Original Research Article

Postnatal foot length of newborn: its correlation with gestational maturity

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ABSTRACT

Background: Neonatal death is one of the major contributors (50%) of Under-five child mortality and 70% of the infant mortality. The main causes of neonatal deaths are prematurity and low birth weight (LBW). This study was undertaken to assess newborn foot length and determine its usefulness in identifying LBW/Preterm Babies.
Methods: This is a cross sectional hospital based study of 173 newborn babies, done in KIMS Hospital, Bengaluru. All live newborn infants were included in the study. Newborn babies with lower limb congenital anomalies were excluded from the study.
Results: Out of 173 newborn, 99 babies were male (57%) and 74 were female (43%). 122 (70.5%) were term and 51(29.5%) were preterm. 48 (38%) were SGA, 120 (69%) were AGA and 5 (3%) were LGA. Their gestational age ranged from 28 to 40 weeks. In this study positive Correlation between foot length and gestational age was found with the "r" value of 0.823. The study also showed a positive correlation between foot length and weight with the "r" value of 0.831.
Conclusions: This study has a good correlation of Foot length with gestational maturity and birth weight. Foot length of 7.45cm can be used as a cut- off point for differentiating between term and preterm babies. Derived equation from this study can be used by ASHAs and Anganwadi workers for the estimation of gestational age in resource poor situations and refer the preterm newborns to higher centres for further management as early as possible to prevent long and short term complications of prematurity.

Keywords: Foot length, Gestational age, Low birth weight, Newborn

INTRODUCTION

Neonatal age is the most vulnerable period. Neonatal death is one of the major contributors (50%) of Under-five child mortality and 70% of the infant mortality. The majority of neonatal deaths (75%) occur during the first week of life and 25% to 45% occur within the first 24 h. The main causes for neonatal deaths are prematurity, low-birth-weight (LBW), infections, asphyxia and birth trauma, accounting for 80% of neonatal deaths.[1] Low birth weight includes both preterm and IUGR newborns and SGA is a better indicator of IUGR as GA is taken into account. About 60% of the LBW babies are born at term after fetal growth restriction as Small-for-Gestational-Age (SGA) babies, whereas the remaining 40% are born preterm.[2]

The burden of SGA births is very high in developing countries and is concentrated highly in south Asia. Nearly 30% of neonates-7.5 million are born with LBW (<2500 g) in India, this accounts for about 42% of the global burden. SGA is associated with an almost 2-fold increased risk of neonatal mortality and >20% of neonatal deaths might be attributed to SGA.[3] Identifying these LBW and preterm babies and referring them to higher centres for effective interventions will help in decreasing neonatal mortality and morbidity. Diagnosis of IUGR is difficult and requires a valid estimate of gestational age

(GA), repeated fetal weight measurements in order to observe change of fetal growth as well as Doppler flow measurement.[4] In developing countries most of deliveries are conducted at peripheral level, where taking accurate weight and assessment of gestational age is difficult because of nonavailability of weighing machines, infrequent access to antenatal care as well as limited access of ultrasonography and trained personnel.

Therefore, in resource poor settings where estimation of an accurate GA is often difficult, alternative methods of identifying SGA newborns are warranted. Some research studies have investigated newborn foot length (FL) as a screening tool for small babies.[5-8] FL is simple and easy to measure without much expertise with the help of a well calibrated ruler or tape. This measurement technique is not altered by subcutaneous fat. A ruler is small, does not take up space, can be taken to deliveries outside in remote areas, and can be adequately cleaned and sanitized. Foot is easily accessible even in premature babies, babies nursed in incubators, and babies receiving intensive care making it easier to measure FL. Therefore, newborn foot length is an easy, quick, and efficient measurement for preterm, critically ill newborns. This study was undertaken to assess newborn foot length and determine its usefulness in identifying LBW/Preterm Babies.

METHODS

The present study is a cross sectional hospital-based study of 173 newborn babies, done in KIMS Hospital and Research Centre, Bengaluru after taking Ethical clearance from the Institution. The duration of study was 1 year from April 2019 to April 2020. All live newborn infants were included in the study. Newborn babies with lower limb congenital anomalies were excluded from the study. After the inclusion of babies in the study, anthropometric parameters (weight and foot length) were recorded within 48 hours.

