Original Research Article

Gestational age assessment of neonates using foot and hand length measurements: a cross sectional tertiary care centre study

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ABSTRACT

Background: Gestational age of neonates computed based on Naegele's formula, ultrasound, or using modified New Ballard score (NBS) is limited in the community setup due to illiteracy, accessibility and expertise. Hence there should be alternative technique which can be done even by inexperienced health care staff and in rural communities. Objective of current study was to find out the correlation of foot and hand length with gestational age among neonates.
Methods: A cross sectional study including 200 neonates and their foot length, hand length, birth weight was recorded. Gestational age assessment was done using modified NBS. Correlation among various study parameters was done using Pearson's correlation coefficient.
Results: Of the 200 neonates studied, the mean foot length was 7.1±0.46 cm with a range of 4-8.5 cm. The mean hand length was 6.0±0.71 cm with a range of 3.8-7.4 cm. The mean foot and hand length of term neonates was higher than preterm neonates. The mean foot and hand length of normal weight neonates was higher than Low birth weight neonates.
Conclusions: Foot and hand length is a simple, quick and reliable measurement which can be used as a proxy measurement to gestational age assessment. It can be easily measured by traditional birth attendants in the community.

Keywords: Gestational age, Foot length, Hand length, Birth weight

INTRODUCTION

Gestational age (GA) is a useful parameter for assessing the maturity of the new born and for prediction of mortality and morbidity. Conventionally, gestational age of neonates is computed based on Naegele's formula or by ultrasonic evaluation during pregnancy or using modified new Ballard scoring (NBS) after birth.[1] Gestational age based on Naegele's formula has lower accuracy in settings with low literacy and are likely to be affected by variation in ovulation.[2] The "gold standard" for GA assessment is ultrasound ideally in the first trimester. Ultrasound requires radiologist, equipment and for maximum accuracy, first-trimester antenatal clinic attendance. Ultrasound as a tool to assess gestational age, is a limiting factor, particularly in developing countries like India where women undergoing the recommended number of at least 4 antenatal visits is low and availability of USG with an expert radiologists is limited in remote villages/community.[3] Assessment of gestational age of neonates using modified new Ballard score (NBS) may not be reliable as its accuracy depends on the skill of examiner and the condition of the neonate.[4] It cannot be used in asphyxiated neonates and babies with depressed neurological state. Thus, there is need to develop a simple, inexpensive and practical method to identify

these highly vulnerable preterm and low birth weight neonates soon after birth. This alternative technique should be simple, reliable, have a good correlation with both birth weight and gestational age. The technique used for measuring such a parameter should be simple enough to be conducted even by allied health care staff and even by traditional birth attendants/ASHA workers.[5] In this study we attempted to validate the use of foot and hand length measurement as an alternative technique for predicting gestational age.

METHODS

Study type, duration and population

This was a cross sectional study conducted in a tertiary care centre Topiwala national medical college and BYL Nair Hospital, Mumbai. The study was conducted over a period of one year between January 2018 to December 2018. Total 200 neonates born in the hospital were included.

Inclusion criteria and exclusion

All neonates born in the hospital during the study period were included in the study. Neonates having skeletal deformities of the foot or hand, foot or hand edema, hypotonia (severe birth asphyxia, with depressed neurological state) were excluded from the study.

Procedure

Detailed examination of the each enrolled new born was done within 6-8 hours of birth. Gestational age, foot length, hand length, birth weight, was recorded. Gestational age assessment was done using modified new Ballard's score (NBS). Foot length of right foot was measured by a steel ruler attached to the foot end of the infantometer. The measurement was taken in centimetres by fixing the tip of heel to the zero mark of the ruler and after straightening the foot and toes. The other end being the tip of great toe. Hand length of right hand was measured from the distal crease to the tip of middle finger using non-stretchable measuring tape and documented in centimetre. Weight of the baby was taken using electronic weighing scale. The scale offered an accuracy of ±5gms.

Statistical analysis

Quantitative data was expressed as mean±SD and categorical data in percentages and ratios. Correlation among various study parameters was done with the help of Pearson's correlation coefficient. The relationship between the anthropometric indicators and the gestational age was derived using linear and non-linear regression. Data was analysed using SPSS 22 software.

Definition

Gestational assessment was done using modified new Ballard's Score and categorised as Preterm and term.[2] Preterm birth is defined as all births before 37 completed weeks of gestation and term birth is defined as all births after 37 completed weeks of gestation. Normal weight of neonates was taken as 2500 grams or more. Very low birth weight (VLBW) is neonates less than 1500 gm and we considered a group of intermediate low birth weights (ILBW) between 1500-2500 gm.

