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MEASURING FOOT LENGTH TO IDENTIFY VULNERABLE NEWBORNS IN NEED OF EXTRA CARE: A CROSS SECTIONAL HOSPITAL BASED STUDY IN SOUTH INDIA

Neonatology

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ABSTRACT

Background: Neonatal mortality remains high in many developing country settings mainly because of low birth weight (LBW) or preterm births (PTB). Easy-to-use anthropometric parameters like foot length which are appropriate for resource-limited settings are necessary, to guarantee these neonates are distinguished and alluded as required for extra care. This research aimed to estimate the sensitivity and specificity, and the positive and negative predictive values of newborn foot length to identify babies who are LBW and PTB.

Materials and Methods: A cross-sectional study of newborn babies in a tertiary care hospital was carried out between July to September 2018. Foot length, birth weight and gestational age were estimated on the first day of life. Receiver Operating Characteristic (ROC) curves were plotted to determine the operational cut-offs.

Results: In hospital 150 babies were recruited and measured within 24 hours of birth. Of the 150 babies, 21 (14.00%) were born LBW (<2500 grams) and 77 (51.33%) were PTB. Mean foot length on the first day was 7.62 ± 0.47 cm. Day one average foot length 7.32 cm at birth was 84.5% (77.70 – 89.89) sensitive and 90.5% (84.64 – 94.68) specific to identify birth weight ≥2500 grams; foot length 7.47 cm had sensitivity and specificity of 76.70% (69.11 – 83.21) and 49.4% (41.15 – 57.68) to identify those having term births.

Conclusion: Measurement of newborn foot length for home births in resource-limited settings has the potential to be used by birth attendants, community health workers so that vulnerable newborns can be identified and receive targeted interventions for improved survival.

KEYWORDS

INTRODUCTION:

Infant mortality has declined drastically in the twentieth century worldwide.[1] However, the decrease in neonatal mortality has been moderate, and neonatal deaths actually contribute nearly half (41.6%) of all under-5 mortality.[2] About one-sixth of all babies are low birth weight (LBW, <2500 g), which is the absolute most significant risk factor for neonatal death.[3] India has one of the most elevated neonatal death rates in the world (23 for every 1000 live births).[4] The extent of births attended by skilled health personnel is low, so most LBW and preterm infants are not recognized and alluded for extra lifesaving care. [5,6] Moreover, the availability of functional weighing scales and other anthropometric instruments is restricted in peripheral field settings. [5] Consequently, straightforward, easy-to-use instruments that are appropriate for resource-limited settings are necessary, to guarantee these neonates are distinguished and alluded as required for extra care and consideration.

Separate research studies from India and around the globe have given an account of studies to examine infant foot length as a screening apparatus for neonates, indicating reliable foot length cut-offs for distinguishing LBW or premature babies across various nations. [7–13] In addition these examinations have presumed that for high-risk children delivered at home, estimating foot length measured in the community may have favourable circumstances over other methods [8]. In contrast to estimating chest circumference, for instance, there is a requirement of training of health workers at periphery and also the procedure of undressing of the baby introduces disturbances and puts him at risk of hypothermia.[10,14] Additionally, a multicentre study led by WHO found that the mean and tenth percentile for the mid-upper arm circumference (MUAC) and chest circumference varied altogether by geological areas and ethnicity.[15]

In the present study, the neonate foot length was measured to recognize LBW and premature deliveries and the sensitivity and specificity estimates were calculated for determining the foot length cut-off. The objective was to determine the importance of utilizing foot length as a screening apparatus in resource-limited settings to distinguish LBW or premature delivery needing additional care.

MATERIALS AND METHODS:

Study setting and participants

We conducted a cross-sectional study between July to September 2018 of newborn babies born at Chettinad Hospital and Research Institute within the first 24 hours of life. Neonates showing signs of any one of the following were excluded: congenital anomalies, upper and lower limb deformities, birth weight <1000 grams, gestational age <28 weeks, genetic abnormalities, dysmorphic features and severe asphyxia. The study was approved by the Institutional Ethics Committee and written, informed consent was obtained from the caregiver of each infant in the study.

Anthropometric data collection

Foot length of the newborn was measured by using a Vernier caliper with no zero error. The length of the foot was measured from prominent point of the heel to the longest toe. The foot was placed in the lateral position and ankle was held and a finger was placed on the dorsum of foot in order to avoid plantar grasp reflex, as it may lead to shortening of length .The length of both the foot was measured and the average was calculated. Birth weight was measured by digital Salter scales which were calibrated at each use with a weight weighing 1000 grams. Gestational age was calculated from last menstrual period. We defined two binary variables to describe outcomes: (1) less than 2500 grams (low birth weight) and (2) less than 37 weeks gestation (PTB).

