INTRAUTERINE GROWTH PREDICTORS

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ABSTRACT

The present study was conducted to construct standards for midarm circumference and midarm/head circumference ratio to identify neonates at risk for metabolic complications and to assess the anthropometric variable which could be used to substitute weight to identify low birth weight neonates.

A study of 2925 consecutive live births showed significant correlation ($p \leq 0.001$) between different anthropometric variables studied. Since midarm circumference (MAC), midarm circumference/head circumference ratio (MAC/HC) and ponderal index (PI) had the least correlation with gestation, these were used as independent markers for gestation. Among these three, MAC had the best correlation with birth weight ($r = 0.808$). A midarm circumference of $\leq$8.6 cm and $\leq$7.4 cm had the best sensitivity and specificity for identifying neonates with a birth weight of $\leq$2500 and $\leq$2000 g, respectively. All the anthropometric variable studied can rule out low birth weight with great accuracy (high negative predictive value >90%)

Key words: *Low birth weight, Growth predictors, Standard curve.*

Assessment of nutritional status at birth is important for identifying infants at risk for metabolic complications associated with abnormal fetal growth. Birth weight has been universally used as a measure of intrauterine growth because of its strong correlation with gestation and also to identify neonates at risk. However, in India where 80% of births occur at home, recording of birth weight presents a major logistic problem(2-3). These factors had led to search for alternative anthropometric parameters to measure fetal growth.

Various workers and studies from our own institution have established correlation of various anthropometric parameters length, chest circumference (CC), midarm circumference (MAC), midarm circumference/head circumference (MAC/HC) ratio with gestational age and neonatal morbidity and mortality(4-12). Because of availability of various indices for intrauterine growth, it is often difficult for the pediatrician to choose the best index.

The present study was planned to project normal values for MAC and MAC/HC ratio in infants born between 28-44 weeks gestation with the goal of providing standards for assessing protein energy sufficiency in the neonates for our population, and also to evaluate the best parameter for assessing intrauterine growth.

Material and Methods

Study group consisted of 2925 consecutive live births at the Departments of Obstetrics and Pediatrics at Safdarjang

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Hospital, New Delhi. Infants born to diabetic or toxemic mothers or born with gross congenital malformations were excluded from the study. In all cases weight, length, midarm, midthigh and head circumferences were obtained by single observer (SRSP) within 24 hours of birth. Whenever moulding or caput succedaneum were extensive, head circumference measurements were postponed till they regressed.

Birth weight was recorded on a beam balance to the nearest 20 g using standard techniques. Supine length was recorded to the nearest 0.1 cm using infantometer. The midarm circumference was measured at the midpoint between the tip of acromian and the olecranon process in the left upper arm with a flexible fibre glass tape to the nearest 0.1 cm. The head circumference was measured by passing the tape between the supraorbital ridges and the maximum occipital prominence. Maximum thigh circumference was recorded at the lowest furrow on the gluteal region, the tape being placed perpendicular to the long axis of the limb. Ponderal index was calculated using the formula weight (g/length $cm^3 \times 100$).

Gestational age of all the infants was calculated from the first day of last menstrual period of their mothers and confirmed by clinical assessment of gestational age using Ballard's Scoring(13) system. When the gestational age by dates differed from clinical evaluation by more than 2 weeks the later was taken as gestation of the baby.

Standard statistical methods of linear regression and correlation, Students "t" test, and sensitivity, specificity analysis were applied to analyse the data.

TABLE I—*Midarm Circumference, MAC/HC Ratio and Birth Weight Measurements in 2925 Infants*

Gestational age (weeks)	N	MAC (cm)	MAC/HC	Birth weight (g)
28	9	6.0 ± 0.69	0.220 ± 0.026	1093.3 ± 54.2
29	9	6.0 ± 0.13	0.216 ± 0.003	1224.4 ± 43.0
30	12	6.3 ± 0.17	0.222 ± 0.005	1345.0 ± 38.4
31	16	6.6 ± 0.20	0.225 ± 0.006	1481.3 ± 43.9
32	29	7.0 ± 0.26	0.232 ± 0.010	1630.3 ± 60.7
33	35	7.3 ± 0.36	0.238 ± 0.012	1837.7 ± 82.4
34	48	7.6 ± 0.47	0.247 ± 0.014	2065.4 ± 218.9
35	73	8.0 ± 0.52	0.253 ± 0.016	2173.3 ± 193.8
36	134	8.4 ± 0.52	0.261 ± 0.016	2424.0 ± 175.9
37	284	8.9 ± 0.84	0.272 ± 0.022	2673.8 ± 337.0
38	454	9.0 ± 0.87	0.272 ± 0.023	2754.2 ± 360.6
39	648	9.1 ± 0.89	0.272 ± 0.023	2815.4 ± 398.1
40	718	9.2 ± 1.04	0.273 ± 0.028	2860.7 ± 429.1
41	281	9.1 ± 0.88	0.271 ± 0.024	2841.1 ± 374.8
42	125	9.1 ± 0.76	0.268 ± 0.022	2839.8 ± 329.8
43	36	9.0 ± 0.94	0.269 ± 0.024	2717.2 ± 392.8
44	14	9.0 ± 0.74	0.263 ± 0.017	2681.4 ± 360.9

Results

Table I depicts the midarm circumference measurements, MAC/HC ratio and birth weights recorded in 2925 infants between 28-44 weeks gestation. There was no significant differences between males and females for gestational age, birth weight, MAC or MAC/HC ratio measurements.

