ARTICLES

INTRAUTERINE GROWTH AS ESTIMATED FROM LIVEBORN BIRTH-WEIGHT DATA AT 24 TO 42 WEEKS OF GESTATION

Lula O. Lubchenco, M.D., Charlotte Hansman, M.D., Marion Dressler, M.D., *and* Edith Boyd, M.D.

Premature Infant Center, Department of Pediatrics, and Child Research Council, University of Colorado Medical Center, Denver, Colorado

DATA ON THE birth weights of 5,635 liveborn Caucasian infants at 24 to 42 weeks of gestation who were admitted to Colorado General Hospital are presented. The sample is sufficiently large, particularly in the smaller weight groups, to present weight curves in the form of percentiles. This, in turn, permits more satisfactory use of the curves as standards for the adequacy of weight gain of individual infants which may be done (*a*) at birth, in relation to previous intrauterine development and (*b*) after birth, in relation to extrauterine environmental factors.

There is, of course, an inherent limitation in estimating intrauterine growth from the weight of infants who have been born at various gestational ages. The sample has an undeterminable bias because premature birth itself is probably related to unphysiological states of variable duration in either mother or fetus. Since the weight of fetuses who remain in utero cannot be measured, the curves presented herein are submitted with these reservations as estimates of intrauterine growth.

DATA AND PRESENTATION

All liveborn infants admitted to the Colorado General Hospital Full-Term and Premature Infant Nurseries from July, 1948, to January, 1961, are included in the sample. However, data from the charts of babies over 36 weeks of gestation admitted after 1955 were excluded because of the very large numbers of babies in these later gestational age groups. Birth weight, gestational age, sex, and race were recorded. Gestational age was calculated from the day of onset of the mother's last normal menstrual period. Of the 7,827 liveborn infants included for study, there were 583 whose records were incomplete because of uncertainty concerning the duration of pregnancy, delays beyond 24 hours in weighing the infant, or failure to record race or sex. The accumulation of unknown causes for incomplete records probably has no appreciable effect on the final curves. Of the 583 infants, 475 were born at Colorado General Hospital and were incomplete for want of a stated menstrual age. The distribution of the weights of these 475 cases was essentially identical to that of the total Colorado General Hospital population of births.

There were 1,167 non-Caucasian infants (Negro, Oriental, Indian) excluded from the sample and 361 whose gestational ages were either less than 24 weeks or more than 42 weeks—these ages being outside the limits of the curves presented herein. Twenty-six infants were born alive with

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ADDRESS: (L.O.L.) Department of Pediatrics, University of Colorado Medical Center, 4200 East Ninth Avenue, Denver 20, Colorado.

gross pathological conditions which affected their birth weights. These included anencephaly, hydrocephaly, hydrops fetalis and maternal diabetes. Fifty-five other infants had stated gestational ages which were not compatible with their birth weights. These babies' weights were all far above the 90th percentile. It was presumed that these were pregnancies in which the mother experienced menstrual-like bleeding after conception. Since only the 90th percentile was affected by these 55 cases and that by not more than 150 gm, these were excluded from the data. The data from the remaining 5,635 records form the basis for the percentile curves.

The socioeconomic stratum represented by this population is defined as medically indigent or part-pay. Infants of Spanish American parents (Spanish, Mexican and Indian extractions) composed 30% of the sample. Their birthweights were found to be similar to the remainder of the Caucasian infants when viewed on a scattergram. No significant differences were present between the mean weights of the Spanish American infants and the other Caucasian races at each week of gestation. A graph was made which combined the birth weights of infants transferred to the Premature Infant Center from other Colorado hospitals with weights of infants born in Colorado General Hospital. The scatter of weights at each gestational age was similar. The weights of these outborn infants served to fill in the data for the early weeks of gestation. There were small, but significant, differences in mean birth weights between boys and girls

