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Laterality and prematurity

N MARLOW, B L ROBERTS, AND R W I COOKE

Department of Child Health, Liverpool Maternity Hospital

SUMMARY Lateral preferences were determined by postal questionnaire for 240 children, without major neurological impairment, who were born at less than 31 weeks' gestation to examine the association between neonatal brain injuries and later lateral preference. Left hand preference was reported in 64 (26·7%) children at a median age of 52 months (range: 24–104 months). Left foot preference was shown by 70 (29·2%) and left eye preference by 86 (35·8%). Significantly more preterm children were left handed compared with parents or siblings in whom expected frequencies of left handedness were found. All index children had serial neonatal cerebral ultrasound examinations, of which 95 were abnormal. Left preference occurred at similar frequencies in those with normal neonatal scans (26·9%), bilateral lesions (28·3%), left sided lesions (23·8%), and right lesions (23·8%). Lateral preference appears to be unaffected by the side or extent of neonatal brain injury in children without major impairments.

Several studies have attempted to document an association between perinatal factors and the presence of left handedness using both specific markers, such as the time to establish spontaneous respiration after birth,[1] and more general indices such as optimality scores,[2] parity, and 'birth stress'.[3] In general, other studies have failed to confirm these findings.[4 5] There is, however, a high frequency of sinistrality among certain patient groups who have a high prevalence of neurological abnormality,[6] including those of very low birth weight.[7 8] Studies in children and adults with congenital and acquired hemiplegia show that major brain injury is important in the establishment of lateral preference.[9]

Among preterm children several causes for this observation have been postulated: a developmental defect,[7] asymmetric brain injury,[6] and the head turning preference of individual neonatal nurseries.[10 11] These studies were undertaken before cerebral imaging techniques were available. The high frequency with which abnormalities are observed on neonatal cerebral ultrasound scanning suggests that cortical brain injury may be an aetiological factor in the determination of hand preference in the very preterm population, and an observed excess of left sided ultrasound abnormality would seem to confirm this.[12]

The concept that biological handedness may be altered by organic brain injury (pathological hand preference) was introduced by Redlich in 1908.[8] Injury to the potential dominant hemisphere may result in transfer of function to the other. Central to this hypothesis is the presence within such populations of left and right handed individuals who have a pathological basis for their lateral preference. Organic brain injuries affect both biological left and right handed individuals, in proportion to their prevalence in the normal population. Assuming an equal distribution of predominantly left and right cortical insults, any brain injured population would show equal proportions of left and right handers. A knowledge of the frequency and laterality of brain lesions thus enables the prediction of the prevalence of left and right preference in a population.

Since 1980 routine cerebral ultrasound scans have been performed on all infants admitted to the neonatal unit at this hospital. This study documents the prevalence of lateral preference in children of less than 31 weeks' gestation in relation to family history and explores the hypothesis that lateral preference is related to the size and extent of neonatally observed brain lesions.

Subjects and methods

All high risk children managed on the Mersey Regional Neonatal Intensive Care Unit at Liverpool Maternity Hospital have been followed up prospectively since 1980. Children of less than 31 weeks' gestation were entered into the study if they were free of cerebral palsy or major visual impairment

and over 2 years of age. A total of 302 parents of 331 children were circulated with a questionnaire asking for details of the hand, foot, and eye preference of the index child, parents, and siblings. Simple instructions were provided requesting that the parents observed their children for two days before completing the questionnaire, giving details of suitable tasks in which to observe each child—hand preference: writing, cutting, and using a spoon; foot preference: kicking a ball, lead foot when climbing stairs or walking on tiptoe; eye preference: 'telescope' of card or paper. Details of the gestation and birth weight of siblings was requested in order to provide a comparison group of term children. Preference was recorded as either left, right, or unsure for each item.

Since 1980 routine neonatal ultrasound scanning has been performed at least weekly during each infant's stay in the unit. Scans were photographed on Polaroid film and an independent assessment was undertaken by one observer (RWIC). Initially scans were performed with an ATL 850A scanner using 5 MHz transducers (1980–2) and latterly 7·5 MHz (1982 onwards). Lesions were classified by degree of abnormality and side. Periventricular haemorrhages were classified as subependymal, intraventricular, or intracerebral; late appearance as persistent ventricular enlargement, small periventricular cysts (<1·0 cm), large periventricular cysts (>1·0 cm), or shunted hydrocephalus.

Children were nursed in incubators arranged parallel to the nursery wall. Because of the normal excess of right preference among the nursing staff, children tended to be nursed with face to the right, which would tend to favour the development of right preference.

