushalmy and Sheerar, 1940). It seems probable that many of the factors which are operating adversely in multiple pregnancies, causing children to be stillborn, to die neonatally or to be mentally defective are similar to those acting in multiple pregnancies resulting in cerebral palsied children.

In the present study of 44 cerebral palsied twins, an attempt is made to elucidate some of these factors.

Materials and Methods

The records of all cerebral palsied patients, who were one of twins, were extracted from the outpatient files of the Edinburgh clinic for the Scottish Council for the Care of Spastics. Cerebral palsied children from any part of Scotland may be referred to this clinic by general practitioners and medical officers for assessment by a medical panel. The patients studied were, therefore, a preselected group.

Of the 488 patients who were examined at the clinic between 1949 and 1956, 45 were one of twins and one was the middle born of triplets.

Data were obtained from the clinic's records, from maternity hospital records and by personal interview with the patients and their parents. One patient was excluded from the study as insufficient information was available. None of the twins suffered from postnatal disease apart from kernicterus.

The patient who was one of triplets was excluded from the analysis of twins and was considered separately.

The remaining 44 twins were matched by age of

mother at delivery, social class of father and birth order with 44 control twins. The controls were extracted from a series of hospital born twins studied by Drillien (1958).

The ages of the cerebral palsied twins ranged from 18 months to 30 years at the time of the study, whereas the ages of the control twins varied only between 5 and 7 years. Of the cerebral palsied twins 70% were born in hospital compared to 100% of the control group.

The distribution of maternal age at delivery of the cerebral palsied twins was found to be similar to that of mothers giving birth to twins in an Edinburgh maternity hospital in 1955 (Table 1).

As seen from Table 2, the distribution of the cerebral palsied twins, by social class of father, showed a slight excess of twins in social classes IV and V, at the expense of III, when compared to the distribution of fathers of all live births in Scotland

TABLE 1

PERCENTAGE DISTRIBUTION, BY AGE OF MOTHER AT DELIVERY, OF 44 CEREBRAL PALSID TWINS AND 65 LIVE BORN TWINS DELIVERED IN THE SIMPSON MEMORIAL MATERNITY PAVILION IN 1955

Age of Mother at Delivery (years)	Percentage of Mothers	
	Mothers of 44 Cerebral Palsied Twins	Mothers of 65 Hospital Born Twins
< 20	0	0
20-24	18.2	23.0
25-29	36.3	31.0
30-35	27.3	29.1
Over 35	18.2	16.9

TABLE 2

PERCENTAGE DISTRIBUTION, BY SOCIAL CLASS OF FATHER, OF 44 CEREBRAL PALSID TWINS AND OF ALL LIVE BIRTHS IN SCOTLAND IN 1951

Social Class	Percentage of Fathers of 44 Cerebral Palsied Twins	Percentage of Fathers of All Live Births in Scotland in 1951
I and II	27.3	22.8
III	31.8	45.7
IV and V	40.9	31.5

(Registrar-General for Scotland, 1951). The control twins were selected to take this factor into account.

Results

Incidence of Twinning. The incidence of twins in this series of cerebral palsied patients is 9%. As the series is preselected the prevalence of twins may not be a true reflection of the prevalence of twins in the cerebral palsied population in general. Other workers, studying unselected material have found lower proportions of twins. In a study of 349 cases of cerebral palsy, Asher and Schonell (1950) found that 5.4% were one of twins. Illingworth (1958), reviewing 205 natal and prenatal cases found that 7.5% were one of twins. In an extensive survey of cerebral palsy in Denmark, 161 out of 2,389 patients (6.7%) were one of twins or triplets (Hansen, 1960). In a regional survey in Edinburgh, the incidence of twins among 160 children with cerebral palsy of prenatal or natal origin was 4.4% (Balf and Ingram, 1955). Shyh-Jong Yue (1955), reviewing a selected series of 301 cases of cerebral palsy found that 27 (9%) were one of twins or triplets.

Distribution of Twins According to Type of Cerebral Palsy. The 488 cases from which the twins were selected were classified according to the type of palsy. The proportion of twins in each type was then calculated (Table 3). The term diplegia refers to a more or less symmetrical paresis of cerebral origin, more severe in the lower limbs than the upper. It includes paraplegia, triplegia and tetraplegia (Balf and Ingram, 1955).