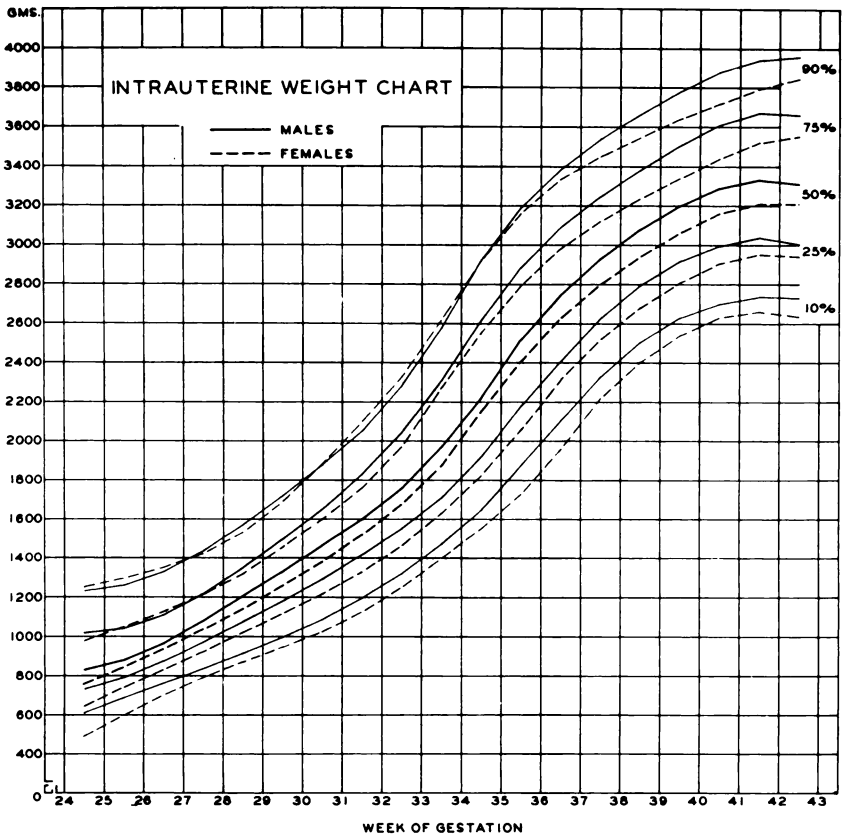

FIG. 1. The weights of liveborn Caucasian infants at gestational ages from 24 to 42 weeks are graphed as percentiles. Because there are small, but significant, differences between boys and girls from 38 to 42 weeks of gestation, percentile curves are given for each (Tables II & III).

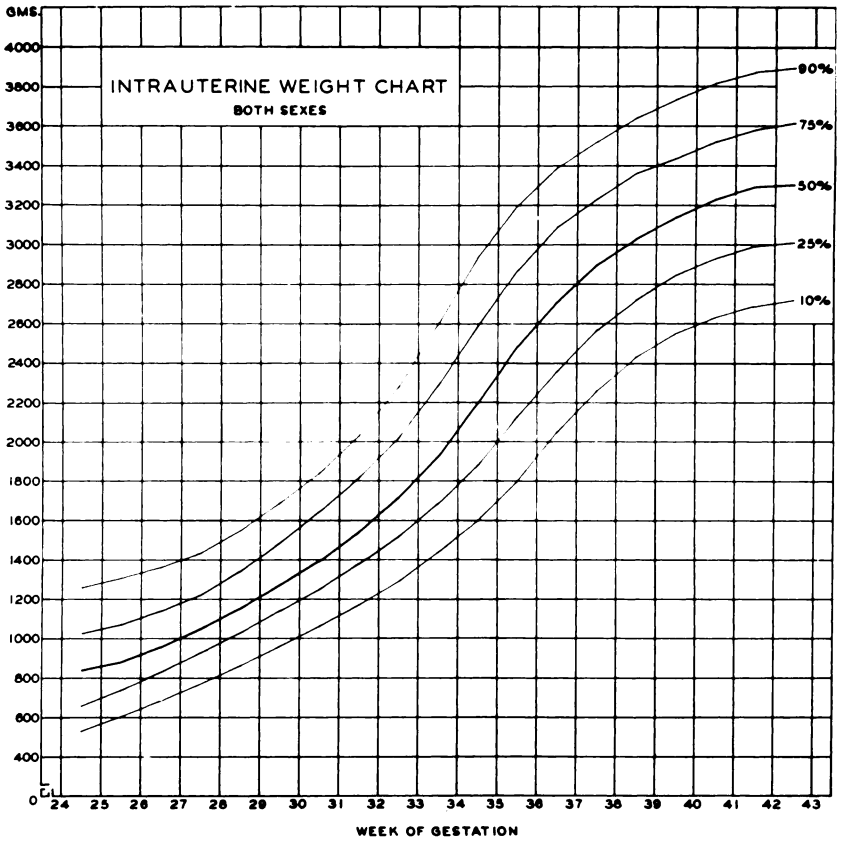

FIG. 2. The weights of liveborn Caucasian infants at gestational ages from 24 to 42 weeks are graphed as percentiles (Table I).

