Original Research Article

A study of postnatal foot length to determine gestational maturity in neonates

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ABSTRACT

Background: Gestational age is a major determinant of newborn prognosis. Early identification of gestational age is a major priority to reduce global mortality from preterm birth. Therefore this study was conducted with an aim to find out an alternate simple, low cost and reliable method to identify accurate gestational ages.

Methods: The cross sectional study was carried out at Rukmani Chainani Maternity and Neonatal Unit, SSGH and Medical College, Baroda from December 2019 to May 2020. Total 500 live newborns of different gestational ages within 72 hrs of birth which were appropriate for gestational age were enrolled in this study. Foot length, head circumference, crown heel length and weight were measured. Gestational age was estimated by antenatal USG, Ballard scoring and LMP. Correlation of foot length to gestational age and other anthropometric variables was done.

Results: There was statistically significant positive correlation found between foot length and gestational age (correlation coefficient of 0.944 and p value of <0.0001). There was also positive correlation found between foot length and weight, head circumference and length with correlation coefficient of 0.942, 0.888 and 0.906, respectively. Using ROC curve, foot length cut-off value of 7.2 cm can be used for identifying preterm babies with sensitivity of 94.4% and specificity of 95.6%. Regression equation for gestational age calculation was GA=6.669+4.0601[FL].

Conclusions: This study had demonstrated that Foot length is a simple and reliable anthropometric measurement to assess gestational age and to screen prematurity.

Keywords: Gestational age, Foot length, Neonate, Preterm

INTRODUCTION

Globally 2.5 million children died in the first month of life in 2018. Neonatal deaths account for 47% of all child deaths under the age of 5 yrs. The world has made substantial progress in child survival. However, the decline in neonatal mortality from 1990 to 2018 has been slower than that of post neonatal under-5 mortality. The majority of all neonatal deaths (75%) occur during the first week of life and about 1 million newborns die within the first 24 hrs. Preterm birth, birth asphyxia, infections, low birth weight and birth defects cause most neonatal deaths.[1]

Gestational age is a major determinant of newborn prognosis. Newborns are categorized as preterm, full term and post term neonates. Early identification of gestational age within 48 hrs of birth, especially in differentiating preterm from full term newborns born at home or in remote areas, is a major priority for researchers and public health practitioners in order to reduce global mortality from preterm birth.

There are various methods for estimation of gestational age such as last menstrual period, antenatal ultrasound, neurological and physical characteristics of infant. But every method has disadvantages of its own. LMP dating is a simple and low-cost method, but assumes the

menstrual cycle to be 28 days and does not take into consideration any delay of ovulation and may cause an inaccuracy of 1-4 weeks.[2] Ultrasound based dating, if performed early in pregnancy (14- 22 weeks gestational age), is considered the gold standard.[3] But, values may be biased when symmetrically large or small fetuses are evaluated and it may not be possible for all infants in developing country. Neonatal estimates of gestational age, including the Ballard and Dubowitz scores, are standardized postnatal scoring systems based on a variety of physical and neurological maturity factors.[4] The New Ballard score gives a valid and reliable assessment of gestational age until at least day 7 of life.[5] However, they are time consuming and have been shown to be inaccurate, overestimating gestational age by 1.8 wks and underestimating by 1.2 weeks.[6]

Anthropometric measures such as birth weight, crown heel length and head circumference are commonly used measures of growth in neonates and they do correlate fairly with maturity. Foot is easily accessible even in premature babies, babies nursed in incubater and babies receiving intensive care, making it easier to measure foot length. Foot length is quite simple to measure where the only requirement is a well calibrated ruler or tape and does not require much expertise.

Therefore this study was conducted with an aim to find out an alternate simple, low cost and reliable predictor of birth weight to identify accurate gestational age that can be used by trained or untrained persons. This study is being done to find a correlation between foot length and gestational age.

METHODS

Unit (Intramural Unit), Department of Pediatrics, S.S.G. Hospital and Medical College, Baroda from December 2019 to May 2020 for a period of six months. Total 500 newborns were enrolled in this study.