The highest incidence of twins (12.3%) was found in the diplegic group. When the diplegic patients were divided into mature and premature (by birth weight) it was found that the incidence of twins among the premature patients was 23.4% (25 in 107), while among the mature patients it was only 1.8% (two in 112). This difference is highly significant statistically ($p < 0.001$). Asher and Schonell (1950), studying unselected material, also found that twins were more prevalent among diplegic patients than in any other type of cerebral palsy.

Fate of the Other Twin. The fate of the other twin was studied in both the cerebral palsied and control groups. A twin was considered to be healthy if he had no physical abnormality and an I.Q. of 80 or over. As seen from Table 4, less than half the twins of the cerebral palsied patients were surviving and healthy. Nearly 23% of them

TABLE 3
DISTRIBUTION OF TWINS ACCORDING TO TYPE OF CEREBRAL PALSY

Type of Palsy	Total Number of Cerebral Palsied Patients*	Number of Twins	Percentage of Twins
Diplegia ..	219	27	12.3
Hemiplegia ..	107	7	6.5
Athetoid ..	89	8	9.0
Other ..	73	2	2.7
Total ..	488	44	9.0

* Including those with congenital and acquired cerebral palsy.

TABLE 4
FATE OF OTHER TWIN IN CEREBRAL PALSID AND CONTROL GROUPS

Fate of Other Twin	Cerebral Palsied Group		Control Group	
	No.	%	No.	%
Surviving and healthy ..	20	45.5	35	79.6
Surviving, but mentally or physically abnormal ..	4	9.1	2	4.5
Died neonatally ..	10	22.7	3	6.8
Died between 1 month and 1 year of age ..	2	4.5	3	6.8
Stillborn ..	2	4.5	1	2.3
Macerated foetus ..	6	13.7	0	0

died neonatally (as compared to 6.8% in the control group). In six pairs, one of the members died *in utero* and was delivered as a macerated foetus. In two pairs one of the twins was stillborn.

Autopsy Findings in Non-surviving Twins. Unfortunately autopsy reports were available on only two of the non-surviving twins. The death of the majority of the non-survivors was attributed to prematurity. The two infants on whom autopsy was performed showed no congenital neurological defects. One infant was found to have a congenital oesophageal atresia and the other died of intracranial haemorrhage.

One of the cerebral palsied twins died at the age of 7 years, after a dental extraction. This child suffered from severe quadriplegia with mental defect, and was one of binocular twins. Her twin died neonatally of bronchopneumonia, but no neuropathological examination was carried out. The brain of the cerebral palsied twin, however, was examined and was found to be larger than normal with an extensive developmental cleft through the right hemisphere, extending into the lateral ventricle.

Distribution of Like-sexed and Unlike-sexed Pairs. Of the cerebral palsied twins 23 were male

and 21 were female. In the control group there were 19 males and 25 females.

In the general population, the proportion of dizygotic to monozygotic twins is 2.3:1 (Smith and Penrose, 1955). On this basis and assuming that among the dizygotic twins there are equal numbers of like- and unlike-sexed pairs, the expected ratio of like-sexed to unlike-sexed twins is 1.9:1.

In the cerebral palsied group (when the twins whose partner was a macerated foetus are excluded) 27 pairs were of the same sex and 11 were of unlike sex. The excess of like-sexed over unlike-sexed twins was greater than would be expected in the group in which the other member was stillborn, died in early infancy or survived but was abnormal (15 like-sexed to three unlike-sexed pairs). There was a slight preponderance of female pairs among the like-sexed twins. When the other member of the pair was a healthy survivor, the ratio was 12 like-sexed to eight unlike-sexed pairs. Although the numbers are too small to be statistically significant ($p > 0.05$), these findings do suggest that the chances of a like-sexed partner of a cerebral palsied twin being a healthy survivor are considerably less than those of an unlike-sexed partner.

Birth Order. In considering the birth order of the twins, the six pairs in which one member was a macerated foetus were excluded. Of the remaining 38 twins, 24 (63%) were first born and 14 (36%) second born. This difference is statistically significant ($p < 0.05$). A preponderance of first-born cerebral palsied twins was also found by Shyh-Jong Yue (1955) and Hansen (1960).

When the entire group of cerebral palsied patients and their twins is divided according to birth order, it was found that of the stillborn and dead twins a greater proportion were second born than were first born (Fig. 1).

