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MID-ARM CIRCUMFERENCE AT BIRTH AS PREDICTOR OF LOW BIRTH WEIGHT AND NEONATAL MORTALITY

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Summary. In Bangladesh, like other developing countries, most births occur at home or in the community, so logistic problems and taboos prevent the weighing of every newborn child. This study was performed to see whether other simpler measurements could be substituted for weight to identify neonates of low birth weight. A total of 1676 live births at the Chittagong Medical College Hospital constituted the study sample, and this showed a high correlation between mid-arm circumference and birth weight ($r = 0.792$, $p < 0{\cdot}000$). A mid-arm circumference of <9·0 cm had the best sensitivity and specificity for identifying newborns with a birth weight of less than 2500 g. These neonates were followed up to record neonatal deaths. Neonatal mortality showed an inverse relation with mid-arm circumference. A mid-arm circumference of <9·0 cm and a birth weight of <2500 g were equally useful in predicting neonatal outcome. Mid-arm circumference is a simple, quick and reliable indicator for predicting low birth weight and neonatal outcome, and can be easily measured by medical practitioners and traditional birth attendants (TBAs) in the community of developing countries like Bangladesh.

Introduction

Birth weight is generally used as a yardstick of maturity and is an important determinant of child survival and development (Ebrahim, 1982; WHO, 1980). Birth-weight-specific mortality and morbidity studies have shown that the lower the birth weight, the higher the mortality and morbidity, and this is equally true for very large babies (Acsadi & Johnson-Acsadi, 1986; Koops, Morgan & Battaglia, 1982; Ghosh *et al*., 1979; Begum & MacIntosh, 1993; Starfield *et al.*, 1982). In particular, the mortality of low birth weight babies (<2500 g) is extremely high (Pratimidhi *et al.*, 1986; Bhargava, Sachdev, Lyer & Ramji, 1985).

Low birth weight (LBW) babies are a major problem in developing countries and constitute over 90% of the world's total of infants with low birth weight (WHO,

1980). In Bangladesh about 27% of births are of low birth weight, which is estimated to be more than one million LBW babies in a year. This poses a major problem for child survival (Ahmed *et al.*, 1992).

In developing countries like Bangladesh, recording every birth weight has always been a problem. Almost 87% of deliveries occur at home or in the community and are attended by birth attendants or relatives (Ahmed, Rahman & Perveen, 1996). Even for deliveries in primary health centres, there is often a paucity of suitable weighing scales. Besides, taboos in the community do not favour measurement of the child because of fear of the bad effects caused by the 'evil eye' resulting from any word of praise (Pratimidhi *et al.*, 1986).

Every newborn child must be measured objectively by a method that helps to identify those at risk or with a low birth weight. Thus measuring newborn growth by a simple, low priced, reliable and acceptable method, applicable by community workers, has become an urgent need. Studies have been performed to see whether simpler measurements could be substituted for weight to identify neonates of low birth weight, and these have shown a correlation between mid-arm, chest, thigh and head circumference, abdominal girth and length with birth weight. However, these studies were limited by their small sample size (Bhargava *et al.*, 1985; Ramji *et al.*, 1986; Khanum & Shahidullah, 1990; Tabib, Nahar & Khan, 1993). This study attempts to choose a simpler method that could be used as a predictor of LBW and neonatal mortality, and to validate it in a large sample in Bangladesh.

Materials and methods

A total of 1676 live-born babies born in Chittagong Medical College Hospital during June–December 1995 constituted the study sample.

Chittagong Medical College Hospital is situated in the port city of Chittagong in Bangladesh. It is a Government 1000-bed teaching hospital with a catchment population of about 10 million from Chittagong and adjoining districts. The obstetric department of the hospital handles about 4000 deliveries a year. About 52% of the cases attend the hospital directly and the rest are referred by district hospitals and community-based doctors.

Anthropometry was performed within 24 hours of delivery by one trained nurse. The birth weight was recorded by beam balance to the nearest 10 g. The weight scale was standardized every day. The mid-arm, chest, thigh and head circumferences were measured using a flexible fibreglass tape to the nearest 1 mm. The mid-arm circumference was taken from the left arm from the mid-point between the tip of the acromion process and the olecranon process. The chest circumference was obtained at the level of the xiphisternum and below the inferior angle of the scapula during quiet respiration. The maximum thigh circumference was recorded at the level of the lowest furrow in the gluteal region, the tape being placed perpendicular to the long axis of the left lower limb. The head circumference (occipital–frontal circumference, OFC) was measured by passing the tape between the supraorbital ridge and the maximum occipital prominence. The supine length was recorded in an improvised infantometer to the nearest 1 mm.

The cohort was followed from birth to the age of 28–31 days, both at hospital and at home, for survival status. Intra-observer measurement error was observed by the principal author, and repeated training and supervision were undertaken to minimize error. The data were analysed using statistical methods of linear regression and correlation coefficients, and appropriate statistical tests were used for significance. The follow-up up to 1 month of age was completed for 1579 (94·2%) babies and the remaining 97 (5·4%) could not be traced and were therefore excluded from the analysis.

Results

There were 1608 (96·0%) singleton and 68 (4·0%) twin live births amongst which 921 (55·0%) were male and 755 (45%) were female. The prevalence of low birth weight was 26·7%, and 1·5% of the babies were of very low birth weight (VLBW), i.e. less than 1500 g. The proportions of male and female LBW babies were 23·7% and 30·5% respectively, a difference that is statistically significant ($Z = 3.20$, $p < 0{\cdot}05$).