A standard deviation score of birth weight for gestational age for each child was calculated using the standards of Keen and Pearse.[13] This was analysed both as a dichotomous variable, using various cut off points, and as a continuous variable. Data were encoded and analysed using the Statistical Package for the Social Sciences (SPSS/PC+). The significance of differences in frequencies were tested using χ^2 statistics with Yates's correction, as appropriate.

Results

Replies were received for 240 (73%) index children, median age 56 months, range 24–104 months. Parental preference was recorded for 232 children. Altogether 90 children had 87 full term siblings over 2 years of age and a further 36 preterm siblings, 21 of whom were less than 31 weeks' gestation at birth. Median birth weight for respondents was 1100 g (range: 560–1500 g) and gestational age 28 weeks (range 24–30 weeks). Median SD score of birth weight for gestational age was −0·27 (range: −3·57 to +1·42). Only 10 children had a SD score below − 2·0 and 21 a score below −1·5.

Parents reported that 64 index children (26·7%) showed left hand preference, 162 (67·5%) right preference, and 14 (5·8%) were unsure. Similar proportions for preference were reported for foot and eye: 70 children (29·2%) showed left foot preference (19 (7·9%) unsure) and 86 (35·8%) left eye preference (24 (10%) unsure). Only 61 (25·4%) children were reported as showing consistent ipsilateral preference for hand, foot, and eye, while 154 (64·2%) showed preference for ipsilateral hand and eye. Similar proportions of right and left handed children showed preference for ipsilateral eye or foot. Children with consistent ipsilateral preference were significantly more likely to show left hand preference (33 of 61 (54·1%)) than those without (31 of 179 (17·3%); χ^2 33·5; df=2; p<0·0001).

Of 87 full term siblings, 11 (12·6%) were reported to show left preference at a median age of 94 months (range 37–288 months). Index children with full term siblings were significantly more likely to show left hand preference than their sibling (25 (27·8%) χ^2 5·35; df=1, p=<0·05) and less likely to show ipsilateral preference for hand, foot and eye (siblings: 75 (85·2%)) or hand and eye (siblings: 62 (70·5%)). The 87 full term siblings had similarly lower frequencies of left foot (nine (10·2%)) and left eye preference (17 (19·5%)) than index children. Only 36 index children had preterm siblings, of whom only four (11·1%) had left preference.

The frequency with which left hand preference was reported among parents and siblings varied from 7·8–14·4% (table 1) and was significantly lower than that found among the index children. Left handed fathers were significantly more common among preterm children with left preference, whereas the frequency of left handed mothers and siblings did not vary significantly between groups (table 1). Stepwise multiple regression using the index child's hand preference as the dependent variable and family preferences as covariates failed to identify any further association. No effect of multiple pregnancy, gender, gestation, SD score of birth weight for gestation, or age at the time of testing could be identified.

One hundred and forty five children had normal cerebral ultrasound scans during the neonatal period, 53 had bilateral abnormalities, and 42 lesions confined to the left or right side (table 2). Of those with abnormal scans the frequency of left preference varied from 23·8–28·4% compared with 26·9% for those with normal scans. Breaking down the scan results by early appearance (periventricular

Table 1 *Association between hand preference of index children and family members. Results are No(%)*

	All index children		*Preference of index children*					
			Left		*Right*		*Unsure*	
Preference of family member:	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*
Mother (n=232)	18 (7·5)	212 (88·3)	6 (9·4)	57 (89·1)	12 (7·6)	144 (91·7)	1 (8·3)	11 (91·7)
Father (n=232)	32 (13·8)	199 (85·8)	12 (18·8)	49 (76·6)	16 (10·2)	141 (89·8)	4 (30·8)	9 (69·2)
Siblings:								
Term (n=90)	13 (14·4)	71 (78·9)	5 (20·0)	19 (76·6)	8 (13·6)	47 (79·7)	0	5 (83·3)
Preterm (n=33)	4 (12·1)	28 (85·0)						

Table 2 *Association of hand preference in index children to neonatal ultrasound appearances. Results are No(%)*

	Total No	*Hand preference of index patients*		
		Right	*Left*	*Unsure*
No brain injury	145	98 (67·6)	39 (26·9)	8 (5·5)
Left sided lesions only:				
Any	21	16 (76·2)	5 (23·8)	
Haemorrhage (grade II+):	10	7 (70·0)	3 (30·0)	
Cystic changes (grade II+):	8	3 (37·5)	4 (50·0)	
Right sided lesions only:				
Any	21	16 (76·2)	5 (23·8)	
Haemorrhage (grade II+):	12	9 (75·0)	3 (25·0)	
Cystic changes (grade II+):	11	7 (63·6)	4 (36·4)	
Bilateral lesions:				
Any	53	32 (60·4)	15 (28·3)	6 (11·3)
Asymmetrical				
{ Left >right	9	5 (55·6)	3 (33·3)	1 (11·1)
{ Right >Left	8	6 (75·0)	2 (25·0)	

haemorrhage) or by late appearance (ventricular dilatation or cystic changes) showed a slight excess of left hand preference among the small number of children with unilateral left sided cystic changes. No other type or distribution of abnormalities appeared to affect hand preference or consistency of preference.

