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Original Article

Paediatrics Section

Anthropometric Linear Measurements as Surrogate Marker in Low Birth Weight Infants: A Cross-sectional Study

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ABSTRACT

Introduction: Low Birth Weight (LBW) is linked to perinatal mortality and morbidity, growth, and cognitive developmental defects, along with a greater tendency to develop non communicable diseases later in life. In many settings, the birth weight of infants is not properly noted; weight is either not measured appropriately or tabulated accurately. This has necessitated the use of alternative indices in lieu of birth weight to reliably identify LBW babies, especially in settings where the availability of weighing scales is very limited.

Aim: To determine the reliability of anthropometric measurements as a surrogate marker of weight in LBW infants born in a tertiary care hospital.

Materials and Methods: This hospital-based cross-sectional study was conducted at Department of Paediatrics and Neonatology, Assam Medical College, Dibrugarh, Assam, India from March 2023 to May 2023. Admitted inborn babies (n=2074) in the postnatal ward and inborn Neonatal Intensive Care Unit (NICU) were included. LBW was defined as <2500 grams. Crown-heel Length (CHL), Chest Circumference (CC), Head Circumference (HC), and Mid-upper Arm Circumference (MUAC) were measured. Student's t-test and Receiver Operating Characteristic (ROC) curve analysis were used to statistically analyse the data.

Results: Out of the 2074 included babies, 1123 were male, and 471 were LBW. The mean birth weight of the LBW cohort was 1.98±0.45 kg compared to 2.78±0.33 kg in the NBW cohort (p-value <0.05). CHL, CC, HC, and MUAC were all significantly lower in the LBW cohort compared to the NBW cohort. MUAC seemed to be the best indicator of LBW. The cut-offs for CHL, HC, CC, and MUAC were 48.5 cm, 33.5 cm, 30.5 cm, and 10.5 cm, respectively.

Conclusion: The MUAC was strongly correlated with birth weight. MUAC is easy to obtain, simple to perform, and does not require sophisticated equipment.

Keywords: Cognitive development, Cut-off, Mid-upper arm circumference, Neonates, Resource constraint

INTRODUCTION

According to the World Health Organisation (WHO), LBW is defined as a birth weight of less than 2500 g at any gestational age [1]. Approximately 15% to 20% of all births globally are LBW, representing around 20 million births annually [2]. The United Nations Children's Fund (UNICEF)-WHO data estimates that one in seven live births belonged to the LBW category in 2015, with nearly 50% from Southern Asia [3]. The prevalence of LBW varies widely across continents, from 7.2 percent in more developed countries to 17.3 percent in Asia [3]. Regional surveys reveal an incidence of 28% in South Asia, 13% in sub-Saharan Africa, and 9% in Latin America [3].

While LBW is more prevalent in developing countries, data on LBW in these regions are scant. Birthweight data was not recorded for nearly one-third, or 39.7 million newborns globally in 2015, with Africa having nearly 50% of this population [3]. These estimates include newborns who were unweighted and those whose birthweights were not captured by key data sources. This is because a significant portion of deliveries occur unassisted in homes or small, ill-equipped health facilities in hard-to-reach areas, where cases of infants with LBW often go unreported [4].

The LBW is associated with multiple adverse health outcomes such as perinatal mortality and morbidity, growth, and cognitive developmental defects [5]. Babies who survive tend to develop non communicable diseases later in life [6]. LBW infants are about 20 times more susceptible to death [5]. LBW is a major cause of public health concern and an important indicator of public health. Globally, the indicator reflects a multipronged public health issue that includes poor maternal nutrition, prolonged illness, physical stress, and inadequate antenatal care [7].

However, in many settings, especially during home births or births not attended by trained medical personnel, many infants are not accurately weighed at birth [8]. Even when birth weight is taken, appropriate recording and tabulation are not ensured. Another problem is the scarcity of functional weighing scales appropriately calibrated to record weight with precision [8]. Also, where available, according to the WHO Collaborative Study on Birth Weight Surrogates, these scales undergo rapid wear-and-tear with regular use, rendering them malfunctioning [9]. Various anthropometric parameters, including body length, foot length, HC, CC, thigh circumference, calf circumference, and MUAC, have been evaluated as surrogates for LBW [10-14]. However, determining the most suitable anthropometric measure is often contingent on the specific context. Some studies recommend using HC [10], CC, MUAC [12], thigh circumference [9], foot length [13], and calf circumference [14], as the most fitting choices.

Similar studies have been conducted in countries such as Uganda, Ethiopia, Nepal, Iran, and India [9,10,15-17]. However, there is a lack of published data from North-Eastern India. Therefore, it is necessary to find a suitable alternative to birth weight and its cut-off point that can be used as a valid indicator for the prompt identification of LBW babies at birth, especially in regions where functional weighing scales are not readily available, which is common in resource-limited countries like India.

Hence, aim of the study was to determine the reliability of anthropometric measurements as a surrogate marker of weight in LBW infants born in a tertiary care hospital. And the objectives were to describe the diagnostic value of anthropometric measurements taken within 48 hours of life to identify LBW babies and also to identify cut-off values for anthropometric measurements in LBW infants.

MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted at Department of Paediatrics and Neonatology, Assam Medical College, Dibrugarh, Assam, India from March 2023 to May 2023. Ethical clearance was obtained from the Institutional Ethics Committee (IEC(H) number 8487). Written informed consent was obtained from all the parents of the neonates.

Inclusion criteria: All inborn babies (term/preterm, LBW/VLBW) admitted at the natal ward and inborn NICU who were willing to participate in the study were included. LBW was defined as <2500 grams [7].

Exclusion criteria: Infants with life-threatening gross congenital malformations, macrocephaly, microcephaly, subgaleal haemorrhage, known cases of Toxoplasmosis, Rubella Cytomegalovirus, Herpes simplex, and Human Immunodeficiency Virus (HIV) (TORCH) infection, fractured humerus, or those whose parents refused to give consent were excluded.

Sample size calculation: The sample size for study was determined using the formula proposed by Naing:

$n=z^2*p(1-p)/d^2$

Using z=1.96, p=12.64% by Chukwudi NK et al., [18], and d=5%, the calculated minimum sample size for the study population was 170 newborn babies. These babies were consecutively recruited until the required number was obtained.

Study Procedure

The eligible newborn babies were recruited within their first 48 hours of life after obtaining consent from their parents. Birth weight was measured at birth, to the nearest 50 g, with the nude infant lying on the available Goonj electronic scale. This was carried out by the labour room nursing staff on duty under the supervision of the attending paediatric resident (who had been trained by the PI) and was duly recorded. Under aseptic precautions as per the Unit protocol, measurements were carried out on the babies by the PI with a non stretchable tape measuring to the nearest 0.1cm and using standard techniques of measurements for HC, mid-arm, and CC.

The HC was measured with a non stretchable tape just above the levels of the supraorbital ridges anteriorly and the occipital prominence posteriorly. This measurement was taken beyond 24 hours of life but before 48 hours. The CC was measured at the level of the nipples during the end-phase of expiration. For Mid-arm Circumference (MAC), the left arm was used for measurement. The length was measured in a supine position using a portable aluminum infantometer with a precision of 0.1cm. All measurements, except HC, were taken within 24 hours. Three consecutive measurements were taken with the average taken as the final measurement. All other necessary management was ensured as per unit protocol along with counseling of the mother regarding the care of LBW babies.

STATISTICAL ANALYSIS

Descriptive statistics were computed for all variables. Continuous variables were expressed as means and standard deviations. Statistical Package for Social Sciences (SPSS) version 25.0 (Chicago, Illinois, USA) statistical software package was used for statistical analysis. Student's t-test, ROC curve analysis, were used to statistically analyse the data; a p-value <0.05 was considered significant.

RESULTS

The total number of newborn babies included in the study was 2074. The male to female ratio was 1123:951. LBW babies accounted for 471 cases compared to 1603 normal birth weight babies.

The mean birth weight of the cohort was 2.60±0.49 kg. The mean CHL, HC, CC, and MUAC of the overall cohort were: 46.92±3.24 cm, 32.73±1.97 cm, 29.6±2.81 cm, and 9.5±1.8 cm. The mean birth weight of the LBW cohort was 1.98±0.45 kg compared to 2.78±0.33 kg in the NBW cohort (p-value <0.05). On comparing the parameters between the two cohorts, CHL, CC, HC, and MUAC were all significantly lower in the LBW cohort compared to the NBW cohort (p-value <0.05) [Table/Fig-1].

Parameters	Overall	LBW N=471	NBW N=1603	p-value
Birth weight (kg)	2.60±0.49	1.98±0.45	2.78±0.33	0.01
CHL (cm)	46.92±3.24	43.76±4.73	47.85±1.79	0.04
HC (cm)	32.73±1.97	30.80±2.51	33.29±1.34	<0.01
CC (cm)	29.60±2.81	27.07±2.90	30.34±2.31	0.03
MUAC (cm)	9.56±1.80	7.93±1.50	10.04±1.59	0.01

[Table/Fig-1]: Comparison of anthropometric parameters.
*Student's t-test used to calculate differences in means; p-value <0.05 considered significant

Overall, MUAC had the highest Area Under ROC (AUROC) (82.3%) compared to other parameters (CHL=77.7%, HC=81.4%, CC=82.2%) [Table/Fig-2]. CHL had a sensitivity of 86% and specificity of 50%. Similarly, the cut-offs of HC, CC, and MUAC were 33.5 cm (sensitivity=89.5%), 30.5 cm (sensitivity=94.7%), and 10.5 cm (sensitivity=96.2%) [Table/Fig-3]. ROC curve analysis was done to determine the area under curves of the different parameters. The area under the curve was highest for MUAC followed by the CC [Table/Fig-4].