RESULTS

Descriptive characteristics of the study population

Two hundred (200) neonates were enrolled in this study, of which 105 (52.5%) of them were males and 95 (47.5%) were females. The gestational age of neonates was in the range of 27-40 weeks with a mean of 36.0±2.8 weeks (95% CI 36.48-37.41). The birth weight of the study subjects ranged from 1020 gm to 4200 gm, with a mean birth weight of 2244±745 gm. Total of 101 (50.5%) of neonates were term, 99 (49.5%) of neonates were preterm. A total of 121 neonates (60.5%) were LBW whereas, 79 (39.5%) were normal weight. The mean foot length of VLBW, ILBW and normal neonates were 5.75, 6.77 and 7.43 cm, respectively. The mean hand length of VLBW, ILBW and normal neonates were 5.13, 5.96, and 6.64 cm, respectively. VLBW neonates had a lower mean foot and hand length than other weight groups.

Table 1: Demographic details and mean differences of foot length among study subjects.

Variables		Number	Percent	Foot length			
				Min	Max	Mean (SD)	P value
Sex	Male	105	52.5	4.5	8.5	7.00 (0.75)	0.012
	Female	95	47.5	4	8.2	6.69 (0.73)	
Maturity	Preterm	99	49.5	4	7.5	6.32 (0.65)	<0.001
	Term	101	50.5	6	8.5	7.30 (0.47)	
Birth weight	VLBW	44	22	4	6.5	5.75 (0.55)	<0.001
	Intermediate LBW	77	38.5	6	7.9	6.70 (0.36)	
	Normal	79	39.5	6.5	8.5	7.43 (0.38)	

Foot and hand length measurement

Of the 200 neonates studied, the mean foot length overall for all neonates was 7.1±0.46 cm (95% CI 7.02-7.22 cm) with a range of 4-8.5 cm. The preterm neonates had a mean foot length of 6.32±0.65 cm with range of 4- 7.5cm and term neonates had a mean foot length of 7.30±0.47cm with range 6-8.5cm (Table 1). The mean hand length overall for all neonates was 6.0±0.71 cm (95% CI 5.95-6.15 cm) with a range of 3.8-7.4 cm. The preterm neonates had a mean hand length of 5.55±0.53cm with a range of 3.8-6.6cm and the term neonates had a mean hand length of 6.56±0.48cm with a range of 5-7.4cm (Table 2).

Table 2: Demographic details and mean differences hand length among study subjects.

| Variables | | Number | Percent | Foot length | | | P value |
				Min	Max	Mean (SD)	
Sex	Male	105	52.5	3.80	7.30	5.92 (0.70)	0.011
	Female	95	47.5	3.90	7.40	6.17 (0.71)	
Maturity	Preterm	99	49.5	3.80	6.60	5.55 (0.53)	<0.001
	Term	101	50.5	5.00	7.40	6.56 (0.48)	
Birth weight	VLBW	44	22	3.80	6.50	5.13 (0.45)	<0.001
	Intermediate LBW	77	38.5	5.00	7.00	5.96 (0.42)	
	Normal	79	39.5	5.00	7.40	6.64 (0.43)	

Non parametric analysis indicated that there was statistically significant difference (p<0.001) in mean foot and hand length between preterm and term neonates and between weight groups in neonates. The mean foot and hand length of terms was higher than preterm neonates. The mean foot and hand length of normal weight neonates was higher than both intermediate LBW (1500-2500 gm) and VLBW groups.

A statistically significant strong positive correlation was observed between gestational age and foot length (r=0.749 and p<0.001) and it was significant between gestational age and hand length (r=0.662 and p<0.01). Using linear regression analysis Gestational age (GA) in weeks can be estimated using the formula:

GA=13.452 + 3.315 X Foot length (Figure 1).

GA=16.088 + 3.296 X Hand length (Figure 2).

Receiver operating characteristic (ROC) curve analysis for cut-off point determination

The corresponding ROC curve for foot and hand length as a surrogate marker for prematurity less than 37 weeks is shown in (Figure 3). ROC analysis to test the accuracy of foot and hand length measurement to predict preterm neonates showed that it had a high area under the curve (AUC) 0.908 (95% CI 0.869-0.948) and 0.921 (95% CI 0.882-0.960) for foot and hand length respectively. Foot and hand length had a strong classification power to differentiate preterms from term babies. It was highly accurate and had a statistically significant power to differentiate preterms from term neonates (p<0.001). The optimal cut off point for foot length was 7.1 cm with sensitivity and specificity of 86.14% and 81.82%, respectively. The optimal cut off point for hand length was 6.15 cm with sensitivity and specificity of 88.12% and 81.80%, respectively.

