MEDICAL PRACTICE

*Research from the South***Mid-arm and chest circumferences at birth as predictors of low birth weight and neonatal mortality in the community**

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Abstract

In developing countries, where about three quarters of births occur at home or in the community, logistic problems prevent the weighing of every newborn child. A study was performed to see whether other simpler measurements could be substituted for weight to identify neonates of low birth weight and those at risk.

A study of 520 hospital births showed a strong correlation ($p < 0.001$) between other anthropometric variables and birth weight, but the correlation was maximum for chest circumference ($r = 0.8696$) and mid-arm circumference ($r = 0.8110$). A mid-arm circumference of ≤ 8.7 cm and a chest circumference of ≤ 30 cm had the best sensitivity and specificity for identifying neonates with a birth weight of 2500 g or less. Measurements on 501 consecutive live births in the community were recorded and the infants followed up at specified ages. Mid-arm circumference was again significantly correlated to birth weight ($r = 0.6918$). Neonatal mortality showed an inverse relation but postneonatal mortality an inconsistent relation with mid-arm circumference. A mid-arm circumference of ≤ 8.7 cm and a birth weight of ≤ 2500 g were equally useful in predicting neonatal outcome.

Mid-arm and chest circumferences are simple, practicable, quick, and reliable indicators for predicting low birth weight and neonatal outcome in the community and can be easily measured by paramedical workers in developing nations.

Introduction

The population of India is currently over 700 million and is expected to reach one billion by the year 2000. Almost 20 million births occur each year. The prevalence of low birth weight (≤ 2500 g) varies from 24% to 40%, and mortality in these infants is extremely high.¹ Primary health care is provided through health centres covering a population of roughly 100 000 and delivered through female multipurpose workers, who each care for 5000 people, and trained birth attendants and village health guides, who each care for 1000 people.

Birth weight is a reliable and sensitive indicator for predicting the immediate or later outcome of a newborn child. In Third World countries like India, however, recording every birth weight has always been a problem. Almost 80% of deliveries occur at home or in the community and are attended by birth attendants or relatives. Even for deliveries in primary health centres there is often a paucity of suitable weighing scales.

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 fetal growth by a simple, low priced, reliable, and acceptable method, applicable by paramedical workers, has become an urgent need for Third World countries, which contribute over 90% of the world's total of infants with low birth weight. This study attempts to meet this need.

Subjects and methods

Data were collected on two groups of infants. The first group consisted of 520 live births at the departments of paediatrics and obstetrics, at this hospital. These children were selected by a simple random sampling procedure. In each case detailed history, information about family background and socioeconomic states, obstetric history, and details of the present pregnancy were collected. In all cases weight, length, and mid-arm, chest, head, and abdominal circumferences were obtained by one of us (JM) within 24 hours after birth.

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The second group consisted of 501 consecutive live births, which were recorded in a prospective follow up of pregnant women in an urban community in a slum. A complete profile of the family household, socioeconomic state, living conditions, and record after pregnancy was available for each case. The prospective cohort was followed from before pregnancy until the live birth. Birth weight and mid-arm circumference were recorded by an auxiliary nurse midwife within 72 hours after birth. The infant was then followed up at the ages of 7 and 28-31 days and at 3, 6, and 9 months (or within one week of those dates) for survival state. The entire study was based on home follow up.

The mid-arm circumference was measured at the midpoint between the tip of the acromion and the olecranon process in the left upper arm with a flexible fibreglass tape to the nearest 0.1 cm. The chest circumference was

obtained at the level of the xiphisternum and below the inferior angle of the scapula during quiet respiration. The head circumference was measured by passing the tape between the supraorbital ridges and the maximum occipital prominence. The abdominal girth was taken at the level of the umbilicus. The length was recorded on an aluminium infantometer to the nearest 0.1 cm. Weight was measured on a beam balance to the nearest 20 g using standard techniques.

Standard statistical methods of linear regression and correlation, multiple regression, Student's *t* test, χ^2 test, and analysis of variance were applied to analyse the data.^{2,3} In the community study the intrapersonal error for measurement of mid-arm circumference⁴ had a technical error of 0.1414 and a coefficient of variance of 1.48. The interpersonal error⁴ had a technical error of 0.2236 and a coefficient of variance of 2.34.