at gestational ages of 38 to 41 weeks. Hence, separate curves for each sex were constructed (Fig. 1). The differences of about 100 gm between the weights of boys and girls is quite small when compared to the range of weights at any gestational age. Therefore, curves combining the weights of boys and girls are also presented (Fig. 2).

Percentile curves were constructed in the following manner. The babies were grouped according to the age of gestation which was recorded in weeks plus days from 24 to 42 weeks. Each group included babies born from the beginning of a week to the beginning of the next week. Birth weights were tabulated at 100-gm intervals and ogives constructed from these data for each week. Values for the 10th, 25th, 50th, 75th, and 90th percentiles were read from the curves. The resulting figures were graphed at the mid-point of the proper week and smoothed arithmetically.

Table I gives the total number of infants at each week of gestation and weights for the 10th, 25th, 50th, 75th, and 90th percentiles. Tables II and III separate the data for males and females. Figures 1 and 2 portray these data in graphic form.

COMMENT

A comparison of these curves was made with data selected from the literature. No other data on intrauterine growth were found which were presented in the form of percentile curves. Therefore, mean weights of Colorado General Hospital babies were calculated for each week of gestation for purposes of comparison (Table I).

The data of Scammon and Calkins,[1,2] Streeter,[3] and Ylppo[4] on birth weight and

gestational age have been tabulated for comparison with each other by Silverman.[5] The means of all four authors for gestational ages from 24 to 36 weeks are at or just below the means for Colorado General Hospital babies. Considering that many of the data of these earlier writers were based on weights at postmortem examinations, it is not surprising to find the means low. Kloosterman[6] summarized mean values for birth weights, including more recent literature. Because his data is given by month rather than week of gestation, only approximate comparisons can be made. There was greater variation in mean weights in these data especially at the seventh and eighth month of gestation.

The weights of Colorado babies at full-term gestation present some interesting findings. The median weight of 3,230 gm at 40 weeks gestation is lower than that of the United States of 3,340 gm for Caucasian infants at 40 weeks.[7] The difference, although small, is consistently below that of the United States year after year. It has been thought that the lower weight at term was related to the socioeconomic bracket from which these patients came. However, children in the Child Research Council, an upper middle socioeconomic group in Denver, have a median birth weight at 40 weeks of 3,220 gm.

The mean weight at 40 weeks of Colorado General Hospital babies is also below the mean reported by Gruenwald in Baltimore[8] of 3,318 and McKeown in Birmingham, England,[9] of 3,434 gm. Other birth weight data which lists full-term infants includes those of gestational ages as low as 37 weeks. However, data giving birth weights of babies over 40 weeks of gestation show even larger differences than those given above. For example, Little's infants[10] in New York at 42 weeks had a mean weight of 3,410 gm; Gruenwald's,[8] 3,508 gm; and McKeown's,[9] 3,502 gm compared to Colorado General Hospital infants with a mean weight of 3,308 gm.

It has been suggested that high altitude may have a role in producing small babies, since 30.8% of babies born in Lake County Colorado, which is 10,000 feet high, weigh

