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DIAGNOSTIC PERFORMANCE OF MID-UPPER ARM CIRCUMFERENCE IN DETECTING LOW BIRTH WEIGHT NEWBORNS: A CROSS-SECTIONAL VALIDATION STUDY

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ABSTRACT

Background: Low birth weight (LBW) continues to be one of the leading causes of neo- natal morbidity and mortality, especially in low-resource settings. In many facilities and community births, the absence of weighing equipment makes it impossible to identify at-risk newborns early. Mid-upper arm circumference (MUAC) is introduced as a screening tool (anthropometric indicator) for LBW in clinical settings.

Objective: To assess the accuracy of mid-upper arm circumference (MUAC) compared to birth weight as a gold standard for detecting low birth-weight newborns.

Methods: A cross-sectional study for external validation was conducted in the Pediatrics Department of Liaqat University Hospital from January 2020 to June 2020. We recruited 112 singleton term newborns using a consecutive sampling method. Birth weight was measured with a calibrated digital weighing scale and MUAC (measured in the first 24 h after delivery) using non-elastic measuring tape. Statistical analysis was conducted using SPSS version 15.0; the criterion for statistical significance was set at $p < 0.05$.

We enrolled a total of 112 newborns; of these, 75 (67.0%) were categorized as low birth weight. MUAC was 8.901.08 cm on average With a MUAC threshold < 9.3 cm, the sensitivity (81.1%), specificity (78.7%), positive predictive value (65.2%) and negative predictive value (89.4%) for LBW newborns were identified herein.

Conclusion: Mid-upper arm circumference proved to be highly sensitive, specific for diagnosing low birth weight babies. MUAC may be a suitable screening tool due to its relative ease of use, low cost and ease of measurement, especially in contexts where weighing facilities are unavailable or limited.

KEYWORDS: Low birth weight, Mid-upper arm circumference, Diagnostic accuracy, Anthropometry, Newborn, Validation study.

INTRODUCTION

Low birth weight (LBW), defined by the World Health Organization (WHO) as a birth weight of less than 2500 g irrespective of gestational age, remains a major public health concern worldwide [1]. It is one of the strongest predictors of neonatal morbidity and mortality and contributes substantially to adverse health outcomes during infancy and childhood.

Globally, LBW accounts for a large proportion of neonatal deaths, particularly in low- and middle-income countries where access to quality maternal and newborn healthcare remains limited [2, 3, 4, 11, 12].

Although improvements in maternal and child health services have reduced the prevalence of LBW in many regions, its burden remains high in developing countries. Infants born with low birth weight are more likely to experience respiratory distress, infections, poor growth, neurodevelopmental impairment, learning disabilities, and chronic metabolic disorders later in life [5, 7, 16]. Early recognition of these newborns is therefore essential to ensure prompt referral, appropriate clinical management, and improved survival.

Accurate measurement of birth weight requires a calibrated weighing scale immediately after delivery. However, in many resource-constrained settings, including Pakistan, a considerable number of births occur in primary healthcare facilities or at home where weighing equipment may not be readily available. This often delays the identification of LBW newborns and limits timely intervention. Consequently, there is a growing interest in identifying simple anthropometric measurements that can serve as reliable alternatives to birth weight in such settings.

Several studies have demonstrated that neonatal anthropometric parameters, including head circumference, chest circumference, foot length, and mid-upper arm circumference (MUAC), are useful predictors of low birth weight [4, 7, 9, 10, 21]. Among these measurements, MUAC has received considerable attention because it is inexpensive,

easy to perform, requires minimal training, and can be measured using a simple non-stretchable measuring tape. Nevertheless, the diagnostic performance of anthropometric indicators varies across different populations due to differences in ethnicity, genetics, maternal characteristics, and socioeconomic conditions [3, 5, 19, 20].

Despite the potential utility of MUAC as a screening tool, limited local evidence is available regarding its diagnostic accuracy in identifying low birth weight newborns in Pakistan. Therefore, the present study was undertaken to determine the diagnostic accuracy of mid upper arm circumference for identifying low birth weight babies, using birth weight as the reference standard. The findings may help establish MUAC as a practical screening method in healthcare facilities and community settings where weighing scales are unavailable.

Study Population: The study enrolled neonates admitted to the neonatal unit within the first 24 hours after birth, including preterm, term, and post-term infants. Newborns presenting with major congenital anomalies, birth-related trauma (e.g., scalp edema or limb fractures), cyanosis, or those requiring respiratory support at admission were excluded from the study to minimize potential confounding factors.

