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Postnatal growth in infants born before 30 weeks' gestation

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SUMMARY The postnatal weight pattern up to 14 weeks after birth was determined in 184 singleton survivors born at 23 to 29 weeks' gestation in whom routine parenteral nutrition was used before milk feeding was established. A mean postnatal weight loss of 14% of birth weight occurred at a mean of 6 days. The more immature infants had significantly higher postnatal weight loss and longer time to regain birth weight despite a higher volume intake in the first week. From the fourth postnatal week all gestational subgroups had a mean weight gain at above intrauterine growth rate. As a result of the initial period of weight loss, however, the mean body weight remained below the 10th percentile of the intrauterine growth curve. The early growth rate in infants small for gestational age was higher than those who were appropriate weight for gestation, although the mean body weight of the former group remained significantly lower at 2 years.

The achievement of an intrauterine growth rate has been recommended as a nutritional goal for low birthweight infants.[1] Published studies on postnatal growth patterns have either very few infants of less than 1000 g birth weight of unknown gestation[2 3] or, if the maturity was stated, few infants below 30 weeks' gestation included in the studies.[4 5] The increasing survival of extremely preterm or low birthweight infants[6 7] has made it necessary to define the postnatal growth pattern for these infants to allow comparison with intrauterine growth data. Although the postnatal growth of small for gestational age infants born close to term has been shown to remain poor compared with appropriate for gestational age infants,[8–10] the growth pattern of those small for gestational age infants who were delivered before 30 weeks' gestation has not been reported. In the present study we determined the postnatal growth patterns of infants born at a gestation of 23 to 29 weeks and made a comparison between those who were appropriate and small for gestational age.

Patients and methods

The study population was derived from consecutive admissions of infants born at 29 weeks' gestation or less to the Queen Victoria Medical Centre between 1977 and 1982 inclusive. Deaths and multiple births were excluded, but the population was unselected in all other ways.

The gestational age was calculated from reliable menstrual history, often confirmed by either a sonar examination or bimanual clinical examination of the uterus in the first trimester. Gestational assessment based on the latter two techniques was used in the few mothers who did not have an accurate menstrual history. Small for gestational age infants were defined as those whose birth weight was below the 10th percentile for a Melbourne population.[11]

Parenteral nutrition was begun routinely in all infants before one week of age according to a standard protocol previously reported.[12 13] A glucose amino acid solution based on Vamin and a fat emulsion were used. This regimen enabled the amino acid intake to be progressively built up from 1·7 to 3·5 g/kg/day, glucose intake from 6 to 18 g/kg/day, and fat intake from 1 to 3 g/kg/day during the first two weeks after birth. The protocol also allowed for standard amounts of electrolytes. trace elements, and vitamins to be infused at a rate that is recommended to promote normal growth.[14] Fresh expressed breast milk from the infant's own mother was given whenever possible.[15] Otherwise, infants were fed a standard 67 kcal/100 ml humanised formula in 1977 and 1978 and a premature 80 kcal/100 ml formula thereafter. Supplemental parenteral nutrition was progressively reduced as the volume of milk feeding was graded up as tolerated. The median age when infants tolerated full milk feeds was 21 days (range 6 to 57 days).

The infant's postnatal growth and nutritional intake data were collected prospectively as part of the nursery's perinatal database. Infants were weighed daily by nursing staff unless they were clinically extremely unstable. Mechanical scales were used for the first two years of study and electronic scales thereafter. Growth data at 2 years were obtained between 22 and 26 months of age, corrected for prematurity. Statistical comparisons between groups were performed by analysis of variance.

Results

One hundred and eighty four survivors born at 23 to 29 weeks' gestation were included in the study. The mean birth weight and number in each gestational group are shown in Table 1. No statistical difference in birth weight was found between this cohort and that reported in the intrauterine growth chart.[11] The distribution for each week of gestation showed minimal skew, suggesting reliable gestational assessment. Thirteen (7%) of the study population were small for gestational age.

The mean body weight for each gestational group was plotted against postnatal age (Fig. 1). Longitudinal growth data were analysed up to the point when more than half the number in each of the group had been discharged from hospital to minimise possible bias resulting from discharge of the heavier infants who might have had a higher growth rate. Each weight curve had two apparent phases: an initial week of weight loss followed by a period of continuous and steady weight gain.