Inclusion criteria

Live newborns of different gestational ages within 72 hrs of birth which were appropriate for gestational age according to intergrowth 21st growth standards. Preterm (31 to 36 wks 6 days) and Term (37 to 41 wks 6 days).

Exclusion criteria

Newborns aged more than 72 hrs. Babies having skeletal deformities of foot. Small for gestational age and large for gestational age babies according to 21st intergrowth standard. Babies having congenital anomalies. Newborns with birth weight <1kg and gestational age <30 wks and >42 wks.

Gestational age assessment was done using Antenatal USG, modified Ballard Scoring and LMP EDD. Antenatal USG if done in early second trimester was preferred over other two methods. Following anthropometric measurements were recorded: foot length, head circumference, crown heel length and weight by using Vernier Caliper, measuring tape, infantometer and electronic weighing scale respectively. In our study, appropriate for gestational age babies were included. It was decided by using Intergrowth 21st growth standards.[7] Foot length was measured from posterior most prominence of heel to the tip of the longest toe of the right foot. At the time of measuring foot length, ventral surface of the foot was straightened. The length of foot was documented in cm. The data was analyzed using Medcalc Software (version 19.2.3). Statistical analysis was made by using the methods like descriptive statistics, correlation and regression analysis and scatter diagram.

RESULTS

Gestational age wise distribution shared 50% preterm and 50% term neonates. Sex distribution was 53% males and 47% females with ratio of 1.12:1. Geographical distribution included rural, urban and tribal areas with distribution 43%, 45% and 12%, respectively. 78% Newborns belonged to Hindu Community and 22% belonged to Muslim Community. There were 10% VLBW, total 53% LBW and 47% normal birth weight newborns. There were 18% of newborns in 31-33 weeks age group, 32% of newborns in 34 to 36 weeks age group and 50% of newborns in ≥37 weeks age group. In the male population, 136 babies (51.3%) were low birth weight babies and 129 babies (48.7%) had birth weight >2.5 kg. In the female population, 130 babies (55.3%) were low birth weight babies and 105 babies (44.7%) had birth weight >2.5 kg.

There was statistically significant relationship between foot length and gestational age, weight, head circumference and length with 'r' value of 0.944, 0.942, 0.888 and 0.906, respectively. There was statistically significant positive correlation between foot length and gestational age with correlation coefficient ('r' value) of 0.849 for preterm neonates and 0.748 for term neonates. There was positive linear correlation in scatter diagram. Using ROC curve, foot length cut off value of 7.2 cm can be used for identifying preterm babies with sensitivity of 94.4% and specificity of 95.6%. Regression equation for gestational age calculation from foot length derived from this study was GA=6.669+4.0601[FL]. Thus, foot length can be calculated by this equation.

**Table 1: Mean anthropometric measurements of foot length, birth weight, head circumference and length.**

Gestational age (wks)	Study population (500)	Foot length (cm) Mean±SD	Birth weight (gm) Mean±SD	Head circumference (cm) Mean±SD	Length (cm) Mean±SD
31	23	6.07±0.19	1306.95±126.98	27.19±1.10	40.36±1.93
32	25	6.34±0.25	1448.12±154.68	28.39±1.33	41.86±1.35
33	41	6.62±0.22	1620.02±170.32	29.53±2.12	43.14±2.72
34	46	6.85±0.21	1905.76±168.40	30.35±0.97	44.38±1.55
35	54	6.98±0.16	2119.74±201.31	30.62±1.09	45.42±1.47
36	61	7.12±0.16	2309.08±156.49	31.52±1.00	46.27±1.64
37	52	7.47±0.20	2546.00±197.62	32.38±0.98	47.61±1.54
38	51	7.77±0.20	2875.39±175.16	33.27±0.94	48.80±1.33
39	58	7.99±0.23	3040.10±230.73	33.56±0.79	49.77±1.73
40	49	8.07±0.22	3137.83±226.59	33.97±0.84	50.17±1.42
41	40	8.23±0.20	3296.02±256.98	34.16±0.89	51.16±1.60

Table 2: Anthropometric variables of the study population.