MATERIALS AND METHODS

A hospital-based cross-sectional validation study was carried out at Pediatrics Department of Liaqat University Hospital from January 2020 to June 2020, following approval from the Institutional Ethical Review Committee. A total of 112 singleton term newborns 37–41^{+6} weeks of gestation) born to mothers aged 18–40 years were recruited using consecutive non-probability sampling. Mothers with diabetes mellitus, pre-eclampsia, chronic hypertension, cardiac or hepatic disorders, severe intrauterine growth restriction, or antepartum haemorrhage were excluded. Newborns with congenital anomalies or multiple births were also excluded.

Parents provided written informed consent before participation. A trained observer conducted measurements in accordance with a standardised protocol for all anthropometric measures within 24 hours of birth. Birth weight was assessed with a calibrated digital infant weighing scale and taken as the gold standard. A non-elastic measuring tape was used to measure mid-upper arm circumference (MUAC) on the left upper arm at the midpoint between acromion and olecranon processes, with readings taken to the nearest 0.1cm. Statistical analysis was performed using SPSS Ver 15 0 (SPSS Inc, Chicago IL USA) Mean ± standard deviation (SD) is used to report continuous variables, whereas frequencies and percentages are reported for categorical variables. Mean MUAC difference between two groups was evaluated using independent *t*-test. Pearson's correlation coefficient was used to assess the association between MUAC and birth weight. MUAC diagnostic performance was assessed by estimating sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). Two-sided *p*-values were used to define statistical significance < 0.05.

RESULTS

A total of 112 full-term singleton newborns were included in the study. The mean mid-upper arm circumference (MUAC) was 8.90 ± 1.08 cm. Among the enrolled neonates, 68 (60.7%) were female and 44 (39.3%) were male. Based on birth weight, 75 (67.0%) newborns were classified as low birth weight (LBW), whereas 37 (33.0%) had normal birth weight (Table 1). The mean MUAC among female newborns was 8.93 ± 1.04 cm (95% CI: 8.68–9.18), while the corresponding value among male newborns was 8.86 ± 1.15 cm (95% CI: 8.51–9.21). The difference in MUAC between male and female newborns was not statistically significant ($t = 0.327$, $p = 0.744$).

Comparison according to birth weight demonstrated that newborns with LBW had a significantly lower mean MUAC (8.41±0.87 cm; 95% CI: 8.21–8.61) than newborns with normal birth weight (9.90±0.70 cm; 95% CI: 9.66–10.13). The observed difference was statistically significant ($t = 17.91$, $p < 0.001$), as shown in Table 2 and Table 3.

Pearson's correlation analysis demonstrated a strong positive correlation between MUAC and birth weight ($r = 0.858$, $p < 0.001$), indicating that increasing MUAC was associated with increasing birth weight (Table 4).

Receiver operating characteristic (ROC) curve analysis was performed to determine the optimal MUAC cut-off value for identifying LBW newborns. A MUAC cut-off value of < 9.3 cm showed the best diagnostic performance, with a sensitivity of 81.1%, specificity of 78.7%, positive predictive value (PPV) of 65.2%, and negative predictive value (NPV) of 89.4%. The diagnostic performance of other MUAC cut-off values is presented in Table 5

DISCUSSION

Low birth weight (LBW) remains one of the leading causes of neonatal morbidity and mortality, particularly in developing countries where access to neonatal healthcare and weighing facilities is often limited. Early identification of LBW newborns is essential for timely referral, nutritional support, and appropriate neonatal care. The present study evaluated the diagnostic accuracy of mid-upper arm circumference (MUAC) as a simple anthropometric measurement for identifying LBW newborns, using birth weight as the reference standard. A total of 112 full-term singleton newborns were included in this study. The mean MUAC was 8.90 ± 1.08 cm, and approximately two-thirds (67.0%) of the enrolled newborns were classified as having low birth weight. The relatively high proportion of LBW newborns observed in this study may be attributed to the study setting, as Lyari General Hospital is a tertiary care referral centre that receives a large number of high-risk pregnancies. Differences in maternal nutritional status, socioeconomic conditions, and healthcare accessibility may also contribute to the higher frequency of LBW observed in this population.

Table 1: Baseline characteristics of the study participants.