MAC increased linearly with increasing gestational age between 28 to 48 weeks, showing slight decline at 41 and 44 weeks ($r = 0.445$, $p \leq 0.001$) (*Table I*). Values ranged from (mean ± SD) 6.0±0.69 cm at 28 weeks to 9.2±1.04 cm at 40 weeks. MAC/HC ratio also increased linearly with gestational age ($r = 0.286$, $p \leq 0.01$). MAC/HC ranged from 0.220±0.26 at 28 weeks to 0.273±0.028 at 40 weeks.

Confidence intervals for an individual observation were calculated for each week of gestation for MAC and MAC/HC ratio standard curves and are represented on the scatterogram (*Fig. 1 & 2*). Similarly, confidence intervals were calculated for the regression lines These values are graphically represented on the scatterogram.

All the growth variables were significantly correlated with each other (*Table II*). Head circumference had the highest correlation with gestation. MAC, MAC/HC and ponderal index had the least correlation with gestation. Since these three variables had the least correlation, these can be used as independent marker for gestation. Among these three variable MAC had the highest correlation with birth weight, followed by MAC/HC ratio.

The regression line of birth weight on mid arm circumference gave 8.47 cm value corresponding to birth weight of 2500 g with sensitivity 76.31%, specificity 87.19% and Youden index 63.50% (Birth Weight = 548.6721 + 365.8763 × MAC). A midarm circumference of <8.6 cm, however, had the best sensitivity (83.66%) and specificity (82.99%) in detecting infants with low birth weight. Hence this value had been used as

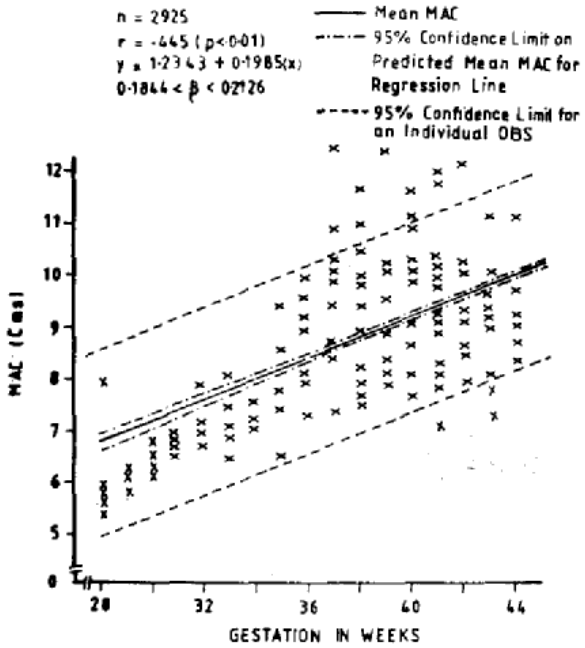

Fig. 1. Standard curves for midarm circumference with respect to gestational age.

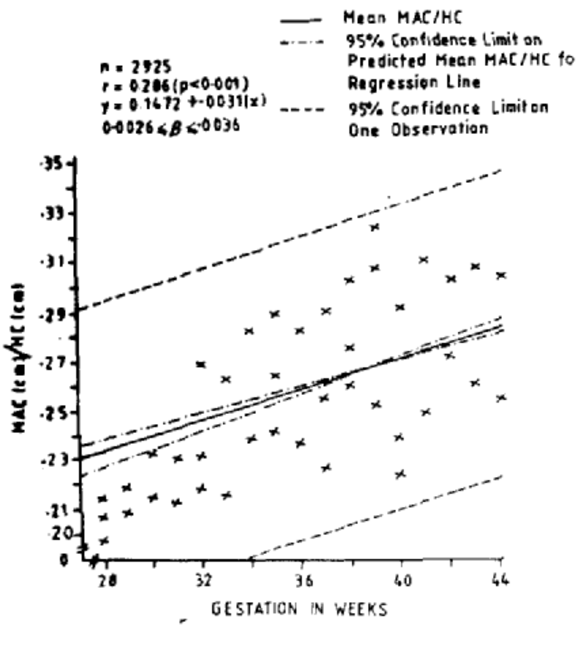

Fig. 2. Standard curves for midarm circumference/head circumference with respect to gestational age.