Discussion

Using a simple postal questionnaire we have demonstrated over twice the expected frequency of left preference among a population of very preterm children. This prevalence, based on a referral hospital population, is higher than a previous comparable report where 19% had left preference.[7] One might anticipate that there would be a bias towards the reporting of right preference among index children from the mainly right handed parents. This questionnaire is considerably less complex than those previously used in which some estimates of the certainty of handedness was included. The age at which parents were asked to assess their children was also younger than most studies in childhood. Although there is stability in preference after 5–7 years,[7] the median age of the index group was 56 months. The frequency with which parents reported left preference or uncertainty was similar in older and younger children.

For the normal population, the preference of left preference ranges from 9·2–17·5% within various reported study groups.[2 4 14–16] The preferences of the siblings and parents of the index children thus fall within the normal distribution. Among the family members males had a higher frequency of left preference as noted by other authors.[2] This difference is not apparent among very low birthweight children in this or one other study.[7] The frequencies of left eye and foot preference found in this study are similar to those observed in large population studies.[17 18] The proportion of index children who had mixed preference for hand and foot (22·6%) is consistent with studies of 7 year old children where 29·5% had mixed preference.[17]

Neonatal cerebral ultrasound scanning showed abnormalities in 95 (39·6%) children. Using the model proposed by Satz,[6] assuming a 50:50 distribution of lesions between left and right and a 10% prevalence of biological left preference, the predicted prevalence of left preference in the study population is 62 (25·8%) (figure). Sixty four children (26·7%) were reported as showing left hand preference. Despite this striking similarity, examination of the data taking account of the ultrasound abnormalities failed to confirm this association. The distribution of preference was similar in those with observed ultra-

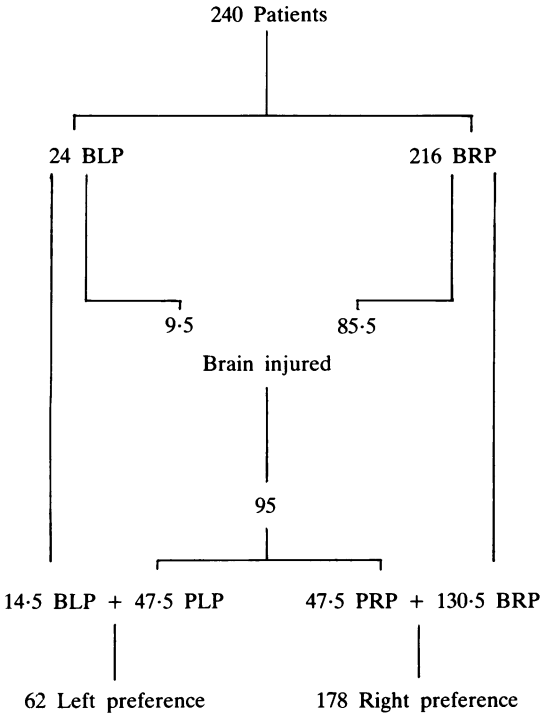

Figure *Theoretical distribution of hand preference based upon the model of Satz. Asumptions made are: (i) 10% population have biological left preference; (ii) there is a 39·6% brain injury rate; and (iii) there is a 50:50 distribution of side of greatest injury. (BL(R)P: biological left (right) preference; PL(R)P: pathological left (right) preference.)*

sound abnormality and those without, and similar in those with asymmetric lesions. When gross abnormalities detected by brain imaging do not clearly demonstrate the predicted effect on laterality it is difficult to hypothesise that less marked abnormalities may cause the observed excess of left preference.

Preterm children at school age have a range of abnormalities of motor, cognitive, behavioural, and neurological function. Data from Ross and colleagues suggest that these abnormalities are found more frequently among preterm children with non-right preference.[7] A subgroup of this index group has been assessed in detail during a study of motor skills in 53 children of <1251 g birth weight.[19] There was no relation between hand preference and motor performance in the index or control children (unpublished data). Rather it would appear that the altered distribution of preference parallels the abnormal neurological and cognitive maturation in preterm children as compared with term children. Further studies are in progress to chart the progress of two subgroups of this study population in terms of neuromotor and cognitive performance, including direct observation of lateral preference. The high frequency of left preference in this population remains unexplained.

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Correspondence to Dr N Marlow, Department of Child Health, Bristol Maternity Hospital, Southwell Street, Bristol BS2 8EG.

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