Gestational age assessment for all babies was done by same examiner using the New Modified Ballard score. Six neurological and six physical signs were used to assess gestational age by NEW BALLARD SCORE taken from Ballard JL et al.[9] By using Fenton's intrauterine growth curves, all babies were categorised into Small for gestational age (SGA), appropriate for gestational age (AGA), and large for gestational age (LGA) group.

Foot length measurement: The foot length of right foot was measured by using a stiff plastic transparent ruler to the nearest 0.05cm thrice by the same observer to avoid the inter-observer bias and the average was recorded. Right FL of each baby was measured from the heel to the tip of great or second toe whichever was the longer length by fixing the tip of heel to the zero mark of the ruler after straightening the foot and toes.

Birth weight: Babies were weighed naked on weighing machine nearest to 50gm within 48 hours of birth. Correlation of foot length with other anthropometric data like the birth weight of newborn and gestational age of preterm and term neonates was made.

Statistical analysis

The collected data was compiled using MS Excel 2007 and statistical analysis was done using SPSS software (version 15). Appropriate statistical methods like Pearson correlation analysis, regression analysis and scatter diagram were used.

RESULTS

A total of 173 newborns were included in this study. Out of 173 newborn, 99 babies were male (57%) and 74 were female (43%). Out of which 122 (70.5%) were term and 51 (29.5%) were preterm, 48 (38%) were SGA, 120 (69%) were AGA and 5 (3%) were LGA. Their gestational age ranged from 28 to 40 weeks (Table 1).

Table 1: Baseline characteristics of subjects.

	Number	Percentage
Male	99	57%
Female	74	43%
Term	122	70.5%
Preterm	51	29.5%
SGA	48	38%
AGA	120	69%
LGA	5	3%

Correlation between foot length and gestational age

On analysis of the correlation between foot length and gestational age, we found a positive correlation with 'r' value of 0.823 (p=0.001) (Table 2). Simple linear regression was performed to know the effect of gestational age and birth weight on foot length. The regression coefficient R^2 of gestational age was found to be 0.675 (95% CI of 3.611-4.451) p-value is <0.001 (Table 2).

Correlation between foot length and birth weight

Between foot length and birth weight on correlation analysis, we found a positive correlation with 'r' value of 0.831 (p=0.001). Simple linear regression performed to know the effect of birth weight on foot length showed regression coefficient R^2 to be 0.68 and p-value is <0.001 (Table 3).

Correlation of gestational age and foot length in term, preterm, SGA, AGA babies

In this study, on correlation of gestational age and foot length, showed positive correlation among preterm

(r=0.91, p=0.001), term (r=0.43, p=0.001), SGA (r=0.92, p=0.001), AGA (r=0.72, p=0.001) (Table - 4,5,6,7).

Table 2: Correlation between the gestational age and foot length.

	Mean	SD	Minimum	Maximum	Correlation coefficient	p-value
GA (weeks)	36.85	2.524	28	40	0.823	<0.001
Foot Length	7.42	0.5153	6	8.5		

Table 3: Correlation between the birth weight and foot length.

	Mean	SD	Minimum	Maximum	Correlation coefficient	p-value
Birth weight (kg)	2.64	0.66	0.96	4.30	0.831	<0.001
Foot length	7.42	0.5153	6	8.5		

Table 4: Correlation between foot length and GA in preterm babies.

Preterm		Mean	SD	Correlation coefficient	p-value
	GA (weeks)	33.76	2.38	0.91	<0.001
	Foot Length	6.923	0.498		

Table 5: Correlation between foot length and GA in term babies.

Term		Mean	SD	Correlation coefficient	p-value
	GA (weeks)	38.14	0.99	0.43	<0.001
	Foot length	7.63	0.35		

Table 6: Correlation between foot length and GA in SGA babies.

SGA		Mean	SD	Correlation coefficient	p-value
	GA (weeks)	35	2.73	0.924	<0.001
	Foot length	7.018	0.493		

Table 7: Correlation between foot length and GA in AGA babies.