TABLE I

INTRAUTERINE GROWTH STANDARD: MALES AND FEMALES

Gestational Age (wk)	*Patients (no.)*	*Mean Weight (gm)*	*Smoothed Percentiles*				
			10th	*25th*	*50th*	*75th*	*90th*
24	24	904	530	660	840	1,025	1,260
25	27	961	605	740	880	1,070	1,305
26	68	1,001	685	830	955	1,140	1,360
27	72	1,065	770	925	1,045	1,220	1,435
28	118	1,236	860	1,025	1,150	1,340	1,550
29	143	1,300	960	1,140	1,270	1,485	1,690
30	109	1,484	1,060	1,250	1,395	1,645	1,840
31	147	1,590	1,170	1,380	1,540	1,815	2,030
32	124	1,732	1,290	1,520	1,715	2,020	2,280
33	118	1,957	1,440	1,685	1,920	2,290	2,600
34	145	2,278	1,600	1,880	2,200	2,595	2,940
35	188	2,483	1,800	2,130	2,485	2,870	3,200
36	202	2,753	2,050	2,360	2,710	3,090	3,390
37	372	2,866	2,260	2,565	2,900	3,230	3,520
38	636	3,025	2,430	2,720	3,030	3,360	3,640
39	1,010	3,130	2,550	2,845	3,140	3,435	3,735
40	1,164	3,226	2,630	2,930	3,230	3,520	3,815
41	632	3,307	2,690	2,990	3,290	3,580	3,870
42	336	3,308	2,720	3,010	3,300	3,610	3,890

TABLE II

INTRAUTERINE GROWTH STANDARD: MALES

Gestational Age (wk)	*Patients (no.)*	*Smoothed Percentiles*				
		10th	*25th*	*50th*	*75th*	*90th*
24	13	610	730	830	1,020	1,230
25	12	685	790	880	1,040	1,260
26	43	760	875	965	1,110	1,330
27	38	835	970	1,080	1,215	1,435
28	64	915	1,075	1,205	1,350	1,570
29	80	995	1,180	1,330	1,495	1,720
30	61	1,085	1,290	1,465	1,650	1,875
31	88	1,195	1,415	1,600	1,830	2,050
32	66	1,320	1,550	1,760	2,045	2,280
33	62	1,470	1,710	1,970	2,310	2,575
34	74	1,645	1,920	2,220	2,620	2,920
35	104	1,875	2,180	2,520	2,885	3,190
36	118	2,105	2,410	2,745	3,090	3,385
37	188	2,330	2,625	2,930	3,245	3,540
38	354	2,505	2,795	3,080	3,380	3,665
39	504	2,630	2,915	3,200	3,505	3,780
40	576	2,700	2,995	3,290	3,610	3,880
41	312	2,735	3,035	3,330	3,670	3,940
42	164	2,730	3,005	3,310	3,660	3,995
Total patients	2,921					

TABLE III

INTRAUTERINE GROWTH STANDARD: FEMALES

Gestational Age (wk)	*Patients (no.)*	*Smoothed Percentiles*				
		10th	*25th*	*50th*	*75th*	*90th*
24	11	490	645	760	980	1,250
25	15	600	740	845	1,050	1,295
26	25	700	830	935	1,125	1,350
27	34	790	925	1,035	1,210	1,420
28	54	870	1,020	1,140	1,320	1,530
29	63	945	1,115	1,255	1,455	1,690
30	48	1,025	1,215	1,380	1,600	1,880
31	59	1,125	1,330	1,515	1,760	2,100
32	58	1,250	1,465	1,675	1,970	2,330
33	56	1,400	1,630	1,875	2,275	2,620
34	71	1,550	1,825	2,155	2,555	2,920
35	84	1,730	2,060	2,410	2,795	3,160
36	84	1,960	2,320	2,630	2,980	3,335
37	184	2,220	2,520	2,800	3,120	3,450
38	282	2,405	2,680	2,940	3,235	3,545
39	506	2,540	2,810	3,060	3,340	3,640
40	588	2,630	2,905	3,160	3,440	3,720
41	320	2,660	2,950	3,210	3,520	3,795
42	172	2,630	2,940	3,210	3,550	3,840
Total patients	2,714					

2,500 gm or less at birth.[11] The median weight of Lake County babies at 40 weeks was 3,072 gm in 1955 and at 42 weeks was 3,000 gm.

USE OF THE INTRAUTERINE GROWTH CHART AT BIRTH

The position of the newly born infant on the intrauterine growth chart may reveal a great deal concerning his intrauterine environment. It may show that at birth his size is quite in proportion to his gestational age. If the infant is unusually large, especially when the parents are of average build, the possibility that the mother is diabetic or prediabetic is to be considered[12] as well as whether there has been an error in calculating the gestational age.

On the other hand, if the infant is unusually small, genetic factors or some disturbance in intrauterine nutrition, such as chronic cardiac disease in the mother, maternal toxemia, and multiple pregnancy should be considered.