When cerebral palsy alone is considered, the first-born twin appears to be at a disadvantage, but when twins who suffered a worse fate are considered the prospects of the second born are considerably poorer than those of the first.

The second born of twins is exposed to a certain degree of extra risk on account of the placental separation which is liable to occur before the child is born (Baird, 1957). The finding that cerebral palsied twins are predominantly first born and the non-survivors predominantly second born suggests that the anoxia suffered by the second born of twins tends to have an immediately lethal effect rather than that resulting in survival with permanent disability. It is possible that in some of the twin pairs both members are abnormal prenatally. The

FIG. 1.—Birth order of cerebral palsied patients and their twins.

disadvantage suffered by the second born, in these cases, is additional to existing foetal abnormality and may result in a fatal outcome.

In a study of mentally-defective twins, Berg and Kirman (1960), found that second-born twins tended to be at a disadvantage both as regards mental defect and early death (including stillbirths). Yerushalmy and Sheerar (1940) found that second-born twins were stillborn more often than first-born. They did not, however, find a relation between birth order and neonatal deaths.

Birth Weight and Incidence of Prematurity. The birth weights of the cerebral palsied patients were compared to:

- (1) Their surviving healthy twins;
- (2) Their twins who were stillborn or died within the first year of life.
- (3) Their twins who survived but were abnormal;
- (4) The twins in the control group.

The six pairs in which one member of the pair was a macerated foetus were excluded from this analysis as there were no comparable twins in the series from which the controls were selected.

The average birth weight of the remaining 38 cerebral palsied twins was 4 lb. 3 oz., as compared with 5 lb. 5 oz. for twins in the control group. The average birth weight of the 20 surviving healthy twins was 4 lb. 13 oz., while that of the 14 stillborn and dead twins was only 3 lb. 8 oz. The four surviving twins who were abnormal had an average birth weight of 4 lb. 2 oz. The distribution of these birth weights is shown in Fig. 2 and Table 5.

TABLE 5

BIRTH WEIGHT DISTRIBUTION OF 44 CEREBRAL PALSID TWINS, 20 SURVIVING AND HEALTHY MEMBERS OF PAIRS, 14 STILLBORN AND DEAD MEMBERS OF PAIRS AND 44 CONTROL TWINS*

Birth Weight (lb.)	Percentage of 44 Cerebral Palsied Twins	Percentage of 20 Surviving Healthy Twins	Percentage of 14 Stillborn and Dead Twins	Percentage of 44 Control Twins
1½-3½	30	9.5	61.6	11.4
3½-5½	46.5	61.9	38.4	43.2
> 5½	23.5	28.6	0	45.4

* The birth weights of the four surviving but abnormal members of pairs are not given.

In the 20 twin pairs in which one member was cerebral palsied and the other was normal, the individual birth weights of all but four of the healthy members were greater than those of their cerebral palsied twins.

FIG. 2.—Comparison of birth weight distribution of cerebral palsied patients with that of surviving healthy twins, stillborn and dead twins, and control twins.

If a birth weight of 5½ lb. or less is accepted as the criterion of prematurity, it is seen from Table 5 that 77% of the cerebral palsied twins were premature compared to 54% of the control twins. Of the surviving healthy twins, 71% were premature compared to 100% of the non-survivors. The incidence of prematurity by weight in the general population is between 7 and 8% of all live births (Douglas, 1950).

Length of Gestation. The gestational times of the cerebral palsied twins, when known, were compared to those of the controls. As would be expected from the lower birth weights of the cerebral palsied patients, the twins in the control group were considerably more mature (Table 6). Of the control twins 45% had an estimated period of gestation of over 38 weeks, compared with only 16.2% of the cerebral palsied twins.

Abnormalities of Pregnancy. Of the cerebral palsied twins, 43% (19 of 44) were born after an abnormal pregnancy, compared to 36% (16 of 44) in the control group, a difference which is not statistically significant (Table 7). Uterine bleeding, however, was commoner in the cerebral palsied group, occurring in 10 cases. In one of these, the haemorrhage occurred during the first three months of pregnancy, in another, haemorrhage occurred

TABLE 6
LENGTH OF GESTATION OF 37 CEREBRAL PALSID TWINS AND 44 CONTROL TWINS

Length of Gestation* (wks)	Cerebral Palsied Twins		Control Twins	
	No.	%	No.	%
< 30	1	2.7	1	2.3
30-34	18	48.7	7	15.9
35-38	12	32.4	16	36.4
> 38	6	16.2	20	45.4

* Calculated from date of last menstrual period.