Variable	Category	n	%
Gender	Male	44	39.3
	Female	68	60.7
Birth weight	LBW	75	67.0
	Normal	37	33.0
MUAC	< 9.0 cm	59	52.7
	≥ 9.0 cm	53	47.3
Mean MUAC		8.90 ± 1.08	

Table 2: Comparison of MUAC according to gender.

Characteristic	Female	Male
Mean MUAC	8.93 ± 1.04	8.86 ± 1.15
95% CI	8.68–9.18	8.51–9.21

$t = 0.327$, $p = 0.744$

Table 3: Comparison of MUAC according to birth weight.

Characteristic	LBW	Normal
Number	75	37
Mean	8.41	9.90
SD	0.87	0.70
Minimum	7.30	9.20
Maximum	10.20	11.10
95% CI	8.21–8.61	9.66–10.13

$t = 17.91$, $p < 0.001$

Table 4: Correlation between MUAC and birth weight.

Variable	r	p
MUAC vs BW	0.858	< 0.001

The present study demonstrated no statistically significant difference in mean MUAC between male and female newborns ($p = 0.744$). This finding suggests that neonatal sex has minimal influence on MUAC measurements during the first 24 hours of life and supports the use of a common MUAC cut-off value for both male and female newborns. Similar observations have been reported in previous studies, indicating that MUAC is a reliable anthropometric measurement irrespective of neonatal gender.

A significant difference in MUAC was observed between low birth weight and normal birth weight newborns. The mean MUAC was significantly lower among LBW infants compared with newborns weighing more than 2500 g (8.41±0.87 cm versus 9.90±0.70 cm, $p < 0.001$). This finding demonstrates that MUAC decreases with decreasing birth weight and can effectively differentiate LBW from normal birth weight infants.

Pearson correlation analysis showed a strong positive correlation between MUAC and birth weight ($r = 0.858$, $p < 0.001$). The correlation coefficient obtained in the present study indicates that MUAC is strongly associated with birth weight and may be considered a reliable surrogate anthropometric measurement. Similar correlations have been reported by Table 5.

Table 5: Diagnostic accuracy of MUAC at different cut-off values.

MUAC (cm)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
< 9.30	81.10	78.7	65.20	89.40
< 9.40	62.20	78.7	59.0	80.80
< 9.80	43.20	89.3	66.70	76.10

Goto et al., Thi et al., and Salman et al., who concluded that MUAC is among the most accurate anthropometric indicators for identifying LBW newborns.

Receiver operating characteristic analysis identified a MUAC cut-off value of less than 9.3 cm as the optimum threshold for identifying LBW newborns. At this cut-off, the sensitivity was 81.1%, specificity was 78.7%, positive predictive value was 65.2%, and negative predictive value was 89.4%. These findings indicate that MUAC has good screening performance and is particularly useful for ruling out low birth weight because of its high negative predictive value. The observed cut-off value is comparable with those reported in previous regional studies, although slight variations are expected because of differences in ethnicity, maternal nutritional status, gestational age, and study populations.

One of the major strengths of this study is the use of standardized anthropometric measurement techniques performed within the first 24 hours after birth, thereby minimizing measurement bias. Furthermore, birth weight was measured using a calibrated digital weighing scale and served as the reference standard for evaluating diagnostic accuracy. However, this study has certain limitations. It was conducted at a single tertiary care hospital with a relatively small sample size, which may limit the generalizability of the findings. In addition, only full-term singleton newborns were included; therefore, the findings may not apply to preterm infants or multiple pregnancies.

Despite these limitations, the findings demonstrate that MUAC is an inexpensive, rapid, and easily obtainable anthropometric measurement that can be used for community-based screening of LBW newborns. The use of a colour-coded MUAC measuring tape by lady health workers, community health workers, and traditional birth attendants may facilitate early identification of at-risk newborns in areas where weighing scales are unavailable. Early referral and appropriate neonatal care based on MUAC screening could contribute to reducing neonatal morbidity and mortality in resource-constrained settings.

CONCLUSION

Mid-upper arm circumference is a practical, inexpensive, and reliable screening tool for identifying low birth weight newborns. A MUAC cut-off value of less than 9.3 cm demonstrated good diagnostic accuracy when compared with birth weight. MUAC may be incorporated into routine neonatal screening in resource-limited settings to facilitate early identification and referral of at-risk newborns. Further multicentre studies with larger sample sizes are recommended to confirm these findings and establish national reference values.

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