Test result variable(s)	Area	Std. Error	Asymptotic sig.	Asymptotic 95% Confidence Interval (CI)	
				Lower bound	Upper bound
CHL	0.777	0.014	<0.001	0.749	0.804
HC	0.814	0.011	<0.001	0.793	0.836
CC	0.822	0.010	<0.001	0.801	0.842
MUAC	0.823	0.011	<0.001	0.801	0.844

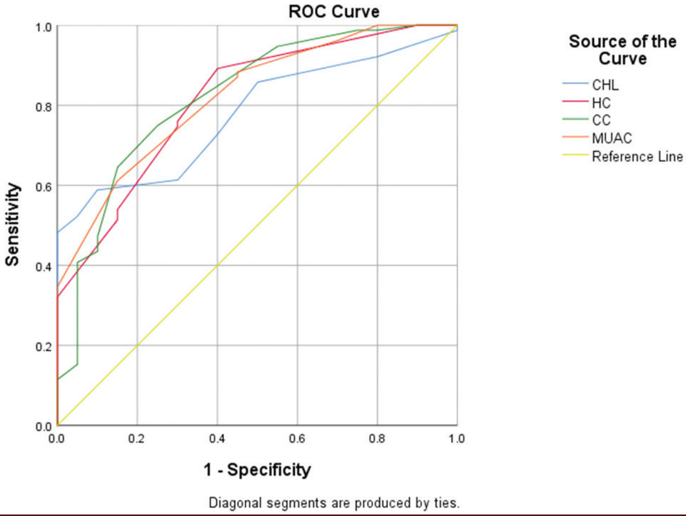
[Table/Fig-2]: AUROCs of the different anthropometric parameters.

Parameters	Sensitivity	Specificity	PPV	NPV
CHL	86.0%	50%	26.4%	94.4%
HC	89.5%	60%	31.9%	96.5%
CC	94.7%	45%	26.5%	97.6%
MUAC	96.2%	30%	22.3%	97.4%

[Table/Fig-3]: Sensitivity and specificity of anthropometric parameters.
PPV: Positive predictive value; NPV: Negative predictive value

DISCUSSION

The present study shows that LBW newborn babies can be identified using anthropometric surrogate measures. In resource-poor settings like in our country, neonatal mortality continues to remain high, and given the fact that many births occur at home, the



[Table/Fig-4]: ROC curve.

failure to identify high-risk LBW newborns delays lifesaving care and timely referral [19].

A low-cost, easily accessible measurement for LBW in the community setting could facilitate the detection of LBW infants and appropriate referral and support. Previous studies have shown that anthropometric measurements are reliable in identifying LBW [10,16-18]. However, there is a paucity of data regarding the measure of choice and its cut-off point in this part of India, so the need was felt to conduct the present study.

In the current study, HC, CC, and MUAC had the highest AUROCs and could identify LBW to a certain degree. However, among all these measures, MUAC seemed to be the best indicator of LBW (AUC 82.3%). At a cut-off point of 10.5 cm, MUAC had a sensitivity of 96.2% in identifying LBW newborns.

The cut-offs for different parameters deduced in the present study are comparable to cut-offs obtained in similar studies in different settings. The present study cut-off for CC was 30.5 cm in the present study, which is comparable to the cut-off in Nepal (30.8 cm) [10] and in Iran (31.2 cm) [17]. Taksande A et al., have previously evaluated anthropometric surrogates in India and found that HC and TC were better indicators for picking up LBW, while CFC and MAC were better in picking up VLBW babies [9]. Das JC et al., in Bangladesh have observed that MAC <9 cm had the best sensitivity (96.2%) and specificity (97.3%) in picking up LBW babies and opined that MAC measurement is easier, convenient, and statistically superior to other anthropometrical parameters [12]. In the study from Ethiopia, CC and MUAC were found to be better surrogate measurements for identifying LBW [15]. In the present study, a MUAC cut-off of ≤10.5 cm identifies infants with LBW with high sensitivity, although the specificity is low. MUAC had an excellent correlation with birth weight.

The use of CC and foot length measurements would require additional training and furnishing of equipment. The selection of a measure should be based on simplicity, acceptability, precision, accuracy, cost, and sensitivity. MUAC can potentially be used in a community setting, especially where weighing scales are not easily available. An important advantage of MUAC is that it is a widely used indicator of nutritional status in children aged >6 months.

The strengths of the study are the large study population and the standardised collection of all anthropometric parameters.

Limitation(s)

Since the present study was a hospital-based study, the estimates of LBW may not reflect what is in the community. The results of the present study need to be validated in the community setting.

CONCLUSION(S)

In the present study, MUAC was found to be an effective and simple tool to screen for LBW when appropriate scales for weight measurement are not accessible. MUAC is easy to obtain, simple to perform, and does not require sophisticated equipment. The feasibility and effectiveness of using MUAC to identify LBW in other high-risk populations in resource-constrained environments need to be explored. The current study emphasises that MUAC is a good indicator of LBW status and can potentially be incorporated into large-scale screening programs for neonates in areas where mortality is high; this could decrease the number of unrecognised and inadequately supported neonates.

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