TABLE 7
ABNORMALITIES OF PREGNANCIES RESULTING IN CEREBRAL PALSID AND CONTROL TWINS

Abnormality	Cerebral Palsied Twins (44)	Control Twins (44)
Threatened abortion	1	0
Antepartum haemorrhage ..	9	1
Viral infections in first six months	2	0
Moderate or severe pre-eclamptic toxæmia	6	7
Unrelated medical conditions ..	0	4
Severe hyperemesis	0	1
Hydramnios	1	3
Total	19 or 43.2%	16 or 36.4%

TABLE 8

ABNORMALITIES OF DELIVERY OF CEREBRAL PALSIED TWINS, SURVIVING HEALTHY TWINS, STILLBORN OR DEAD TWINS AND CONTROL TWINS

Mode of Delivery	Cerebral Palsied Twins (44)	Surviving Healthy Twins (20)	Stillborn and Dead Twins (14)	Control Twins (44)
Spontaneous breech	9	3	4	1
Assisted breech	7	2	0	19
Forceps	2	0	1	2
Prolonged labour	2	2	0	0
Caesarean section	2	0	0	3
Face presentation	1	0	0	0
Spontaneous vertex delivery	21	13	9	19
Total with an abnormal delivery	23 or 52.3%	7 or 35%	5 or 55.5%	25 or 56.8%

both in early and late pregnancy, and in the remaining eight, the haemorrhage was after the 28th week, giving an incidence of antepartum haemorrhage of 24.5%.

In the control group, uterine haemorrhage during pregnancy occurred in only one case.

In the nine cases of antepartum haemorrhage, the other twin was healthy in five instances, died neonatally in two, was a macerated foetus in one and survived but was mentally handicapped in one. Two of the pregnancies in which antepartum haemorrhage occurred resulted in monozygotic twins, the non-cerebral palsied member of the pair being a healthy survivor in one case and mentally handicapped in the other.

Abnormalities of Parturition. Abnormalities of parturition were noted for the cerebral palsied twins, the 20 surviving members of pairs and the 14 stillborn or dead members and the control twins. As seen from Table 8, the cerebral palsied twins showed no greater incidence of abnormal parturition than the control twins. The difference in the incidence of abnormal delivery between the healthy survivors and the non-survivors was also not significant. The frequency of breech delivery was high in all groups, a finding presumably related to the high proportion of premature deliveries and the presence of a multiple pregnancy. Breech presentation, which usually occurs in only 3-4% of all pregnancies, is associated with an increased risk of mortality (Baird, 1957).

In this study, however, abnormalities of pregnancy and delivery, with the exception of uterine bleeding, were as frequent among the control twins as among the cerebral palsied.

Neonatal Course. The proportion of cerebral palsied patients, their surviving healthy twins, and the control twins showing abnormal neonatal

signs was noted (Table 9). The following neonatal signs were considered abnormal: delay in initiating respiration, signs of shock, cyanotic episodes, refusal to suck and severe jaundice.

In the cerebral palsied group 68% of the patients showed abnormal neonatal signs compared to 18% of their surviving healthy twins and 13% of the control twins. These differences are highly significant statistically ($p < 0.001$).

Five of the cerebral palsied twins showed abnormal neonatal signs after a completely normal pregnancy and delivery. In two of these, the signs were those of cerebral irritation. None of the control twins, born after an uncomplicated pregnancy and delivery, showed abnormal signs neonatally.

Signs of kernikterus were shown by four cerebral palsied twins, all dizygotic, who subsequently developed athetosis. In three of these Rh incompatibility was demonstrated. The other members of three of the pairs were healthy survivors and were not jaundiced neonatally. In the remaining pair, both twins showed signs of kernikterus and Rh incompatibility was demonstrated. The non-cerebral palsied twin died after exchange transfusion.

