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Birthweight between 14 and 42 weeks' gestation

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SUMMARY Data representing fetal weight gain between 14 and 42 weeks' gestation are presented; firstly to provide suitable curves enabling the growth of the very immature infant to be monitored and secondly to examine the influence of the improved techniques of paediatric and obstetric assessment developed since the publication of previous studies.

Data have been collected from the 57 866 livebirths in Sheffield between 1976 and 1984 and from therapeutically terminated and spontaneously aborted fetuses over the same period. It seems that preterm livebirths do not form a different population with respect to weight from the fetus still in utero, at least until the beginning of the third trimester. Previous studies have reported a bimodality of weight distribution in preterm infants at each gestational age which has been attributed to errors in gestational assessment. The pattern of distribution of weight in this study suggests that early ultrasonography and paediatric assessment techniques have exerted a considerable influence on the accuracy of gestational assessment.

The mean weights of the sample differ considerably from those of the Gairdner and Pearson chart which are, therefore, considered to be inappropriate for the Sheffield population.

The importance of accurate data for birthweight at the lower gestational ages has increased with the improving survival of these babies. Existing growth data are unsatisfactory, however, because:

(1) In most studies there is a bimodal or skewed distribution of weight.[1–6] This has been thought to be due to a substantial proportion of babies whose gestational age was wrongly assessed.[7 8]

(2) There are little data on infants of less than 28 weeks' gestation and those which do exist are limited by small sample size[6 9] and the uncertainty of accurate gestational age.[1 6]

(3) The widely used Gairdner and Pearson chart[10] has a number of inherent problems especially for the earlier gestations. Based on the Tanner and Thomson[11] data between 32 and 40 weeks' gestation, the curves are extrapolated down to values given by Babson[12] at 28 weeks derived from various sources in the United States.[1 9 12] It is unclear whether there are significant differences in preterm infant weight between different countries and between different populations within a country.[4 12]

It is commonly felt that the Gairdner and Pearson charts generate a disproportionately large number of small for dates preterm infants. This is certainly true for the Sheffield population where 80% of infants of 32 weeks' gestation and 92% at 34 weeks' gestation fall below their 50th centile.

It is now apparent that it is important to identify those genuinely growth retarded infants who are more than 2 SD below the mean, because of the increased possibility of pathological causes of low birthweight and risk of handicap.[13]

(4) It is uncertain whether growth curves based on liveborn infants are representative of intrauterine growth,[8] and it is commonly suspected that preterm infants may be a different population in respect of weight, from fetuses in utero.

This paper attempts to remedy these deficiencies.

Sample

The sample was derived from three subgroups—liveborn infants (1454) and fetuses of therapeutic (109) and spontaneous (40) abortions. The total sample size was 1603 and the gestational range was 14 to 42 weeks. Only morphologically and apparently chromosomally normal singletons were included: hydropic infants, infants of diabetic mothers, and macerated fetuses were excluded.

Liveborn infants. Data were obtained from all three maternity units in Sheffield; The Jessop Hospital for Women, Northern General Hospital, and Nether Edge Hospital. There were 57 866 births during the period from 1976 to 1984. In order to cope with the very large numbers of births it was necessary to collect data selectively and bias the sample in favour of infants of under 30 weeks' gestation, as follows:

(a) Twenty two to 30 weeks' gestation; all infants born in Northern General Hospital between 1976 and 1984.

(b) Twenty two to 34 weeks' gestation; all infants born in Nether Edge and Jessop Hospitals between 1976 and 1984.

(c) In addition, all outborn infants of 30 weeks' gestation or less referred to the Jessop Hospital. Neonatal Intensive Care Unit between 1976 and 1984 other than from the three centres above, recognising that these infants may form a biased sample.

(d) Thirty five to 42 weeks' gestation; infants born between 1982 and 1984, by a systematic stratified sample. Because of the small sample size of the earlier gestational ages it was not possible to consider such variables as sex or maternal parity. In order to give continuity, and to detect possible differences between our population and the existing data for 35 weeks' gestation and above, a representative sample was obtained from the first five births per month at each week of gestation, increasing to 10 per month for the gestational period 38 to 40 weeks inclusive where the growth rate was expected to decline steeply.

