Birthweight ratio revisited

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Abstract

In order to test the hypothesis suggested in a recent report that the birthweight ratio might be a useful predictor of several important clinical outcome measures in babies of less than 31 weeks' gestation, we examined the association between the birthweight ratio and aspects of both short and long term outcome in 436 Leeds babies of less than 31 weeks' gestation. Unlike the report, and contrary to what we had expected, we were unable to find any significant association between birthweight ratio and length of time on the ventilator, mortality, neurological outcome, or intellectual outcome.

The birthweight ratio is a new and convenient method for relating a baby's birth weight to its expected weight for gestational age. It is calculated by dividing the birth weight by a median reference birth weight, preferably one derived from a population that excludes elective preterm delivery, to reduce the influence of babies small for gestational age.¹ The main advantage over centile charts is that the birthweight ratio is a continuous numerical variable that can be handled mathematically and used by computers, whereas it is usually only possible to make categorical statements about a baby's position on the centiles, such as 'between the 10th and the 25th'.

We have always been taught to define a baby as 'light for dates' (or 'small for dates'; or even 'growth retarded', which is not necessarily an appropriate term) if its birth weight is below the 3rd centile for gestation. Because light for dates babies may have been exposed to intrauterine insults or deprivation they are more likely to suffer from neurodevelopmental problems than those who are adequately grown.²⁻⁵ It is also thought that light for dates babies are 'stressed' and better prepared for premature birth. They usually have less severe respiratory distress syndrome as a consequence.^{6,7} The recent paper by Morley *et al*, however, seems to contradict both these views.⁸ They found that babies with lower birthweight ratios were ventilated for longer than those with higher ratios suggesting either a greater severity of respiratory disease among the less well grown or at least a greater propensity to develop chronic lung disease. They also found no association between birthweight ratio and neurodevelopmental outcome at 18 months other than slightly better language scores in the highest birthweight ratio group.

Because the findings of Morley *et al* seem to contradict what we have always been taught,

and because if their findings are generally applicable birthweight ratio could be used as a prognostic factor both in research and for the counselling of parents, we decided to see if the Cambridge findings were applicable to babies born in Leeds.

Patients and methods

So that we could look at correlations with birthweight ratio in some detail, in terms of both short and long term outcome, we studied three separate groups of patients.

GROUP 1

Group 1 comprised all 372 babies born before 31 weeks' gestation at St James's University Hospital between January 1985 and December 1989, of whom 57 died. Data on birth weight, gestation, mortality before discharge, and duration of ventilation were collected from the computer database. Throughout the period of the study electronic scales were used routinely to weigh babies. Gestational age was calculated from early ultrasound scans in nearly every case.

GROUP 2

To see if a group of babies with confirmed cerebral palsy had a different mean birthweight ratio from our general population of preterm babies (group 1) we calculated the birthweight ratio of babies who presented to our Child Developmental Centre in the period 1982-8 with confirmed cerebral palsy. Among this group were 62 babies born at less than 31 weeks' gestation; 45 had spastic diplegia, nine quadriplegia, six hemiplegia, and two had athetoid cerebral palsy.

GROUP 3

A group of 64 very low birthweight survivors born at St James's University Hospital in 1982 and 1983 had detailed assessments carried out at the age of 5 years for an outcome study. The assessment included neurological examination and ascertainment of intelligence quotient (IQ) and verbal ability (VQ) scores, using the Wechsler preschool primary scale of intelligence scales. This group of infants was studied for an association between birthweight ratio and both neurological and intellectual outcome.

The data were analysed by Student's *t* test, χ^2 test, and regression analysis. Two approaches were used to allow for the possible confounding

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effect of gestation: firstly a linear regression analysis was done to look for an association between gestation and birthweight ratio; secondly, multiple regression analysis was used when adjustment for confounding factors was required.

Results

GROUP 1

The birthweight ratio data for all babies in group 1 (that is, all babies of less than 31 weeks' gestation born between January 1985 and December 1989) conformed closely to a Gaussian distribution (χ^2 test, $p=0.09$), with no apparent skewness. The sample mean (SEM) was 1.0097 (0.0095) (fig 1).

The mean (SEM) birthweight ratio of the 57 babies in group 1 who died was 1.026 (0.0083). This was not significantly different from that of the survivors (Student's t test, $p=0.466$). There was, however, a significant difference between the mean gestational ages of the two groups, 27.3 weeks and 28.9 weeks, respectively ($p<0.001$).

In addition to adjusting for gestation with multiple regression, we checked to see if there was any significant correlation between birthweight ratio and gestation that would have prevented us from detecting an influence of birthweight ratio independent of gestation; there was none ($r=-0.077$, $p=0.13$).