AGA		Mean	SD	Correlation coefficient	p-value
	GA (weeks)	37.53	2.05	0.721	<0.001
	Foot length	7.538	0.40		

DISCUSSION

Early identification of gestational age within 48 hours of birth, especially in differentiating preterm from full term newborns born at home or in remote areas, in order to reduce global mortality from preterm birth is of at most importance.

This study was undertaken to devise a simple method of estimating gestational age so that Para medical workers like ASHAs and Anganwadi workers at remote places and resource poor settings could easily identify preterm babies and refer them to higher centres for further management.

In this study of 173 newborn babies, 57% (99) were male and 43% (74) were female. These values are similar to results in studies done by Rakkappan et al, (53.7% male, 46.3% female) and Amar et al, (51.4% males and 48.6% females).[7,8] Term babies were 70.5% (122) while preterm were 29.5% (51).

This is comparable to James et al, shown term (76.5%), preterm (39.6%).[10] Shahbu Saran et al, showed preterm (15.5%), term (76.4%) and Gohli et al, shown term (89.5%) and preterm (10.4%).[11,12] Above two studies shown preterm babies are lesser in number than the present study. These differences may be due to poor maternal nutrition, poverty and geographical factors.

Gestational age range from 28-40 weeks and a mean of 36.86 and the percentage of SGA, AGA and LGA babies was 28%, 79% and 3%, respectively. The birth weight of babies in the present study range from 0.96-4.3kg with a

mean of 2.64kg, and SD 0.66, comparable with Akukwu et al, Nigerian shown birth weight range from 0.85kg-4.5kg , Gowri et al, showed 0.7kg-3.8kg.[13,14]

The FL in our study showed a mean±SD of 7.42±0.52. We observed that mean±SD for FL of term babies (7.63±0.35 cm) was higher than mean±SD for FL in preterm babies (6.92±0.49 cm).

The study showed a positive correlation between GA and FL, with r value 0.823 (p= 0.001). These findings are in line with other study done previously by Srivastava A et al, Hadush MY et al, which showed r value of 0.87 and 0.85 respectively.[15,16]

The r 2 value is found to be 0.67 indicates 67% variation in the foot length explained by gestational age. The relationship between foot length and gestational age found by linear regression analysis in our study is:

FL= 1.230+0.168*GA

Where, FL=Foot length in cm and GA=Gestational age in weeks.

Srivastava A et al, proposed FL (mm)=2.4 × GA (weeks)-15.1.[17] Birth weight and foot length also showed positive correlation with r-value of 0.831 (p=0.001).

The regression coefficient R2 was found to be 0.688 with p value of 0.001. The estimated simple linear regression equation in the study is:

Foot length (cm)=5.709+0.648*Birth weight

Where, FL=Foot length in cm and BW=birth weight in kg.

Srivastava A et al, proposed Foot length (mm)=55.10+7.60 Birth Weight.[17]

Determination of cut off points for identifying preterm and term babies

Foot length of 7.45cm was identified from linear regression analysis as the cut-off point corresponding to a gestational age of 37 weeks. Previous studies done by Kim HJ et al, Srivastava A et al, found the 74.5 mm and 73.6 mm of foot length respectively corresponds to 37 weeks of GA, babies having foot length less than that value can be classified as preterm.[17,15]

Limitations of this study was that GA correlation was based on the New Ballard score, that has a high chance of error and need expertise and no comparison of foot length with the best estimate of GA (LMP confirmed by ultrasonography). Moreover, our study was done in a hospital-based setting, so the prevalence of preterm was higher than in a community setting.

CONCLUSION

The study has a good correlation of Foot length with gestational maturity and birthweight. Foot length of 7.45cm can be used as a cut- off point for differentiating between term and preterm babies. Derived equation from this study can be used by ASHAs and Anganwadi workers for the estimation of gestational age in resource poor situations like in rural areas and also in emergencies when they give home visit and refer the preterm newborns to higher centres for further management as early as possible to prevent long and short term complications of prematurity.

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