Variables	N	Mean	95% CI	SD	Minimum	Maximum	P value
Gestational age (weeks)	500	36.48	36.23-36.73	2.84	31	41	<0.0001
Weight (gm)	500	2433.2	2377-2489	639	1110	3998	<0.0001
Head circumference (cm)	500	31.75	31.55-31.95	2.25	25	36	<0.0001
Length (cm)	500	46.83	46.53-47.03	3.45	38	55	<0.0001
Foot length (cm)	500	7.3	7.24-7.36	0.66	5.7	8.6	<0.0001

Table 3: Correlation of foot length with other anthropometric variables.

	Variables	GA	Weight	HC	Length
Foot length	Correlation coefficient	0.944	0.942	0.888	0.906
	Significance Level P	<0.0001	<0.0001	<0.0001	<0.0001
	N	500	500	500	500
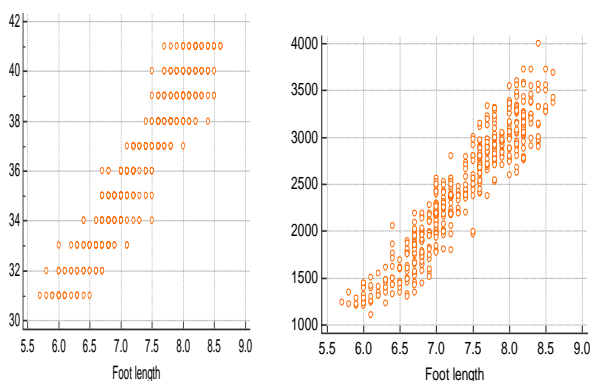
Figure 1: Scatter diagram showing positive linear correlation between foot length and other anthropometric variables.
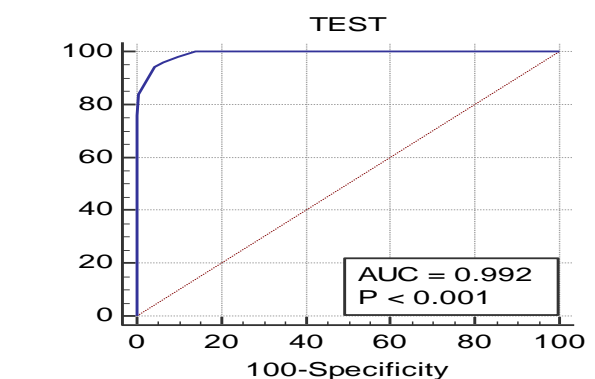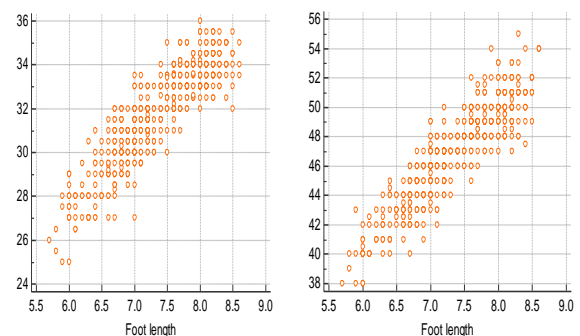
Figure 2: ROC curve for foot length for identifying preterm babies.

DISCUSSION

Table 1 shows mean values of anthropometric variables in each gestational age group. The foot length in present study ranged from 5.7 cm to 8.6 cm with mean of 7.3±2.84 cm. The gestational age in present study ranged from 31 weeks to 41 weeks with mean of 36±2.84 weeks. The birth weight in present study ranged from 1110 grams to 3998 grams with mean of 2433±639 grams. The head circumference in present study ranged from 25 cm to 36 cm with mean of 31.75±2.25 cm. The length in present study ranged from 38 cm to 55 cm with mean of 46.83±3.45 cm (Table 2). In the study of Srinivasa S. the mean values for gestational age, birth weight, head circumference, length and foot length were 37.95±2.30 weeks, 2.75±0.47 kg, 33.51±1.72 cm, 47.84±2.58 cm and 7.58±0.44 cm, respectively.[8] Mean foot length and length were comparable to our study.