TABLE II–*Correlation Coefficient Matrix between Anthropometric Variables*

Variable	Gestation	Birth weight	Length	HC	MAC	MTH	MAC/HC	PI
Gestation	1.000							
Birth weight	0.531	1.000						
Length	0.592	0.785	1.000					
Head circumference	0.651	0.757	0.755	1.000				
Midarm circumference	0.445	0.808	0.659	0.655	1.000			
Maximum circumference	0.496	0.832	0.703	0.669	0.803	1.000		
MAC/HC ratio	0.286	0.668*	0.505	0.392	0.946	0.702	1.000	
Ponderal index	0.166	0.590*	0.002 (NS)	0.301	0.454	0.441	0.434	1.000

HC = Head circumference, MAC = Midarm circumference, MAC/HC = Midarm/head circumference ratio, MTH = Mid thigh circumference, PI = Ponderal index.
** $p \leq 0.01$, NS = Not significant, other values are significant at $p < 0.001$

the cut off value in the present study. MAC/HC ratio of 0.255 corresponded to a birth weight 2500 g when calculated from the regression equation. (Birth Weight = –585.6939 + 12262.7392 × MAC/HC; sensitivity 60.78%, specificity 86.15%, Youden index 46.94%, misclassification 21.60%). MAC/HC ratio ≤0.265 however had the best sensitivity (78.43%) and specificity (73.74%), in predicting neonates with birth weight of 2500 g or less. Ponderal index of 2.26 corresponded to birth weight of 2500 g when calculated from the regression equation (Birth Weight = 181.4359 + 1023.009 × Ponderal index; sensitivity 45.69%, specificity 93.49%, Youden index 39.19% and misclassification 21.2%). Ponderal index of <2.5, however, had the sensitivity of 83.13% and specificity of 56.16% in predicting infants of low birth weight. The best cut off values for MAC, MAC/HC and PI for 2000 g infants are depicted in *Table III.*

Discussion

Low birth weight is highly predictive of neonatal morbidity and mortality. Various anthropometric growth variables have been

TABLE III–*Statistical Validity of MAC, MAC/HC Ratio, PI for Identifying Neonates below 2000 g*

	MAC <7.4 cm	MAC/HC ratio <0.244	Ponderal index <2.1
Sensitivity	79.00	81.21	85.08
Specificity	97.81	88.70	91.47
Youden index	76.81	69.91	76.55
Misclassification	3.35	11.76	8.92
Positive predictive value	70.44	81.22	85.08
Negative predictive value	98.60	98.62	98.94

studied in different studies to identify neonates with low birth weight with good degree of accuracy and hence in predicting neonatal outcome(5,9,14). Since MAC, MAC/HC ratio and PI had the least correlation with gestation as compared to others, these could be used as independent variables.

A midarm circumference of <8.6 cm and <7.5 cm, which were used as cut off values in the present study, had the best sensitivity and specificity and were good predictors for infants of birth weight below ≤2500 g and ≤2000 g, respectively. Similar values had been observed by other studies in different population(5-9). The strong correlation between birth weight and midarm circumference (r=0.808) observed in our population suggests that this simple tool can be used to measure fetal growth at community level also where recording birth weight in all cases is not feasible.

MAC/HC ratio had been used in neonates to measure fetal growth; it is independent of race and sex. Various authors have found different cut off values to identify SGA babies(8,9,11). MAC/HC ratio has recently been found to be more useful in identifying, symptomatic growth retarded and growth accelerated infants(15). MAC/HC ratio of <0.225 had sensitivity and specificity comparable to other published data for screening SGA infants(8). However, to identify disproportionate growth retardation, ponderal index (PI) was a useful variable. PI value ≤2.2 can identify neonates of 2000 g or below with greater accuracy (sensitivity 85.08% and specificity 91.47%). Disproportionately grown infants constitute a high population who are especially prone to perinatal and metabolic complications including hypoglycemia, polycythemia and birth asphyxia(11,16,17).

The present study suggests that each anthropometric variable can rule out intrauterine growth retardation with reasonable accuracy (high negative predictive value >98%). Midarm circumference being simple and good indicator for predicting low birth weight can be easily utilized at community level to detect neonates who are at risk. MAC/HC ratio shall be more useful to identify symptomatic SGA or LGA babies as had been observed by the ongoing study in the same institution (unpublished data). Ponderal index can diagnose proportionately grown SGA babies with reasonable good accuracy. However, it has the limitation of error in measuring length which will become cubed when ponderal index is calculated.

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NOTES AND NEWS

SATELLITE CONFERENCE ON DIARRHEA AND MALNUTRITION

Satellite Conference on Diarrhea and Malnutrition has been organized under the auspices of Research Society and Division of Gastroenterology, Department of Pediatrics, at Seth G.S. Medical College and K.E.M. Hospital, Bombay on December 6-7, 1991. Eminent Pediatric Gastroenterologists from UK will be faculty members. The last date for registration is November 30, 1991. Registration fee: Rs. 150/- only.

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