Ovularity. Of the cerebral palsied twins, 10 were members of probable uniovular pairs (including both cerebral palsied members of one pair) and 25 were members of probable binovular pairs. The ovularity of the remaining twins is uncertain. In only one of the nine uniovular pairs (11%) was the other member of the pair a healthy survivor as compared with 18 members of the 25 binovular pairs (72%). The advantage of binovularity over uniovularity was shown in a study of stillbirth and neonatal mortality rates of twins by Yerushalmy and Sheerar (1940). They found that the rates for uniovular twins were higher than those for binovular twins, the excess being accounted for by the larger proportion of uniovular twins in which both members of the pair died. Except in the three cases described below the criteria for monozygosity were first, evidence of a single placenta (as described in the maternity hospital records) and second, similarity of appearance when both twins survived.

TABLE 9

PROPORTION OF CEREBRAL PALSIED PATIENTS SHOWING ABNORMAL NEONATAL SIGNS COMPARED TO THEIR SURVIVING HEALTHY TWINS AND THE CONTROL TWINS

Cerebral Palsied Twins (44)		Surviving Healthy Twins (20)		Control Twins (44)	
No.	%	No.	%	No.	%
30	68.2	4	21.2	6	13.6

In four of the 10 uniovular pairs, the other member of the pair was surviving (one was normal, two were mentally retarded and both members of one pair were cerebral palsied). Blood groups of the patients and their twins were ascertained in three of these cases to substantiate the evidence of monozygosity. The twins in the remaining pair were both in homes for mentally handicapped children and blood grouping was not carried out.

Details of Three Cases of Uniovular Twins

Case 1. M.R. and W.R. are probable uniovular male twins, born in hospital after an uneventful first pregnancy lasting 34 weeks. M.R., the first born, was delivered spontaneously by the vertex, while W.R. was a spontaneous breech delivery. Their birth weights were 5 lb. 5 oz. and 4 lb. 12 oz. respectively. There was a single placenta. The neonatal period was uneventful. Both twins have paraplegia of moderate severity and in addition W.R. has a pes cavus. The I.Q. of M.R. is 49 and that of W.R. is 63. Their facial appearance and body build are very similar except that M.R. is 1 in. taller than his twin. The Rh genotypes, ABO and MN blood group systems are identical.

The identical involvement of the paresis in these twins, although their birth histories differ, suggests that natal abnormalities are not responsible for the cerebral defects. The cerebral palsy may be related to the prematurity, but the striking similarity of the disabilities of these twins suggests a genetic condition, even in the absence of a positive family history.

Case 2. W.H. and G.H. are probable uniovular female twins, W.H. being cerebral palsied and G.H. being normal. The twins were born in hospital one month prematurely after a pregnancy complicated by pre-eclamptic toxæmia. A severe antepartum haemorrhage due to placenta prævia occurred 24 hours before delivery and labour was induced surgically. Both twins were delivered spontaneously by the vertex. The affected twin, born second, weighed 5 lb. and the healthy twin, 5 lb. 4 oz. There was a single large placenta, single chorion and double amnion. The condition of both twins immediately after birth was stated to be poor after which the condition of the unaffected twin became satisfactory. The cerebral palsied twin, however, had cyanotic attacks during the first few days and fed poorly during the entire neonatal period. The affected twin suffers from severe paraplegia and is mentally retarded (I.Q. 72). The unaffected twin is a trained nurse with above average intelligence. The twins have similar facial features, skin, hair, and eye colour. The healthy twin is, however, three inches taller than her sister. The Rh genotypes, ABO and MN blood group systems are identical.

In this case it is possible that uterine haemorrhage

caused separation of only part of the placenta with resultant anoxia in only one foetus.

Case 3. J.B. and K.B. are probable uniovular male twins, the former cerebral palsied and mentally retarded and the latter physically healthy, but also mentally retarded. A severe antepartum haemorrhage, due to Grade III placenta prævia, occurred just before delivery because of which caesarean section was carried out. There was a single placenta. The condition of both babies immediately after birth was stated to be poor. J.B. weighed 5 lb. at birth and K.B. weighed 3 lb. 11 oz. The twins look extremely alike. Both twins are mentally retarded. The Rh genotypes, ABO and MN blood group systems are identical.

The principal disability in these twins is their mental retardation. Unlike the two previous cases it seems probable that natal and perinatal factors were important in causing cerebral damage, the involvement being more extensive in the cerebral palsied twin than in his brother.