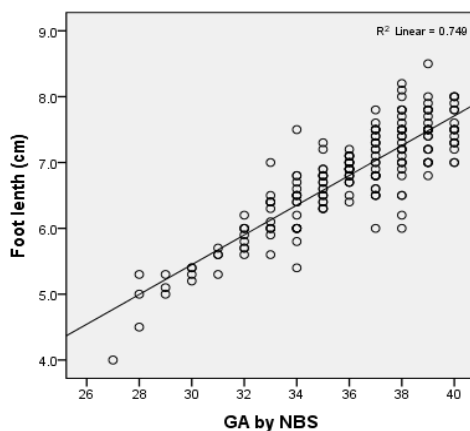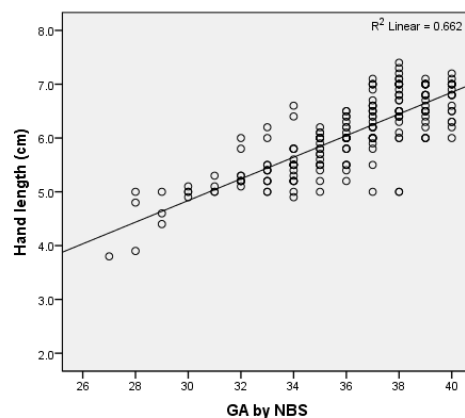**Figure 1: Scatterplot with regression line showing liner association of gestational age (GA) versus foot length (FL) of neonates.**

Figure 2: Scatterplot with regression line showing liner association of gestational age versus hand length of neonates.
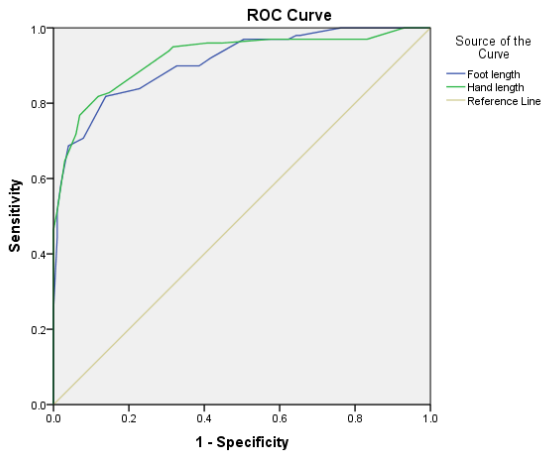
Figure 3: ROC curve for foot and hand length measurements for neonates.

DISCUSSION

The early identification of preterm and low birth weight neonates is important to reduce mortality and morbidity. Out of 200 neonates, almost had equal number of term and preterm. 99 (49.5%) were preterm and 101 (50.5%) were term neonates. And these observations were comparable with Sateesha et al which had 40.7% preterm and 59.3% term neonates.[6] James et al study showed 76.4% term and 39.6% preterm neonates.[7]

The preterm neonates had a mean foot length of 6.32±0.65 cm with range of 4-7.5cm. The term neonates had a mean foot length of 7.30±0.47cm with range 6-8.5cm. This shows that foot length increases as the gestational age increases. These findings are comparable to Kulkarni et al study which showed mean foot length of preterm neonates ranged from 4.6 cm to 6.89 cm and the mean foot length of term neonates ranged from 6.99 cm to 7.58 cm and also comparable with Gohil et al study.[9] Sharan et al study showed the mean foot length in preterm neonates as 7.18±0.57 cm and term neonates as 8.0±0.28 cm which are slightly higher than our study.[10] Foot length of 7.1 cm was used as cut off point for identifying preterms with sensitivity and specificity of 86.14% and 81.82%, respectively. A study performed by Fawziah et al showed that the optimal cut off foot length for full-term categorization was 7.1 cm with a sensitivity of 75% and specificity of 98.1% which is comparable with present study.[11] A study conducted in Thi et al, Srinivasa et al, Dagnew et al found that a foot length 7.3 cm, 7.4 cm, 7.4 respectively as cut off in identifying preterms.[12-14] The mean hand length was 6.0±0.71 cm (95% CI 5.95-6.15 cm) with a range of 3.8-7.4 cm. This study had higher value comparable to Sateesha et al with mean hand length of study group was 5.41±0.67 cm and was also comparable with Nehete et al.[6,15] Few studies are there to compare the hand length. Regression analysis was comparable to study done by Kumar et al study and Thawani et al study.[16,17]

Limitations

Limitations of current study were smaller sample size, it was a hospital-based study, needs to be validated in community setting. In current study instead of vernier calipers for the measurement of foot and hand, we have used steel ruler and measuring tape, as the vernier calipers are not easily available in the rural setting.

CONCLUSION

Foot and hand length is a simple, quick and reliable anthropometric measurement which can be used as a proxy measurement for gestational age assessment. It can be easily measured by medical practitioners and traditional birth attendants in the community. Therefore, foot length and hand length can be implemented as surrogate markers for gestational age in the community at large scale were facility for assessing gestational age by experts is not available.

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