Data processing and statistical analysis

The distribution of gender, birth weight, foot length and gestational age estimates for the babies were measured on the first day and presented as percentages. Non-parametric receiver operating characteristics (ROC) analysis was conducted on foot lengths for the outcome variables of LBW and PTB. To produce an operational foot length cut-off for babies with LBW or PTB, a range of foot lengths was then defined and sensitivity, specificity, positive and negative predictive values (PPV and NPV) were calculated for these foot lengths. Data was analyzed using SPSS version 23.0.

RESULTS

Study population

During the study period, 200 babies were born at Chettinad Hospital and Research Institute of whom 150 (75%) were recruited to the study and had their feet measured on the first day of life. According to maternal reports, the mean age of participating mothers was 26.28 ± 3.97 years, 66 (44.00%) were primigravid and the mean weeks of delivery was 37.28 ± 1.78. Of the 150, 82 (54.67%) had Lower segment cesarean section.

The mean birth weight was 2.95 ± 0.49 kg and mean average foot length was 7.62 ± 0.47 cm. Of the 150 babies, 21 (14.00%) were born LBW (<2500 grams) and 77 (51.33%) were PTB. Amongst the PTB, 19 (24.67%) had LBW children.

The mean average foot length of the babies measured on the first day of life was 7.62 ± 0.47 cm. The right foot length was 7.61 ± 0.48 cm while the left foot was 7.62 ± 0.47 cm, which was not statistically different. (Table 01)

Sensitivity, specificity and predictive values of foot length

Sensitivity and specificity estimates for different foot lengths measured on the first day to identify small babies are shown in figures 01 and 02 in the form of non-parametric receiver operating characteristics (ROC) curves.

Using the Youden's Index – the highest combination of sensitivity and specificity we found the best operational cut-off to predict normal birth weight was a newborn foot length of 7.32 cm. It had a sensitivity and specificity of 84.5% (95% confidence interval (CI) 77.70 – 89.89) and 90.5% (95% CI 84.64 – 94.68) respectively to identify birth weight >2500 grams. Similarly, best cut-off to predict term birth was a foot length of 7.47 cm which had sensitivity and specificity of 76.7% (95% CI 69.11 – 83.21) and 49.4% (95% CI 41.15 – 57.68) respectively.

The positive predictive value (PPV) and negative predictive value (NPV) for the foot length cut-offs of 7.32 cm were 98.2% and 48.7% to predict normal birth weight with an accuracy of 85.33%; however for the 7.47 cm cut-off for term delivery, the PPV and NPV were only 58.9% and 69.1% respectively with an accuracy of 62.66%.

Table 01: Characteristics of newborns measured within 24 hours of birth (n = 150)

Variables	Category	n	%
Gender	**Male**	79	52.67
	Female	71	47.33
Birth Weight (g)	**<2500**	21	14.00
	≥ 2500	129	86.00
Gestation Weeks	**<37 weeks**	77	51.33
	≥ 37 weeks	73	48.67
Mean Foot Length (cm)	**Right**	7.61 ± 0.48	
	Left	7.62 ± 0.47	
	Average	7.62 ± 0.47	

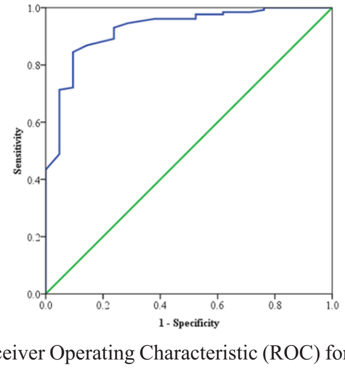

Figure 01: Receiver Operating Characteristic (ROC) for normal birth weight and foot length of newborns measured within 24 hours of birth (n = 150)

***Footnote:* AUC: 0.925 (0.867 – 0.983); p<0.001**

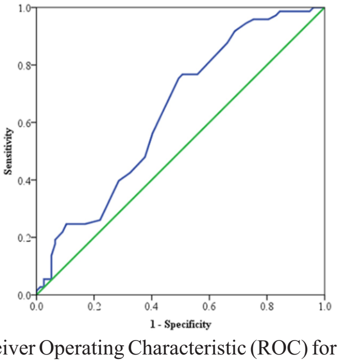

Figure 02: Receiver Operating Characteristic (ROC) for term delivery and foot length of newborns measured within 24 hours of birth (n = 150)

***Footnote:* AUC: 0.637 (0.549 – 0.726); p<0.05**

DISCUSSION

In a resource limited setting with high neonatal mortality rates and limited access to equipment for accurately estimating gestational age (GA), there is a need for alternative methods to identify LBW and PTB newborns. We found that foot length had reasonable sensitivity and specificity for detection of LBW and PTB newborns. Furthermore, high PPV to detect normal birth weight was observed which prevents misclassification of LBW as normal.

The characteristics of our newborns were similar to previous reports from India and the world.[8,16–19] LBW rates was 14 % which was similar to those reported by Mukherjee et al. [20] Elizabeth et al. [21] and Marchant et al. [8] where it ranged from 12–15%. The mean foot length of 7.62 cm also corresponded well to those reported in studies from other parts India by Gavhane et al. [19] (7.42 cm) and Mukherjee et al. [20] (7.27 cm). However, prematurity rate (51.33%) was much higher than those reported in other studies.[16,22] This could be accounted to the limited sample size and difference in geographical region.