Birthweight ratio was divided into five categories and these were regressed as discrete vari-

ables against whether each subject died in the neonatal or postneonatal period; adjustment was made for gestational age. There was no significant association ($p=0.89$) (table 1). The birthweight ratio was also regressed as a continuous variable against whether each subject died in the neonatal or postneonatal period, adjusting for gestation by multiple regression analysis. No significant association was found ($p=0.9$).

Linear regression analysis was used to examine the relationship between the birthweight ratio of the survivors of the neonatal period and the duration of mechanical ventilation. No significant association was found ($r=-0.0097$) (fig 2). Multiple regression was then used to make adjustment for gestation and once again no significant association was found ($p=0.211$).

The survivors were then divided into five discrete birthweight ratio classes (<0.8 , $0.8-<0.9$, $0.9-<1.0$, $1.0-<1.1$, ≥ 1.1) and these were related to the duration of ventilation divided into four classes (during the first 24 hours and greater than seven, 14, and 28 days). There was no significant association between birthweight ratio category and the duration of mechanical ventilation (χ^2 test, $p=0.83$). Multiple regression analysis was used to relate birthweight ratio as a discrete and a continuous variable to duration of ventilation among the survivors; adjusting for gestation no association was found ($p=0.18$). Table 2 shows the percentage of babies in each birthweight ratio category

Figure 1 Frequency distribution of birthweight ratios for babies in group 1.

Figure 2 Regression line of duration of ventilatory support in days and birthweight ratio.

Table 1 Association between birthweight ratio and number of babies that died adjusted for gestational age

	Birthweight ratio				
	<0.8 (n=49)	0.8-<0.9 (n=42)	0.9-<1.0 (n=64)	1.0-<1.1 (n=102)	≥1.1 (n=115)
Gestation:					
Mean gestational age	29.1	28.5	29	28.6	28.4
No (%) that died ≤28 days old	5 (8)	8 (14)	7 (10)	11 (11)	20 (18)
No (%) that died >28 days old	1 (1.7)	0	2 (3)	0	3 (2)

$p=0.9$ for birthweight ratio (as a continuous variable) regressed against whether each subject died in the postneonatal period (adjusting for gestation).

Table 2 Association between birthweight ratio and need for mechanical ventilation

	Birthweight ratio				
	<0.8 (n=44)	0.8-0.9 (n=34)	0.9-1.0 (n=57)	1.0-1.1 (n=91)	≥1.1 (n=95)
No (%) ventilated during first 24 hours	37 (84)	28 (82)	38 (67)	66 (73)	73 (77)*
No (%) ventilated for >7 days	14 (32)	15 (44)	18 (32)	20 (22)	33 (35)**
No (%) ventilated for >14 days	8 (18)	10 (29)	15 (26)	15 (17)	24 (25)***
No (%) ventilated for >28 days	4 (9)	2 (6)	8 (14)	6 (7)	12 (13)****

*p=0.18, **p=0.84, ***p=0.58, ****p=0.14, for birthweight ratio (as a continuous variable) regressed against the need for ventilation in the first 24 hours and greater than 7, 14, 28 days (adjusting for gestation).

needing mechanical ventilation during the first 24 hours and for greater than seven, 14, and 28 days. There was no significant association between birthweight ratio groups and the need for mechanical ventilation in any of the categories after adjusting for gestation (p=0.18, p=0.84, p=0.58, and p=0.14, respectively).

GROUP 2

The birthweight ratios of the children with confirmed cerebral palsy also fitted a Gaussian distribution (mean (SEM) 1.057 (0.023)). This mean birthweight ratio was slightly higher than that of the group 1 babies, but the difference was not significant (p=0.061). There was, however, a significant difference in gestational age between the two groups, those with cerebral palsy having a lower mean gestational age (28.14 weeks) than the group 1 mean (28.93 weeks, p=0.003).

There was no difference in birthweight ratio among the various cerebral palsy groups: dip-

legia (n=45), quadriplegia (n=9), hemiplegia (n=6), and athetoid (n=2).

GROUP 3

Data about the infants in the very low birthweight follow up study were analysed in a similar way. The mean (SEM) birthweight ratio for this group was 0.94 (0.021). Nine babies in the group had cerebral palsy (diplegia (n=7), quadriplegia (n=1), and hemiplegia (n=1)). The mean (SD) birthweight ratio of the babies with cerebral palsy was 0.987 (0.024). This was not significantly different from the population mean (p=0.52). The mean gestational age was also not significantly different (28.7 weeks for babies without cerebral palsy compared with 27.89 weeks for those with cerebral palsy, p=0.16).