The mean (SD) postnatal weight loss was 14 (6)% of birth weight and the mean (SD) age at this lowest weight was 6 (3) days. The mean (SD) time required to regain birthweight was 18 (7) days. Table 2 shows a significant trend with increasing prematurity of

Table 1 *Birth weights (g) of the study population*

Gestation (wks)	*Study population*		*Intrauterine data[11]*	
	n	*Mean (SD)*	*n*	*Mean (SD)*
23	2	655 (75)		
24	10	735 (71)	35	680 (120)
25	8	799 (155)	56	784 (110)
26	31	881 (99)	77	835 (166)
27	44	969 (140)	84	1082 (149)
28	42	1077 (185)	95	1120 (217)
29	47	1177 (172)	96	1225 (180)

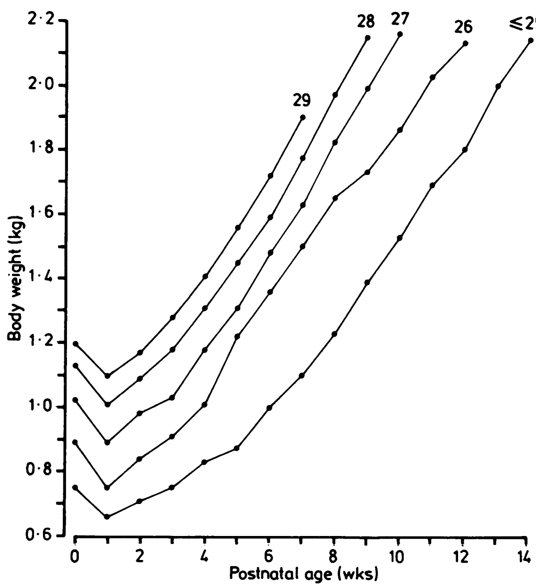

Fig. 1 *Mean body weight* v *postnatal age for each gestational group.*

Table 2 *Early postnatal weight changes (mean (SD))*

	Gestation (wks)				
	<25	*26*	*27*	*28*	*29*
Postnatal weight loss (% of birth weight)*	21 (6)	15 (6)	14 (5)	14 (5)	12 (6)
Age at lowest weight (days)	6 (3)	6 (5)	6 (3)	6 (3)	6 (3)
Time to regain birth weight (days)*	24 (5)	18 (9)	19 (7)	17 (4)	15 (6)

*Trend of higher postnatal weight loss (r=−0·36) and longer time to regain birth weight (r=−0·35) with increasing prematurity (p<0·01).

Table 3 *Volume and energy intake (mean (SD))*

	Gestation (wks)					*All infants*
	<25	*26*	*27*	*28*	*29*	
Mean volume intake (ml/kg/day):						
Week 1*	154 (19)	145 (25)	143 (27)	136 (20)	133 (20)	140 (23)
Week 2	153 (18)	146 (38)	156 (19)	159 (19)	159 (20)	155 (24)
Week 3*	157 (46)	149 (22)	154 (23)	160 (31)	164 (36)	157 (31)
Week 4*	157 (31)	150 (24)	157 (22)	163 (31)	165 (39)	159 (30)
Mean energy intake (kcal/kg/day):						
Week 1*	57 (19)	60 (14)	64 (15)	67 (13)	71 (21)	65 (17)
Week 2*	83 (23)	93 (22)	100 (24)	107 (19)	108 (24)	100 (24)
Week 3*	102 (19)	99 (22)	110 (24)	116 (24)	119 (29)	111 (25)
Week 4*	108 (24)	111 (22)	118 (26)	116 (27)	124 (28)	116 (26)

*Trend of higher volume intake in week 1 (r=−0·30), lower volume intake in weeks 3 and 4 (r=0·20 and 0·21), and lower energy intake in weeks 1 to 4 (r=0·25, 0·36, 0·35, and 0·23, respectively) with increasing prematurity (p<0·01).