Of special interest is the pattern of growth of twins in utero. When the median weight of twins is plotted on the intrauterine growth curve, it can be seen that the median weights of twins and single born infants are on the 50th percentile of intrauterine growth until 34 weeks of gestation. From 35 to 42 weeks there is a progressive deviation of the median weight of twins from the 50th percentile so that at 42 weeks it is on the 10th percentile of the intrauterine growth chart. Similar findings have been reported by McKeown[9] and Guttmacher and Kohl.[13]

Another way in which the intrauterine growth chart might be useful is in a retrospective study of the growth of older premature infants in relation to their growth

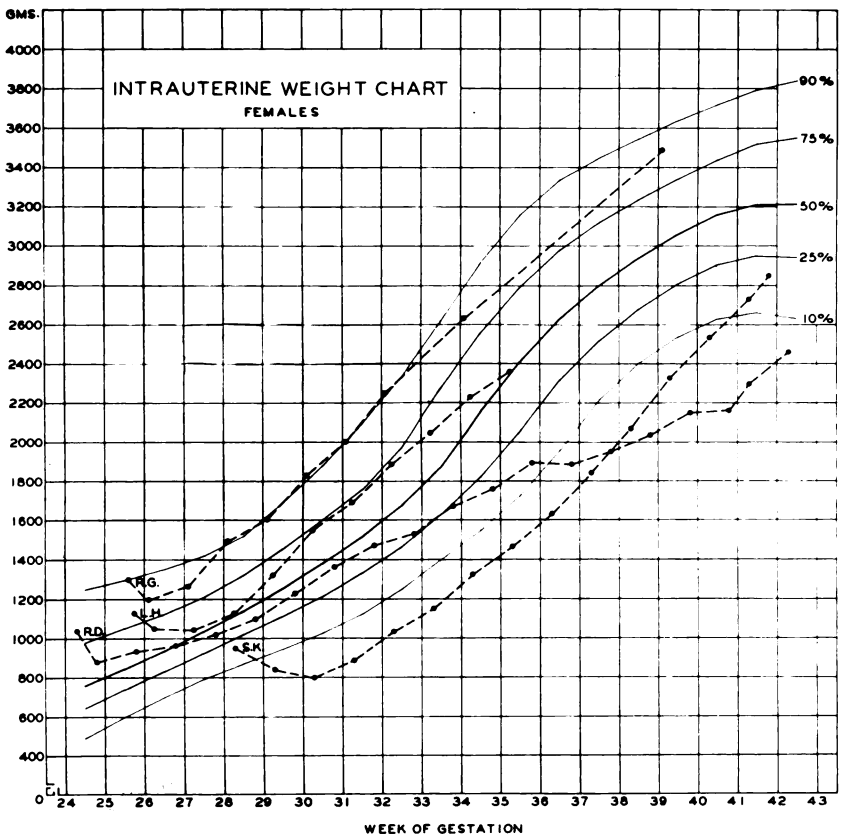

FIG. 3. Examples of the postnatal growth of selected premature infants discussed in the text are portrayed.