The IQs of the very low birthweight group were normally distributed around a mean of 94.8. There was no significant correlation between either birthweight ratio and IQ (fig 3) or between gestation and IQ (r=-0.17 and 0.2, respectively). The VQs for the group were normally distributed about a mean of 97.1, and there were no significant correlations between birthweight ratio or gestational age or VQ (r=-0.2 and 0.2). Multiple regression analysis was then used to analyse the association between birthweight ratio as a discrete variable and IQ and VQ, adjusting for gestational age. No significant association was found (p=0.74 and p=0.58, respectively) (table 3).

Morley *et al* found an association between birthweight ratio and body weight, body length, and head circumference at 18 months when adjustment was made for gestational age. We have no data to verify these findings.

Discussion

The birthweight ratio is a concept that has instant appeal. It is much easier to handle than centile charts and overcomes the previous arbitrary categorisation of babies according to centile lines. Its use should allow more sensitive analysis of outcome depending on intrauterine

Figure 3 Regression line of IQ and birthweight ratio.

Table 3 Association between birthweight ratio, IQ, and VQ

	Birthweight ratio				
	<0.8 (n=14)	0.8-0.9 (n=10)	0.9-1.0 (n=15)	1.0-1.1 (n=11)	≥1.1 (n=14)
Mean (SEM) IQ	94.6 (3.5)	99.7 (4.1)	98 (5.1)	92.5 (4.4)	89 (4.5)
Mean (SEM) VQ	98.2 (3.8)	101.7 (4.4)	99.13 (4.6)	97 (4.3)	91.2 (3.7)

growth. The Cambridge data seem to confirm this hope in relation to the severity of respiratory disease, the postneonatal mortality rate, long term growth, and possibly language development. Its potential usefulness is so great that we felt it should be tested on another group.

In the calculation of birthweight ratios for babies born in Leeds we made use of the median birthweight data produced by Lucas *et al* because we do not yet have sufficient data of our own.¹ The close proximity of our mean birthweight ratio to unity and the normal distribution about the mean suggests that these data are suitable. We did not see the slight negative skewness that was seen in the distribution of the Cambridge data, but numbers in both groups are too small to make much of this difference. It is unlikely that we studied a significantly lower proportion of babies delivered electively for suspected intrauterine growth failure.

The mean birthweight ratio of our group of babies weighing less than 1500 g (group 3) was, not surprisingly, significantly lower than that for our general population of babies born at less than 31 weeks' gestation because the weight limit will have excluded some babies with higher birthweight ratios.

We were unable to show any association between the birthweight ratio and either the need for, or the duration of, ventilatory support (fig 2, table 2). This was a surprise because we had expected to find that babies whose birth weights were lower than expected for gestational age would have less severe respiratory distress syndromes and less chronic lung disease than those who were better grown. Unlike the Cambridge study, which may have excluded some babies dying during the first day or two of life, our data on mortality are complete.

Morley *et al* found a significant association between birthweight ratio category and postneonatal mortality, suggesting that babies with a low birthweight ratio had a higher postneonatal mortality rate. We found no statistical association between birthweight ratio and mortality rate either during or after the neonatal period. An interesting difference between our group and that described by Morley *et al* is the much lower postneonatal mortality rate among Leeds babies (1.87% compared with 6.77%); it was so low that we are unable to comment on any relationship with birthweight ratio. The overall mortality rates for the two cohorts are, however, similar (16.5% in Cambridge and 15.5% in Leeds). The observed shift in age at death may be explained either by an intrinsic difference between the two populations or by a difference in clinical practice. There is insufficient information to take this any further.

We have no ready explanation for the many differences between our findings and those of

Morley *et al*, or conventional teaching, although perhaps the current use of steroids, both prenatally and postnatally, may have altered the pattern of respiratory distress compared with older studies.

We would have expected to find an association between birthweight ratio and developmental outcome, because adverse prenatal factors affect both somatic growth and the growth and development of the central nervous system. The Cambridge study was unable to show such an effect, except for slightly better language scores at 18 months in infants with the highest birthweight ratios. Despite having detailed neurological and psychometric developmental assessments at the age of 5 years we were also unable to find any association between birthweight ratio and either neurological or intellectual outcome. We can offer no clear explanation for the lack of relationship between birthweight ratio and developmental outcome in our study and of Morley *et al*, except that both groups may have been too small to show it reliably. In the case of older studies it may be that, because estimates of gestation were less reliable than they are now, the effects of gestation were more difficult to disentangle from the effects of growth alone. In addition, the use of conventional centiles is already biased by the over-representation of growth retarded babies, and result in the selection of only the most extremely light for dates babies to compare with the rest of the population.

We are forced to conclude that for our babies the birthweight ratio is of no value in probabilistic calculations concerning the likely mortality, the duration of ventilator treatment, or the neurodevelopmental outcome among preterm babies of less than 31 weeks' gestation. We think that it is important for the question to be examined among a much larger number of infants from other centres.

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