Triplets. One of the cerebral palsied patients (excluded from the analysis of twins) was the sole survivor of triplets. The patient, a female, suffers from severe diplegia and is mentally retarded. She was the second born of triplets and was delivered spontaneously by the vertex after a toxæmic pregnancy. The remaining two triplets, both female, were stillborn. They were delivered spontaneously, but their presentation is uncertain as is the ovularity. The cerebral palsied triplet weighed 1 lb. 8 oz. at birth. The birth weights of the remaining triplets is not known. They were, however, stated to be very small. It is probable that extreme prematurity in this case was responsible for the death of two of the triplets and extensive cerebral damage in the survivor.

Mothers' Reproductive Histories. Eight of the 44 mothers of cerebral palsied twins had had a previous or subsequent pregnancy ending in abortion or stillbirth. Seven of the 44 mothers in the control group gave a similar history. The number of siblings who were mentally defective, suffered from or died of a congenital abnormality numbered four in the cerebral palsied group as opposed to three in the control group.

Clinical Findings

INTELLIGENCE. Cerebral palsied children who are seen at the clinic are examined by a medical psychologist and an assessment of their intelligence is made. Intelligence test scores were also available

TABLE 10
INTELLIGENCE QUOTIENTS OF CEREBRAL PALSIED
TWINS AND CONTROL TWINS

Intelligence Quotients	Cerebral Palsied Twins (44)		Control Twins (44)	
	No.	%	No.	%
80 or over	19	43.2	42	95.5
60-80	11	25.0	—	—
< 60	14	31.8	2	4.5

for the control twins. As seen from Table 10, all but two of the control twins had an estimated I.Q. of 80 or over, compared with only 19 (43%) of the cerebral palsied twins. The remaining two control twins and 14 of the 44 (32%) cerebral palsied twins were considered severely mentally handicapped with I.Q.s less than 60.

VISUAL AND AUDITORY DEFECTS. Visual defects were present in 16 (36%) of the cerebral palsied twins and in only two of the controls. A quarter of the cerebral palsied twins suffered from strabismus. None of the controls and 9% of the cerebral palsied twins had difficulty in hearing.

SPEECH. Speech defects were present in 27 (61%) of the cerebral palsied patients, eight of whom had no speech at all. In the control group, 11% of the twins had defective speech.

EPILEPSY. Nine (20%) of the cerebral palsied patients suffered from epilepsy. Six of these had surviving twins, only one of whom is epileptic.

Discussion

In a study of the association between complications of pregnancy and cerebral palsy, Lilienfeld and Pasamanick (1955) suggested a 'continuum of reproductive wastage' with a lethal component consisting of abortions, stillbirths and neonatal deaths, and a sublethal component consisting of cerebral palsy and related conditions. A similar concept can be applied to the birth weight distribution of cerebral palsied patients and their twins. There is a lethal component associated with very low birth weights and consisting of stillbirths and neonatal deaths, and a sublethal component associated with intermediate birth weights and consisting of cerebral palsy. The majority of twins weighing over 5½ lb. at birth are healthy survivors.

In comparing members of twin pairs it is interesting to speculate what aetiological factors could affect one twin and spare the other in so many cases. To a large extent the differences can be attributed

to differences in birth weight only, but other factors should be considered.

Although the overall incidence of abnormalities of pregnancy was no greater in the cerebral palsied group than in the control group, the incidence of uterine haemorrhage was considerably higher, occurring in nearly a quarter of the pregnancies resulting in cerebral palsied children. An association between uterine bleeding during pregnancy and the production of cerebral palsy has been shown by Latham, Anderson and Eastman (1954). Ante-partum haemorrhage may precipitate premature birth or may result in placental insufficiency with subsequent foetal anoxia. It is possible that this could affect one twin more than the other.

Abnormal parturition, which was as frequent in the control group as in the cerebral palsied group, does not appear to be an important aetiological factor in the production of cerebral palsy in twins.

In a previous study (Ingram and Russell, 1961) of the reproductive histories of mothers of children suffering from congenital diplegia, it was found that a high proportion of the pregnancies of these mothers ended in abortion, stillbirth, neonatal death or malformed children. The mothers also tended to be older at delivery than expected. Although the numbers in the present study are small, they suggest that mothers of cerebral palsied twins do not have any more unsuccessful pregnancies and are not any older at the time of delivery than would be expected.