The mean anthropometric measurements in all anthropometric parameters against different birth weight categories are shown in Table 1. The means of all the anthropometric parameters of the babies increased progressively with increasing birth weight.

It is evident from Table 2 that all the variables in the matrix correlated with the birth weight and with each other. However, the mid-arm circumference had the highest correlation with birth weight ($r = 0.792$, $p < 0{\cdot}001$).

In identifying infants weighing <2500 g, it was found that mid-arm circumference (MUAC) had a cut-off value of 90 mm (9·0 cm). The regression equation from which the cut-off value was derived is:

$$\text{Birth Weight} = -514{\cdot}2061 + 33{\cdot}4911 \times \text{MUAC (mm)}$$

$$\text{MUAC} \times 33{\cdot}4911 = \text{Birth Weight} + 514{\cdot}2061$$

Thus each millimetre increase in MUAC is related to an increase of 36 g in birth weight. It is calculated from Table 3 that the 90 mm (9·0 cm) cut-off of mid-arm circumference (MUAC) has a sensitivity of 94·0% and specificity of 82·0% in identifying babies <2500 g, i.e. LBW babies.

It is evident from Table 4 that neonatal mortality is inversely related to mid-arm circumference, an increase in mid-arm circumference being associated with a decrease in mortality. Mid-arm circumference is as useful for predicting neonatal mortality as birth weight, with a sensitivity and specificity of 59·0% and 77·6% respectively.

Discussion

Birth weight is a reliable and sensitive indicator for predicting the immediate and late outcomes of newborn children (Bhargava *et al.*, 1985). In Bangladesh, like other developing countries, almost 87·0% of births occur at home or in the community and are attended mainly by TBAs and relatives (Ahmed *et al.*, 1996). The recording of the birth weight of every birth is not feasible due to the scarcity or absence of weighing scales. The present study shows that there is a significant correlation between birth weight and other anthropometric parameters. Mid-arm circumference has the highest

Table 1. Birth weight and anthropometric parameters

Birth weight (g)	Number of babies	OFC (mm)		MUAC (mm)		Chest circum. (mm)		Thigh circum. (mm)		Length (mm)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<1500	24	279	29	67	7	256	41	107	14	422	37
1500–1999	58	305	20	80	6	275	23	126	14	444	24
2000–2499	333	322	20	91	7	295	17	145	11	470	30
2500–2999	684	336	10	99	8	313	11	158	21	489	19
3000–3499	379	347	15	107	6	329	11	170	12	505	25
3500–3999	87	353	11	116	12	342	17	185	12	520	17
4000+	14	376	28	127	10	354	15	197	32	528	28

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Table 2. Correlation matrix between anthropometric parameters

Anthropometry	OFC	MUAC	Chest circumference	Thigh circumference	Length
MUAC	0·550				
Chest circumference	0·589	0·669			
Thigh circumference	0·456	0·626	0·568		
Length	0·487	0·512	0·548	0·434	
Birth weight	0·641	0·792	0·748	0·641	0·605

Table 3. Identification of LBW by mid-arm circumference

Birth weight (g)	Mid-arm circumference		Total
	<9·0 cm	≥9·0 cm	
<2500	184	264	448
≥2500	12	1216	1228
Total	196	1480	1676

Sensitivity, 94·0%; specificity, 82·0%.

Table 4. Predictability of neonatal mortality by birth weight and mid-arm circumference

	Dead	Alive	Total
Birth weight*			
<2500 g	63	352	415
≥2500 g	32	1132	1164
Total	95	1484	1579
Mid-arm circumference**			
<9·0 cm	56	333	389
≥9·0 cm	39	1151	1190
Total	95	1484	1579

*$\chi^2 = 83{\cdot}61$, $p < 0{\cdot}001$. Sensitivity, 66·3%; specificity, 76·3%.
**$\chi^2 = 64{\cdot}09$, $p < 0{\cdot}001$. Sensitivity, 59·0%; specificity, 77·6%.

correlation with birth weight, and this is in agreement with Khanum & Shahidullah (1990), Bhatia & Tyasi (1984) and Vaquera *et al.* (1983).

A mid-arm circumference of <90 mm (9·0 cm), which was used as a cut-off value in this study, was a good predictor of infants with low birth weight but the cut-off

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value identified by Khanum & Shahidullah (1990) in Bangladeshi children was 8·8 cm. The cut-off value of 9 cm has a higher sensitivity and similar specificity in identifying LBW babies.

Newborn infants with low birth weight and those with mid-arm circumferences of <9·0 cm had a significantly higher mortality than those weighing 2500 g or more ($p<0·001$) and with a mid-arm circumference of 9 cm or more ($p<0·001$). Birth weight and mid-arm circumference were equally effective in predicting neonatal mortality. Vaquera *et al.* (1983) also found a mid-arm circumference of <9·0 cm to be a useful indicator for predicting risk of death during the first 14 days of life.

As low birth weight is highly predictive of the immediate or late outcome of newborn children and a mid-arm circumference of <9·0 cm can identify infants with low birth weight with a fair degree of accuracy, this could conveniently be introduced into the existing system of health care delivery as an alternative to weighing. Besides, measurement of mid-arm circumference is simple, quick and easy to learn, and taboos do not resist its measurement. Finally, this simple device would be much simpler to use by medical practitioners and TBAs alike, and a simple tape could easily be provided as part of their delivery kit. Thus it could be put to wider use, and at-risk neonates in the community could be identified more easily.

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