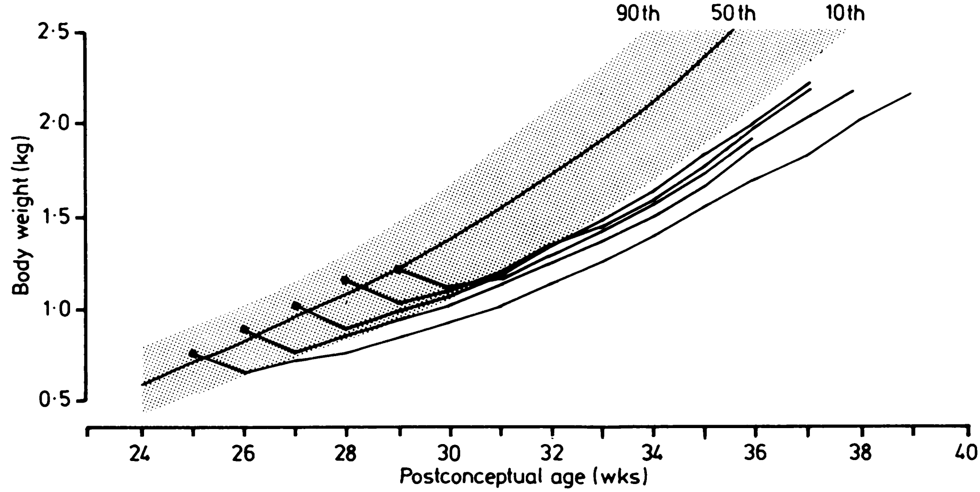

Fig. 2 *Superimposition of postnatal growth curves for each gestational group on the intrauterine growth chart.*

higher postnatal weight loss and longer time to regain birth weight (p<0·01).

Mean volume intake ranged from 140 ml/kg/day in the first week to 159 ml/kg/day in the fourth week. Mean energy intake ranged from 65 kcal/kg/day in the first week to 116 kcal/kg/day in the fourth week. Table 3 shows a significant trend with increasing prematurity of higher volume intake in the first week, lower volume intake in the third and fourth week, and lower energy intake during the first four weeks (p<0·01).

In Figure 2 postnatal growth curves have been superimposed on the intrauterine growth chart. No significant differences in body weight existed between each gestational group at respective postconceptual ages. As a result of the initial period of weight loss, however, the mean body weight remained below the 10th percentile of the intrauterine growth curve.

Mean daily growth rates were obtained by dividing weekly increments in weight by actual weight at the beginning of the period and by seven days. The resulting mean growth velocity per unit of body size, expressed as g/kg/day, is shown in Table 4 for appropriate for gestational age infants. No significant difference in growth rates were found between gestational groups at different postnatal ages. Table 5 shows that the growth rate of small for gestational age infants was higher than that of appropriate for gestational age infants, although the differences were not significant.

Data on body weight at 2 years of age corrected for prematurity were available in 173 (94%) of the 184 survivors (Table 6). No significant differences

Table 4 *Mean daily growth rates in appropriate for gestational age infants (g/kg/day)*

Postnatal age (wks)	*Gestation (wks)*				
	<25	*26*	*27*	*28*	*29*
1	−18·3	−20·2	−15·8	−14·8	−12·3
2	10·6	28·8	12·8	11·2	10·5
3	12·3	12·0	11·4	13·6	14·5
4	14·1	15·5	17·1	16·3	14·2
5	14·4	14·2	15·4	15·8	18·1
6	14·0	14·7	17·2	15·8	16·7
7	17·6	15·7	16·5	16·4	15·7
8	17·5	15·7	18·2	15·8	
9	17·5	15·0	14·0	13·5	
10	16·0	16·7	11·9		
11	16·0	14·5			
12	14·4	13·9			
13	15·0				
14	12·0				

Table 5 *Comparison of growth rates (g/kg/day) in appropriate and small for gestational age infants (mean (SD))*

	Infants	
Postnatal age (wks)	*Appropriate for gestational age*	*Small for gestational age*
1	−15·8 (1·2)	−15·5 (9·9)
2	11·0 (0·7)	14·9 (9·3)
3	12·2 (1·3)	16·5 (7·6)
4	15·4 (0·5)	15·1 (7·6)
5	15·8 (0·4)	17·0 (7·9)
6	16·5 (0·3)	21·0 (8·2)
7	16·4 (0·2)	18·0 (8·8)
8	16·5 (0·4)	18·2 (5·3)
9	15·1 (0·6)	15·4 (9·7)
10	13·5 (0·5)	15·7 (6·3)
11		16·2 (6·5)
12		8·8 (6·3)
13		11·4 (5·7)

Table 6 *Body weight at 2 years of age*

Infants	*No of children*	*Body weight (kg) (mean (SD))*
Appropriate for gestational age	162	11·4 (1·3)*
<25 wks	19	11·0 (1·3)
26 wks	30	11·3 (1·5)
27 wks	39	11·5 (1·4)
28 wks	34	11·4 (1·7)
29 wks	40	11·8 (1·6)
Small for gestational age	11	10·2 (1·3)*

*Appropriate *v* small for gestational age, p<0·01.

were found between gestational groups in appropriate for gestational age children. The mean weight for both appropriate and small for gestational age groups was between the third and the 10th percentiles based on standards from an Australian population.[16] Small for gestational age children remained significantly lighter than appropriate for gestational age children (p<0·01).