Fetuses. The fetal sample consisted of therapeutically and spontaneously aborted fetuses of between 14 and 27 weeks' gestation inclusive, examined and subjected to measurement by the Histopathology Department at Jessop Hospital between 1976 and 1984.

Gestation was assessed as completed weeks, as recommended by the World Health Organisation, on the basis of mothers' menstrual history, obstetric examination, early ultrasonography and paediatric assessment, or pathological examination of the products of conception to give the most consistent result. Ambiguous or incomplete data were excluded. All data conforming to the above criteria were included. Subjective bias in sampling was avoided by not excluding those fetuses whose weight seemed grossly at variance with the population on the scatter diagram.

Methods and results

Mean weights and standard deviations were calculated for each completed gestational week for the liveborn and each of the two groups of fetuses (Tables 1 and 2). The suspicion that the outborn infants could be a biased sample was not confirmed. Although there were slight differences between the mean weights of the inborn and outborn infants, for each gestational age from 24 to 30 weeks' gestation inclusive the variations were not consistent nor were they statistically significant (P>0·10 (two tailed *t* test)). The mean weights of the liveborn were plotted by hospital of origin where comparable data were available (Fig. 1). The resulting graph shows noticeable differences in the means, but of an inconsistent nature that is unlikely to represent population differences. It is probable that the variation is due to differences in paediatric gestational assessment practice and illustrates the extent of observer variation in comparative studies.

The mean weights of the three sample groups were compared graphically (Fig. 2). Between 18 and

Table 1 *Weights (g) in relation to gestational ages in liveborn infants*

Gestation (weeks)	*No*	*Mean (SD)*	*Range*
22	4	542 (159)	340–730
23	5	690 (136)	480–920
24	16	700 (120)	520–960
25	26	728 (120)	500–1050
26	36	911 (161)	580–1300
27	50	1041 (181)	440–1410
28	85	1230 (236)	800–1980
29	52	1332 (264)	760–2320
30	89	1467 (277)	900–2105
31	60	1580 (288)	780–2520
32	101	1757 (303)	980–2460
33	114	1977 (330)	1240–2820
34	156	2156 (331)	1200–3580
35	60	2428 (472)	1312–3300
36	60	2738 (417)	2000–3690
37	60	2969 (426)	1900–3800
38	120	3218 (394)	2380–4340
39	120	3428 (418)	2500–4540
40	120	3463 (383)	2410–4540
41	60	3582 (401)	2720–4422
42	60	3629 (354)	3000–4520

Table 2 *Weights (g) in relation to gestational ages in therapeutically and spontaneously aborted fetuses*

Gestation (weeks)	*Terminations*			*Spontaneous abortions*		
	No	*Mean (SD)*	*Range*	*No*	*Mean (SD)*	*Range*
14	14	63 (23)	40–110			
15	23	91 (28)	50–150			
16	19	118 (26)	70–185			
17	22	160 (53)	45–250	1	120	
18	6	246 (68)	160–365	2	250 (14)	240–260
19	5	276 (32)	230–330	5	295 (86)	210–440
20	10	360 (47)	285–435	9	315 (35)	245–370
21	5	423 (87)	325–530	8	441 (101)	325–630
22	1	550		4	505 (57)	440–590
23	1	530		5	581 (63)	480–640
24	0			3	576 (81)	520–670
25	2	760 (0)	760–760	1	810	
26	1	630		1	720	
27				1	800	