The mean values of head circumference, length, foot length, birth weight and gestational age were 31.82±2.31 cm, 46.93±3.53 cm, 7.36±0.71 cm, 2455±663 grams and 36.5±2.95 weeks, respectively in Male category. The mean values of head circumference, length, foot length, birth weight and gestational age were 31.62±2.1 cm, 46.76±3.09 cm, 7.31±0.59 cm, 2407±612 grams and 36.45±2.71 weeks, respectively in Female category. Males had slightly higher anthropometric values compared to females which was not statistically significant as p value was >0.05. Anthropometric variables were also compared between males and females in study of Srinivasa S et al. Males had a slightly higher anthropometric values compared to females which was not statistically significant as p value >0.05.[8] This is comparable to our study.

The mean values of head circumference, length, foot length, birth weight and gestational age were 30.03±1.69 cm, 44.30±2.38 cm, 6.78±0.38 cm, 1902±381 grams and 34±1.60 weeks, respectively in preterm newborns. The mean values of head circumference, length, foot length, birth weight and gestational age were 33.43±1.08 cm, 49.4±1.85 cm, 7.89±0.33 cm, 2963±331 grams and 38±1.36 weeks, respectively in term newborns. Term newborns had higher anthropometric values compared to preterm newborns with p value of <0.0001. This difference was statistically significant. The mean values of anthropometric variables were compared between Preterm and Term in the study of Srinivasa S et al. The mean values for anthropometric variables were significantly higher in term babies compared to preterm babies with p value of <0.001.[8] This is comparable to our study.

We observed a significant positive correlation between foot length and other anthropometric variables namely gestational age, birth weight, head circumference and length with 'r' value of 0.944, 0.942, 0.888 and 0.906 respectively in whole study population (Table 3). There was positive linear correlation between foot length and other variables (Figure 1). Where as in study of Srinivasa, there was significant positive correlation between foot length and other anthropometric variables namely gestational age, birth weight, head circumference and length with 'r' value of 0.876, 0.9, 0.865 and 0.847, respectively.[8] Our study had highest correlation of foot length with gestational age. In the study of Rakkappan et al, there was significant positive correlation between foot length and other anthropometric variables namely gestational age, birth weight and head circumference with 'r' value of 0.807, 0.918 and 0.850 respectively which was lower than our study.[9]

There was statistically significant positive correlation between foot length and gestational age with correlation coefficient ('r' value) of 0.849 for preterm neonates and 0.748 for term neonates. There was positive linear correlation in scatter diagram. In the study of Deepa et al, correlation coefficient for foot length to gestational age was 0.810 for preterm AGA and 0.44 for term AGA which was lower than our study.[10]

Using ROC curve, foot length cut off value of 7.2 cm can be used for identifying preterm babies with sensitivity of 94.4% and specificity of 95.6% (Figure 2). This is comparable to the study of Srinivasa et al in which FL ≤7.4 cm had 98.81% sensitivity and 79.09% specificity for detecting preterm neonates.[8] In the study of Shrivastava A et al, foot length of 7.37cm was identified as a cut-off point for differentiating between term and preterm babies.[11] This is comparable to our study. In the study of Mutia Farah et al, foot length <7.05 cm had a sensitivity of 75% and specificity of 98.1% to detect preterm babies.[12]

Using ROC curve, foot length of ≤7.2 cm can be delineated for identifying preterm neonates and foot length of >7.2 cm can be delineated for identifying term neonates. Regression equation for gestational age calculation from foot length derived from this study was GA=6.669+4.0601[FL]. Thus, foot length can be calculated by this equation.

CONCLUSION

This study evaluated the measurement of foot length as an important anthropometric measure in neonates. The foot length correlated significantly with gestational age, weight, HC and length. The foot length had maximum correlation with gestational age (correlation coefficient 0.944). This study also demonstrated the capability of foot length to predict gestational age by regression equation and thereby identifying high risk babies with prematurity. To conclude, this study had demonstrated that Foot length is a simple, quick and reliable anthropometric measurement to assess gestational age.

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