In accordance with other studies we found a statistically significant differences in anthropometric measurements between LBW and PTB babies when compared to normal weight and term newborns.[16,21,23] For the anthropometric measure of foot length, the AUCs for distinguishing PTB newborns were noticeably lower contrasted with the AUCs for recognizing LBW newborns. Previous studies additionally revealed somewhat higher sensitivities and specificities for detecting LBW than for PTB. [8,10,17,22,24] We believe our estimating strategy was adequate as the observed AUCs for predicting LBW and PTB in our study were identical to findings from previous studies. [9,19,21,25,26]

The derived cut-offs at 7.32 cm for normal birth weight, were in accordance with previous studies describing cut-offs of 7.0–8.0 cm for foot length.[17,19–21,23] When recognizing PTB, the cut-off for foot length has been accounted for as 7.5–8.0 cm which is also similar to our cut-off.[8,11,19,21] In general, the studies conducted in India when compared with different parts of the world report shorter operational cut-offs for recognizing LBW and PTB. [8,10,16,19,27,28] This could indicate towards the requirement for region specific cut-offs. Nonetheless, it is to be noted that the methodology for choosing the cut-offs varies among studies. The most frequently utilized strategy, which we too have applied in our study, was to decide the cut-off as the one yielding the highest average of sensitivity and specificity to detect an outcome.[16,18,20,22,23] In any case, different studies used the highest [(sensitivity + specificity)/2] ratio, [25] the point with the maximum sensitivity and specificity such that the sensitivity was at least 80% [26] or linear regression to obtain an ideal cut-off.[24] This could clarify some of the difference in the cut-offs noted. Finally, differences between male and female newborns were limited. Nonetheless, foot length was marginally shorter for females (7.60 vs 7.64; p=0.62) proposing that sex-specific cut-offs could likewise be considered for foot length.

Sensitivity was 84.5% (77.70 – 89.89) and specificity was 90.5% (84.64 – 94.68) for the operational cut-offs for identifying normal birth weight newborns. Furthermore, the foot length of 7.32 yielded high PPV (98.2%), whereas NPV was below 0.50. Especially the use of chest circumferences gave promising results showing the highest values of sensitivity, specificity, PPV and NPV for detecting SGA. Among newborns with a foot length ≥7.32 cm, 98.2% would be correctly categorized as non-LBW. This suggests that foot length is a valid tool to identify non-LBW. On the contrary, the low NPV meant that among newborns with a foot length <7.32 cm more than half of the newborns would wrongly be classified as LBW.

The outcomes of being misinterpreted as LBW is limited as the interventions will just advance additional considerations. However, the consequences of misclassifying a LBW newborn as non-LBW could be of critical significance, as LBW is related with a higher risk of mortality. With regards to the high neonatal mortality rate in India, a high NPV is of noteworthy significance than a high PPV. Although all anthropometric measurements are simple and requires little training to master, the health care workers serving at a primary level should receive repetitive training and must be supervised in an attempt to avoid measurement errors. In a setting with a limited public health care system, it would be preferable with one anthropometric cut-off for identification of the at-risk newborns in need of extra care, avoiding a scenario with multiple anthropometric cut-offs identifying a variety of conditions. This might only induce confusion among health care professionals and unnecessary amount of time is spent. It has previously been argued that foot length is preferable as the exposure to hypothermia is limited.[10] Based on our results we would recommend foot length to be performed in order identify LBW newborns, however due to low AUC, PPV and NPV in case of identifying PTB further exploration is required to implement the same.

The study is however not without limitations. Firstly, this was a cross sectional hospital based study of babies within 24 hours of birth: findings suggest that measuring newborn foot length after birth could be useful to identify babies needing extra care. However, temporality couldn't be established as to whether foot length is also affected by adverse maternal factors. Secondly, we had a small sample size. Although the hospital based recruitment was not representative of the population level, the prevalence of LBW and PTB was consistent with previous findings. Also, the diagnostic ability of newborn anthropometry to correctly identify LBW and PTB found in our study was comparable to what has been observed in studies from India with birth weight ranges similar to ours.

The findings of this study should be confirmed in larger studies. Furthermore, there might be differences in the size of newborns with different ethnic and geographic origin.[29,30] It would therefore be beneficially if future studies on the diagnostic ability of foot length to identify LBW and PTB shall be conducted in populations with both similar as well as different maternal and newborn characteristics as compared to ours.

CONCLUSION:

In resource-limited settings where neonatal mortality remains disproportionately high, there are many missed opportunities to provide extra care to LBW or PTB newborns at home. This study has shown that the simple and inexpensive measurement of newborn foot length can be used to screen for the same with great potential for impact on newborn survival.

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