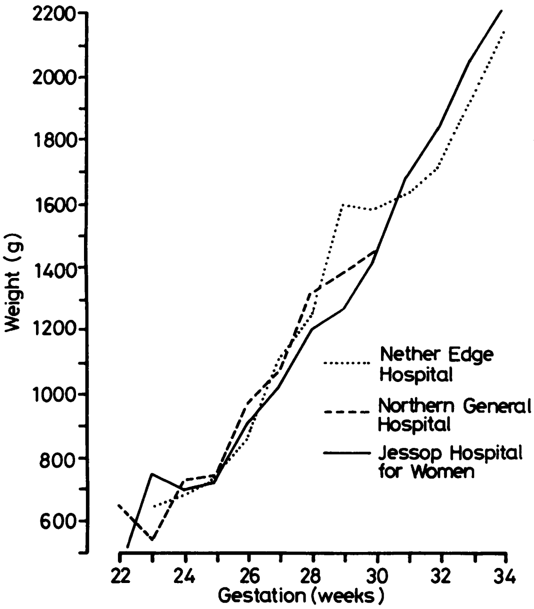

Fig. 1 *Mean liveborn weights by hospital of origin.*

22 weeks' gestation the mean weights of the two groups of fetuses are coincident suggesting that the two groups belong to the same population with respect to weight. Between 22 and 27 weeks' gestation the numbers in any one group become too small for analysis. A trend is visible, however, suggesting that the liveborns are heavier than both groups of aborted fetuses. One possible explanation of the trend is that the larger fetuses withstand the process of labour whereas the smaller do not. This obviously requires further data collection and analysis. From 28 to 42 weeks' gestation the plotted means form a smooth curve.

The data from the three sample groups were composited on the basis that:

(a) It is clear that whatever differences there are in the physiological processes experienced by fetuses abruptly terminated therapeutically and those spontaneously aborted, the weight of the fetus up to that point is not affected.

(b) Between 22 and 28 weeks' gestation the definition of an infant as an abortion or livebirth has been as much a question of obstetric or paediatric policy as the condition of the fetus or infant.