The most important aetiological factor in the production of cerebral palsy in twins appears to be immaturity as indicated by low birth weight. The birth weights of the cerebral palsied twins and their estimated maturity were considerably less than those of the control twins. Two explanations are suggested for these findings. It may be that among children who are prematurely born as a result of a multiple pregnancy, those who are smallest and least mature have the greatest tendency to develop cerebral palsy. It has been established that prematurity predisposes to intracranial injury (Craig, 1938; Parsons, 1944) and that the lower the birth weight and the less the maturity the higher is the mortality (Benda, 1945; Crosse, 1957). Premature infants are also more liable to suffer complications in the neonatal period, leading to subsequent physical and mental handicap. The excess of cerebral palsied over control twins showing abnormal neonatal signs may be related to their lower average birth weights. The prevalence of twins among diplegic patients is due almost entirely to prematurely born twins. Among maturely born diplegic patients only two of 112 patients were one of twins. As the incidence of prematurity among

diplegic patients (over 40%) is higher than in any other type of cerebral palsy, it is probable that prematurity alone is responsible for the high incidence of twins in this group. Plural pregnancy in itself carries greater risks to the foetus than a single pregnancy (Baird, 1957). It may be that the high incidence of cerebral palsy in twins is due entirely to the combination of prematurity and multiple pregnancy which heavily predisposes the infant to cerebral damage.

However, as multiple pregnancy is common to both the cerebral palsied and the control twins, it can be postulated that the greater degree of prematurity of the cerebral palsied twins is due to additional and adverse factors acting *in utero*. A prenatally injured foetus tends to be prematurely born. This concept was originally suggested by Freud (1897) and supported by Collier (1899, 1923) to explain the relationship between Little's disease and premature birth. More recently it has been shown that infants with congenital malformations tend to be born prematurely (Murphy, 1940). It is possible that an unfavourable intrauterine environment results in cerebral damage to one or both products of the multiple pregnancy. Even in a monozygotic twin pregnancy, the intrauterine environment may not be identical (Price, 1950), and factors acting adversely on one foetus may spare the other. Pre-existing foetal abnormality partly accounts for the finding that neonatal abnormalities, but not abnormalities of parturition, are considerably higher among the cerebral palsied twins than among the controls. An infant with a congenital cerebral defect may show neonatal signs similar to those shown by a birth injured foetus.

The high casualty rates and low birth weights of the other members of the twin pairs substantiate either of the above explanations. An extensive neuropathological study of non-surviving members of twin pairs would be of value in elucidating the problem further.

Summary

Forty-four pairs of twins are described in which one member of each pair suffers from cerebral palsy. They are compared with 44 control twin pairs.

Incidence of Twinning. The 44 cerebral palsied twins were extracted from 488 consecutive cases of cerebral palsy, giving an incidence of twinning of 9%, the highest incidence being among diplegic patients.

Fate of the Other Twin. Less than half of the twins of cerebral palsied patients were surviving and healthy. The majority were stillborn (including

those delivered as macerated foetuses), died neonatally or within the first year of life or were mentally handicapped.

Sex Distribution. The ratio of like-sexed to unlike-sexed pairs was greater than would be expected in pairs in which one member was cerebral palsied and the other was stillborn or had died in early infancy.

Birth Order. There was an excess of first-born cerebral palsied twins and second-born stillborn or dead twins.

Birth Weight. The average birth weight of the cerebral palsied patients was less than that of their surviving healthy twins and of the control twins. The stillborn or dead twins had the lowest average birth weight of all groups and were all premature.

Maturity. The maturity of the cerebral palsied twins, based on the estimated period of gestation, was considerably less than that of the control twins.

Pregnancy and Parturition. The incidence of abnormal pregnancy and parturition was no greater in the cerebral palsied group than in the control group. The ages of the mothers at the time of delivery were no greater than expected.

Neonatal Course. The cerebral palsied patients showed more abnormal neonatal signs than did their surviving twins and the control twins.

Ovularity. The casualty rate among the nine pairs of probable uniovular twins was higher than that among the 25 pairs of probable binovular twins. Three pairs of uniovular twins in which both members survived are described.

Clinical Findings. The incidence of mental impairment, visual, auditory and speech defects was considerably higher among the cerebral palsied twins than among the controls.

Conclusion. In the majority of cerebral palsied twins the cerebral defect is unrelated to abnormalities of pregnancy and parturition or to maternal age. The most important factor appears to be low birth weight due either to multiple pregnancy alone, or to a combination of multiple pregnancy and pre-existing foetal abnormality.

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