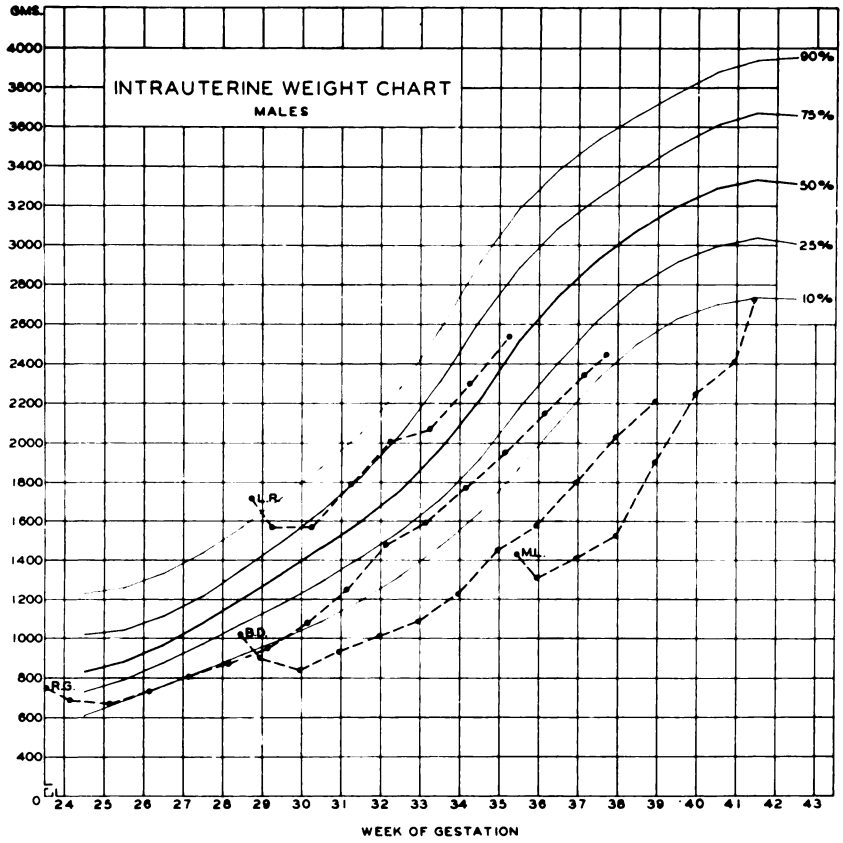

FIG. 4. Examples of the postnatal growth of selected premature infants discussed in the text are portrayed.

in utero. A preliminary study of this type concerning Colorado General Hospital premature infants under 1,500 gm at birth revealed them to be small at approximately 10 years of age and also small for their gestational ages at birth. At 10 years of age, 80% of the 50 children in this small birth weight range were below the 50th percentile, and 42% of them were below the 10th percentile. When the birth percentile standings were examined, 80% were below the 50th percentile and 22% were below the 10th percentile.[14] Data such as these help define areas needing further study.

A common practice in selecting premature infants for various studies is to group them according to birth weight. From a practical standpoint, birth weight criteria are quite satisfactory; but for more detailed investigations, it may be necessary to consider gestational age as well as size. The use of the intrauterine growth chart enables one to eliminate the very immature infant at one extreme of gestation and the undernourished infant at the other end of gestation. The intrauterine growth chart may also serve to identify the unusual infant for special studies.

USE OF THE INTRAUTERINE GROWTH CHART AFTER BIRTH

When the postnatal growth of the prematurely born infant is compared to the standards for intrauterine growth, a perspective is obtained which differs from that of comparing his growth to the postnatal growth of other infants in his birth weight group. The weight loss following birth results in a marked downward deviation of the curve from that of uninterrupted pregnancy. Subsequent growth is noted to continue parallel to but consistently below the

original birth percentile standing. Such cases are illustrated in Figures 3 and 4 by infants of different gestational ages and percentile standings at birth.

The intrauterine growth chart assists in determining when the premature infant has "caught up," that is, regained the percentile zone standing he had at birth. Patient SK (Fig. 3) is an example of such an infant.

In contrast to patient SK, patient RD (Fig. 3) started life above the 75th percentile and after a moderate weight loss gained steadily but slowly throughout her hospital course. How far her weight deviated from expected prenatal growth was not apparent until her progress was plotted on the intrauterine growth chart. It is important to determine whether such growth is the result simply of insufficient feeding or of some underlying physiological imbalance or disease process.

Another interesting example is seen in the growth curve of ML (Fig. 4). He was an infant of extremely low birth weight for his gestational age who, after a short initial weight loss, grew very rapidly as compared to the general trend of the percentile curves. It is interesting to note that if the estimate of gestational age was incorrect by one month, this infant's weight roughly parallels that of the group—not the usual, but not an unobserved pattern. However, such rapid growth has been reported in infants who have evidence of the placental insufficiency syndrome. It is hoped that these curves will be useful in evaluating already established clinical data.

SUMMARY

Percentile curves representing intrauterine growth of Caucasian infants in Colorado are constructed from the birthweights of liveborn infants at gestational ages ranging from 24 to 42 weeks. The median weights of Colorado babies were found to be lower at 40 weeks of gestation than the national median, and mean weights at 40 and 42 weeks were lower than those given by other authors. The use of the intrauterine growth chart in studying the nutrition of babies at birth and during their postnatal growth period has been described.

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