TABLE I—Correlation matrix between anthropometric variables for 520 infants born in hospital

	Mid-arm circumference	Birth weight	Head circumference	Chest circumference	Length
Birth weight (g)	0.8110				
Head circumference (cm)	0.6240	0.7264			
Chest circumference (cm)	0.8998	0.8696	0.7243		
Length (cm)	0.6808	0.8023	0.7417	0.7869	
Abdominal girth (cm)	0.7113	0.7705	0.5963	0.8052	0.6505

All correlations $p < 0.001$.

Regression lines of birth weight on mid-arm and chest circumferences. Corresponding values of mid-arm and chest circumferences for 2500 g (....) and 2000 g (—) are depicted. For mid-arm circumference: birth weight = $-1042.6658 + (414.0524 \times \text{mid-arm circumference})$; for chest circumference: birth weight = $-3440.2403 + (199.2987 \times \text{chest circumference})$.

TABLE II—Predictability of neonatal mortality in 501 infants born in the community by birth weight and mid-arm circumference

	No who died	No who lived	Total
Birth weight (g)*:			
≤ 2500	12	190	202
> 2500	5	294	299
Total	17	484	501
Mid-arm circumference (cm)†:			
≤ 8.7	11	111	122
> 8.7	6	373	379
Total	17	484	501

* $\chi^2 = 6.70$ ($p < 0.01$), sensitivity 70.6%, specificity 61.0%, Youden index 31.6%.

† $\chi^2 = 15.56$ ($p < 0.001$), sensitivity 64.7%, specificity 77.1%, Youden index 41.8%.

Results

HOSPITAL POPULATION

For the hospital population all infant variables were significantly correlated with each other (table I). Chest circumference had the highest correlation with birth weight, followed by mid-arm circumference. The figure depicts the linear regression analysis and the resultant regression lines of birth weight on mid-arm and chest circumferences.

A mid-arm circumference of 8.6 cm corresponded to a birth weight of 2500 g (sensitivity 72.52%, specificity 85.9%, Youden index 58.42%) as calculated from the regression equation (figure). A mid-arm circumference of ≤ 8.7 cm, however, had the best sensitivity (77.92%) and specificity (83.55%) in detecting infants with low birth weight; we therefore used it as the cut off value in this study. The 95% confidence limit for birth weight using a mid-arm circumference of 8.7 cm was 2559.59 ± 466.41 g. Similarly, a chest circumference of 29.8 cm corresponded to a birth weight of 2500 g when calculated from the regression equation (sensitivity 69.37%, specificity

91.95%, Youden index 61.31%) (figure). A chest circumference of ≤ 30 cm, however, had the best sensitivity (82.88%) and specificity (83.89%) in predicting infants with birth weights of 2500 g or less; the 95% confidence limit for birth weight using a chest circumference of 30 cm was 2538.72 ± 392.98 g. The figure also indicates the corresponding values of mid-arm (7.4 cm) and chest circumferences (27.3 cm) for a birth weight of 2000 g. A mid-arm circumference of ≤ 7.5 cm had the best sensitivity (71.05%) and specificity (98.55%) for predicting infants with birth weights ≤ 2000 g. Similarly, a chest circumference of ≤ 27.5 cm had the best sensitivity (73.68%) and specificity (98.55%) for identifying infants ≤ 2000 g.

Multiple regression analysis of birth weight on chest and mid-arm circumferences was: birth weight = $-3.0983527 + (0.142088 \times \text{chest circumference}) + (0.158039 \times \text{mid-arm circumference})$ ($r = 0.8897$; for 0.1421 $t = 18.06$, $p < 0.001$; for 0.1580 $t = 9.01$, $p < 0.001$). From the analysis of variance of birth weight the F ratio (981.89) was significant ($p < 0.01$), thus indicating the usefulness of chest and mid-arm circumferences in predicting birth weight. The 95% confidence limit for birth weight with a mid-arm circumference of 8.7 cm and chest circumference of 30 cm was 2539.2 ± 621.3 g.

COMMUNITY POPULATION

Only mid-arm circumferences could be measured in the infants born in the community as complete undressing of the infant was not permitted owing to social customs, beliefs, and taboos. Analysis of the relation between birth weight and mid-arm circumference for these infants also showed a strong correlation: birth weight = $-0.3433 + (0.3288 \times \text{mid-arm circumference})$ ($r = 0.6918$, $p < 0.001$; for 0.3288 $t = 19.95$, $p < 0.001$).

Neonatal mortality showed an inverse relation with mid-arm circumference, an increase in mid-arm circumference being associated with a decrease in mortality. Postneonatal mortality, however, showed an inconsistent relation with mid-arm circumference. Table II gives the predictability of neonatal mortality by birth weight and mid-arm circumference. A mid-arm circumference of ≤ 8.7 cm and a birth weight of ≤ 2500 g were equally useful in predicting neonatal outcome.