Discussion

Although it is generally accepted that preterm infants should promptly resume postnatal growth at a rate approximating intrauterine growth, whether this goal is achievable or desirable has not been determined in those born before 30 weeks' gestation. The difficulties inherent in constructing intrauterine growth standards have been reviewed.[17] One problem is that of collecting a sufficiently large sample of liveborn infants at below 30 weeks' gestation.[18] Furthermore, it has been emphasised that preterm birth is itself an abnormal event and that unfavourable maternal factors and fetal disorders leading to preterm birth might significantly bias the sample. This criticism was considered invalid, however, for birth dimensions up to the beginning of the third trimester.[19]

Our findings show that from the fourth postnatal week all subgroups gained weight at a rate consistently above the reported intrauterine growth rate on the 50th percentile of 14·4 g/kg/day.[20] This figure was derived from previously published data on fetal body weights between 24 weeks' and 42 weeks' gestation.[21] As a result of the initial period of weight loss, however, the infants fell below the 10th percentile and therefore fulfil a stringent criterion of extrauterine growth retardation. These data highlight the misleading nature of comparisons with intrauterine growth curves. This apparent contradication in results from Table 4 and Figure 2 has also been reported in a previous study in which two reasons were given.[22] Firstly, if the time to regain birth weight is prolonged, catch up growth at a rate in excess of intrauterine growth is required to return to the birth percentile. Secondly, as the weight drops to a lower percentile during the non-growing phase, a faster rate of weight gain is required simply to maintain the position on the lower percentile as the intrauterine growth rate on the 10th percentile is greater than that on the 50th.

The initial period of weight loss is partly attributable to contraction of total body water that occurs after birth.[23] The significant trend towards increasing delay in regaining birth weight with increasing prematurity suggests, however, that other factors were operative. The higher insensible water loss through the skin of infants who are more preterm probably resulted in the significantly greater postnatal weight loss despite a significant higher volume intake in the first week after birth. Increasing prematurity is associated with increasing frequency and severity of respiratory failure with its inherent complications of ventilator management,[24] a prolonged period of catabolism,[25] and difficulty in establishing nutritional adequacy.[26] These factors probably contributed to the significantly lower energy intake with increasing prematurity found in this study, though the relation between the poorer energy intake and the less favourable early postnatal weight changes remains unclear.

No attempt has been made to compare the postnatal growth of infants who were fed mother's preterm milk with that of infants fed formula. Evidence has suggested that the population of mothers who chose to feed their own preterm infants differed from those who did not.[22] This fact will therefore complicate the interpretation of findings, involving the non-randomised comparison of infants fed maternal milk with those fed formula. Poorer growth performance of low birthweight infants fed human milk has previously been observed.[22 27]

No comparison was attempted between 'well' and 'sick' infants as all required treatment with oxygen and, with the exception of several infants born at 28–29 weeks' gestation, all received assisted ventilation. The 13 small for gestational age infants in the study did not differ in their clinical course compared with their appropriate for gestational age peers within the same gestational subgroup. Comparison of appropriate and small for gestational age infants in the present study revealed, however, that the postnatal growth rate was higher in the small for gestational age group, although the mean body weight at 2 years of age remained lower than that in the appropriate for gestational age group. This finding is different from the significant postnatal growth retardation in small for gestational age populations born close to term.[8–10] The duration of fetal growth restriction before birth might account for any difference in the potential for catch up growth postnatally. One study on infants under 2000 g birth weight that included some infants below 30 weeks' gestation made the comment that there was suprisingly little difference between the weight gain of small for gestational age infants and that of the whole population,[22] although no data were published that allow comparison with the present study.

The infants in the present study are lighter, more preterm, and sicker than those previously studied.[2–5] Nevertheless, more rapid postnatal weight gain was achieved. The use of routine parenteral nutrition before enteral feeding was established has probably contributed to the improvement. Similar to previous reports, only those who survived were included in the study. As 77% of those who died did so before 1 week of age[6] selection of only survivors in the study population was unlikely to have significantly biased the postnatal growth data after the first week in the present study, although the number of infants in the earlier gestational subgroups was reduced by exclusion of the deaths. We have shown that early extrauterine growth rates after extremely preterm birth, similar to or above intrauterine growth rates, are attainable. Catch up growth that re-establishes the birth percentile on the estimated delivery date was, however, difficult to achieve. A previous study of a more mature cohort of very low birthweight infants also found that the mean weight at the expected delivery date was below the third percentile.[28] If faster weight gain could reduce the duration of admission to hospital without an attendant metabolic stress to the infant the promotion of better postnatal growth can be justified on social or financial grounds. Research is nevertheless required to investigate the relation between early growth performance and long term neurodevelopmental outcome.

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