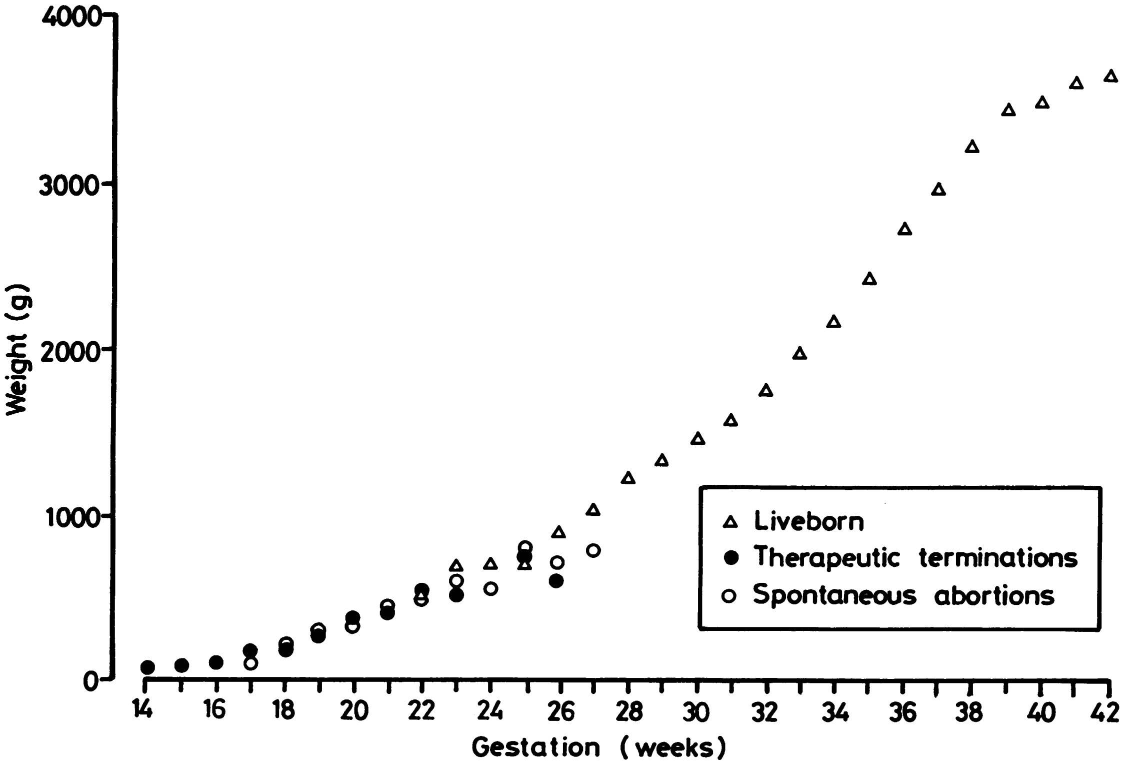

Fig. 2 *Mean weights by gestational age of the three sample groups.*

Table 3 *Weight values (g) by gestational week derived from composited data*

Gestation (week)	*No*	*Median*	*Mean (SD)*	*Range*
20	19	320	339 (50)	245–435
21	11	370	394 (62)	325–490
22	9	530	526 (101)	340–730
23	11	640	625 (117)	480–920
24	18	670	685 (127)	520–960
25	25	730	738 (119)	500–1050
26	37	900	904 (166)	580–1300
27	51	1040	1037 (183)	440–1410
28	85	1250	1206 (209)	800–1980
29	52	1330	1332 (264)	760–2320
30	89	1420	1467 (277)	900–2105
31	60	1640	1580 (288)	780–2520
32	101	1800	1757 (303)	980–2460
33	114	2010	1977 (330)	1240–2820
34	156	2160	2156 (331)	1200–3580
35	60	2540	2428 (472)	1312–3300
36	60	2730	2738 (417)	2000–3690
37	60	2930	2969 (426)	1900–3800
38	120	3100	3218 (394)	2380–4340
39	120	3520	3428 (418)	2500–4540
40	120	3490	3463 (383)	2410–4540
41	60	3580	3552 (401)	2720–4422
42	60	3642	3629 (354)	3000–4520

Table 4 *Mean weight (g) by gestational week derived from smooth graphing and incremental gain (g) per week*

Gestation (week)	*Mean*	*Increment*
20	320	
21	395	75
22	485	90
23	580	95
24	680	90
25	780	110
26	900	120
27	1040	140
28	1200	160
29	1330	130
30	1475	145
31	1630	155
32	1785	155
33	1960	175
34	2155	195
35	2430	275
36	2720	290
37	2970	250
38	3220	250
39	3400	180
40	3490	90
41	3550	60
42	3600	50

The composited data thus produced (Table 3) was expressed graphically for gestations of 20 to 42 weeks as curves for the means and ±1 and 2 SD. The main irregularities show as positive deviation of the curves at 22, 23, and 28 weeks and are due to the presence of five infants (three at 28 weeks) whose weights (730 g, 930 g, and 1820 g, 1900 g, 1990 g respectively) were grossly at variance with the population on the scatter diagram. Otherwise the graph produced required minor smoothing, mainly of the ±2 SD curves which is the expected consequence of the differences of sample size and weight ranges of the crude data. Median and mean values were generally coincident indicating the symmetrical distribution of the population at most gestational weeks.

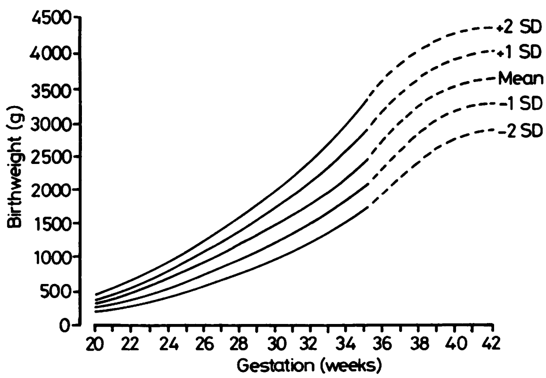

Fig. 3 *Smoothed curves for birthweight in relation to gestational age.*

Figure 3 shows the final smoothed curves from 20 to 42 weeks' gestation that are suitable for use in the neonatal unit. Table 4 gives the smoothed means and expected weight increments per gestational week that are considered to reflect expected fetal growth. The distributions of weight at representative gestations are shown as histograms in Fig. 4. There is an absence of appreciable bimodality, and although there is some evidence of positive skew at 38 weeks' gestation, this is not reproduced elsewhere.

Discussion

A new growth chart to include the very immature is presented. It is suggested that the criticism that growth curves based on preterm livebirths do not reflect the growth of the fetus in utero is invalid at least into the beginning of the third trimester.

This study, in common with most in the past, used data on gestation and weight given by many different observers. Despite this, and in contrast with previous studies,[1 3 5 14] the raw data give relatively smooth curves with no generalised positive skew with diminishing gestation.