Discussion

Birth weight is a reliable and sensitive indicator for predicting the immediate or later outcome for a newborn child. In Third World countries, however, where almost 80% of the births occur in the community, recording the weight for every birth may not be feasible. The present study shows the significant correlation of other anthropometric measurements to birth weight (table I). Chest and mid-arm circumferences had the best correlation with birth weight, whereas other reports have found mid-arm circumference to have the best correlation.^{5,6}

A mid-arm circumference of ≤ 8.7 cm and a chest circumference of ≤ 30 cm, which were used as cut off values in this study, were good predictors of infants with low birth weight. In India a birth weight of 2000 g or less has been recommended as the criterion for admitting infants into special care neonatal units.⁷ A mid-arm

circumference of ≤ 7.5 cm and a chest circumference of ≤ 27.5 cm also had a good predictive value in identifying this risk group. The strong correlation between birth weight and mid-arm circumference ($r = 0.8110$) observed in our population born in hospital was also observed in our population born in the community ($r = 0.6918$), where the measurements were recorded by paramedical workers. This clearly shows that simple measurements, such as mid-arm circumference, can safely and practicably replace the weight record as a measure of fetal growth for identifying infants with low birth weight when recording birth weight is not feasible.

As low birth weight is highly predictive of neonatal mortality and mid-arm and chest circumferences can identify infants with low birth weight with a fair degree of accuracy it would be logical to assume that these variables would be useful in predicting neonatal outcome. This assumption was tested in the community for birth weight and mid-arm circumference. Newborn infants with low birth weight and those with mid-arm circumference ≤ 8.7 cm had a significantly higher mortality than those weighing over 2500 g ($p < 0.01$) or with a mid-arm circumference of over 8.7 cm ($p < 0.001$). Birth weight and mid-arm circumference were equally useful in predicting neonatal mortality. Thus if a mid-arm circumference of 8.7 cm was used as the cut off value screening of only a quarter of the population (24%) would identify almost two thirds (64%) of infants at risk of neonatal death. In a study of selected hospital births a mid-arm circumference of ≤ 9.0 cm was observed to be a useful indicator for predicting risk of death during the first 14 days of life.⁶

This study shows that measurements like mid-arm and chest circumferences are simple, quick, and reliable indicators for predicting low birth weight and neonatal outcome in the community. These measurements are easy to learn and can conveniently be introduced into the existing systems of health care in the community of developing nations for use by paramedical workers to detect neonates who are at risk.

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What is the treatment of choice for status epilepticus in a child if the intravenous route is not easily obtainable? Some authorities recommend diazepam rectal solution (Stesolid) but I read in the "BMJ" (29 June, 1980) that peak concentration is reached within 30 minutes—surely too slow for status epilepticus. So does paraldehyde intramuscularly still have an important role?

An intravenous injection of a benzodiazepine drug, usually diazepam or clonazepam, is the treatment of choice for status epilepticus in a child because these drugs cross the blood-brain barrier extremely quickly and are effective in more than 75% of patients.¹ If, however, the intravenous route is not possible rectal administration may be used. A preparation of diazepam (Stesolid rectal tubes) is available for rectal administration and is supplied in a plastic container with an applicator designed for insertion into the rectum. The injectible solution of diazepam (Valium) or clonazepam (Rivotril) may be used with a disposable 1 or 2 ml syringe (without attached needle), which is inserted gently into the rectum, but this is less satisfactory than Stesolid rectal tubes. Absorption from the rectum is rapid, peak concentrations occurring in 10-30 minutes² and when intravenous administration is not

possible—for instance, when a suitable vein cannot be found or when the child is at home without immediate medical attention—it is a valuable alternative. Nevertheless, it cannot achieve the rapidity of effect of intravenous administration, and the latter should always be used whenever possible. Intramuscular administration of diazepam is unsatisfactory because absorption from this site is poor. Paraldehyde is no longer favoured as a first line treatment, largely because of its unpleasant physical properties and its liability to produce local sterile abscesses on intramuscular administration. Its kinetics have been little studied, but its therapeutic action appears to come on rapidly and it is a relatively safe drug. It may, therefore, still have a place in treating children whose status epilepticus has not responded to a benzodiazepine drug.—A RICHENS, professor of pharmacology and therapeutics, Cardiff.

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