This finding is consistent with the striking modification of the bimodal or skewed distribution of weight in preterm infants described previously. Since the cause of the anomaly in distribution has been attributed to mistaken gestation it suggests that

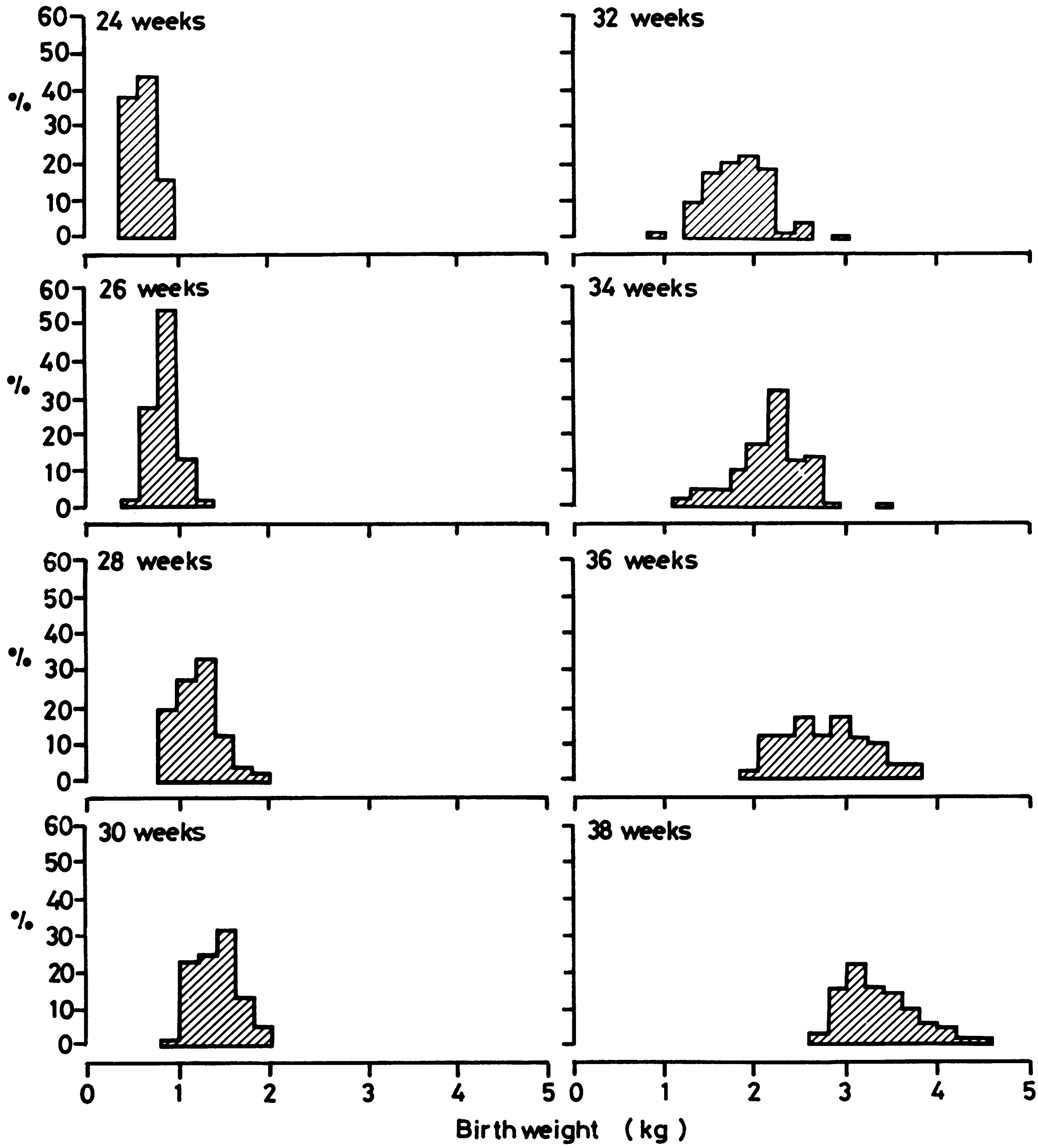

Fig. 4 *Distribution of weight by gestational age.*

major improvements in gestational assessment have taken place.

All previous studies are based on data recorded before 1971. Dubowitz[15] described a method of paediatric assessment in 1970 which became widely used especially with the introduction of neonatal intensive care in the mid 1970s. Early obstetric ultrasonography was first established in Sheffield in 1976, became widely used in 1978, and at present is used in approximately 70% of pregnancies, particularly where fetal size or gestation, or both, are in doubt. This study, therefore, covers a period where both techniques of gestational assessment became available, and it seems that they have been responsible for the increased accuracy of gestational assessment and the change in the distribution pattern of weight in preterm infants in comparison with studies before 1971. It is noteworthy that the five subjects previously mentioned as being deviant for weight in their population were born in the early years of the period under study. In all cases their weights approximate to the mean weight of infants three to four weeks older.

This suggests that gross errors of gestation are now rare and the remaining inaccuracies tend to be of the order of three to four weeks. This presumably is the consequence of the 20% incidence of post conceptional bleeding in otherwise unremarkable pregnancies.[8] These findings are in contrast to those of Milner and Richards[5] who found that a third of all infants at each gestation from 28 to 34 weeks were wrongly assessed. The mean weights of the sample differ considerably from, and are lower than, those of Gairdner and Pearson between 29 and 37 weeks but are similar to those of Lindell[16] for Swedish infants of 34 to 42 weeks' gestation and Gruenwald[2] for infants of 28 to 38 weeks in the United States. In comparison with other studies[1 3 4 9 12] coincidence with, or variation from, the given means is not consistent and varies with gestation.

This is not surprising as there are major problems in attempting comparison. There are population differences, for example caucasion only,[1 9] caucasian middle class,[12] and socioeconomically disadvantaged,[6] superimposed on the inevitable geographical differences between centres. Within these populations the samples selected vary in the attempt made to obtain data from the most 'normal' infants; hence stillbirths,[17] perinatal deaths,[2] and illegitimate[3 5] births may or may not have been included. To deal with the excess of large preterm infants various corrections have been applied ranging from the simple elimination of 'abnormal' observations to the application of mathematical analysis.[2 5]

These problems are compounded by the inconsistency of expression of central tendency (means or medians) and measures of dispersion (standard deviation or centiles).

The mean and median should be coincident if weight is distributed in a statistically normal fashion, as is reported in this and some earlier carefully controlled studies.[7 9] It is clear, however, that this is not the case in many other previous studies, suggesting that their excluded cases have skewed the data, or that their samples are atypical.

Some of these problems may be overcome if new techniques in fetal ultrasonography can generate sufficient longitudinal fetal growth data, representing true average growth, to replace existing cross sectional data,[18] although the problem of specifying gestational age is as yet unresolved. In terms of monitoring postnatal growth, especially that of very preterm infants, such an approach may suggest that parameters other than weight are more appropriate.

No improvement, however, in the techniques of collecting data (whether longitudinal or cross sectional) can resolve the fundamental problem of what constitutes normality in the context of the normal fetal growth of the human population. In other words, is normality the true representation of the entire population or is it synonymous with ideal in which case exclusions must be made according to some criteria? There are good reasons for paediatricians favouring either definition of normality, but until the question is resolved or until a common definition of what constitutes normality is adopted, comparison between fetal growth data will remain problematic.

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Fifty years ago

The medical treatment of congenital pyloric stenosis

ELISABETH SVENSGAARD (*Copenhagen*)—*Arch Dis Child* 1935;**10**:443–56

'From 1911 to 1922 in the Children's Department of the Rigshospital, Copenhagen, congenital pyloric stenosis was treated by gastric lavage and feeding through a duodenal tube. From 1922 to 1927 atropine was given and since 1927, eumydrin. During these periods respectively, 71, 47, and 61 patients were treated. The following summarizes the results in these three groups of patients: the average number of days spent in the hospital were 108, 96, and 77 and the mortality 7·1 per cent., 6·4 per cent., and 1·6 per cent. The average initial loss of weight (not including the fatal cases), was 0·263 kgm., 0·230 kgm., and 0·089 kgm. Average weight upon discharge was 3,995, 4,540, and 4,605 kgm. The average increase in weight was 0·95, 1·27, and 1·27 kgm. The average increase in weight per week was 62, 91, and 122 gm.

'The satisfactory results of eumydrin and its superiority to the other two methods of treatment are not emphasized so much in the light of its mortality rate, which is low in all three periods (and where the number of cases is also too small to permit the drawing of definite conclusions), but with regard to the results of the treatment as seen in the patients discharged. . . .'

(Dr Svensgaard submitted the exclusively medical Rigshospital experience for publication in order 'to counterbalance the growing enthusiasm for operation'. But it seems that surgical enthusiasm was not checked, and how thankful we can be that with improvements in the correction of preoperative electrolyte abnormalities and with advances in anaesthesia, surgeons can now claim a negligible mortality. Most babies leave hospital in under seven days, rather than the 77 to 108 cited above! PAMELA A DAVIES.)