Newborn mid-upper arm circumference as valid proxy measure of gestational age

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Received - 06 January 2020 Initial Review - 13 January 2020 Accepted - 30 January 2020

ABSTRACT

Background: Prematurity is a significant contributor to neonatal mortality in India. Conventionally, gestational age (GA) of newborn is estimated using Naegele's formula and New Ballard scoring (NBS), a physical and neurological maturity scoring method of newborn. **Objective:** The current study was aimed to find out an estimation of GA using neonatal mid-upper arm circumference (MUAC). **Materials and Methods:** This hospital-based prospective observational study was conducted in the sick newborn care unit and postnatal ward of a tertiary hospital of Central India. A total of 1303 newborns were included in the study. The MUAC was taken and the GA assessed by NBS and Naegele's formula was filled in a pro forma. **Results:** A total of 1303 neonates were evaluated. The mean MUAC varied from 6.20±0.5 cm among the preterm newborns to 10.27±0.5 cm among newborns born after the 40th week of gestation. The mean MUAC was 8.04±0.6 cm irrespective of GA. MUAC was found to be significantly correlated with GA (r=0.903, p<0.01). **Conclusion:** MUAC in newborns can be used as surrogate of GA and can be used for its estimation.

Key words: *Gestational age, Mid-upper arm circumference, Newborns, Sick newborn care unit*

Globally, neonatal mortality has declined from 28% in 1990 to 23% in 2010 which is an average of 1.7% a year, much slower than for under-five mortality (2.2% per year). Out of the 3.072 million neonatal deaths reported worldwide by the World Health Organization in 2010, nearly one-third occurred in India [1]. The neonatal mortality rate (NMR) declined from 49 deaths per 1000 live births in the 5 years before the 1992-93 NFHS survey to 30 deaths per 1000 live births in the 5 years before the 2015-16 NFHS survey. During the same period, the under-five mortality rate declined from 109 deaths per 1000 live births to 50 deaths per 1000 live births. The NMR decreased by 48% over 23 years. Madhya Pradesh contributes to the second highest NMR in India (36.9 per 1000 live births) [2].

Preterm birth rates are increasing in almost all countries with reliable data. Prematurity is the leading cause of newborn deaths and now the second leading cause of death after pneumonia in children under the age of 5 years. An estimated 1 million babies die globally every year because of prematurity, of which about 375,000 neonatal deaths occur due to prematurity and low birth weight contributed by India alone [3]. There are studies done in the past using neonatal mid-upper arm circumference (MUAC) for the assessment of gestational age (GA) in newborns. In remote areas of India, where pediatricians and obstetricians are not available, the neonatal morbidity and mortality are high. The majority of pregnant Indian women have no contact with institutional maternal care and ultrasonic examination. They are mostly dependent on Dai and Anganwadi workers for their deliveries.

Therefore, this study was planned to find an alternative, simple, inexpensive, and reliable method of assessment of the GA for the early detection and referral of vulnerable newborns to prevent mortality and morbidity.

MATERIALS AND METHODS

This prospective observational hospital-based study was carried out during 2017-2018 in intramural newborns admitted in sick newborn care unit and postnatal wards of a tertiary hospital of Central India. Approval for research protocol was obtained from the Institutional Ethical Committee and written consent was obtained from mothers. We assessed singleton neonates following sequential deliveries. A total of 1303 newborns were included in the study. GA of the newborns was calculated using Naegele's formula [4] and by New Ballard scoring (NBS) [5]. NBS is the gold standard of our study.

MUAC assessment was performed for each of the newborns between 24 and 48 h after birth. MUAC was measured at the midpoint between the tip of the acromion and the olecranon process of the left upper arm using MUAC tape. Correlation between MUAC and GA was analyzed by the Pearson correlation coefficient (r) and regression analysis. To avoid interobserver bias, anthropometric measurement and assessment of GA were carried out by a single investigator. Measurements were done 3 times and mean was used in the analysis.

Newborns with congenital malformation, severe asphyxia, critically sick, and without parental consent were excluded from the study. Neonates born to mothers who were not aware of their last menstrual period (LMP) or with irregular menstrual cycle or on oral contraceptives were also excluded from the study. Analysis was done with SPSS version 20.0 software. Chi-square or Fischer's exact test as applicable was used and mean was compared using one-way ANOVA. A 95% confidence level with $p<0.05$ was considered to be statistically significant.

RESULTS

We evaluated 1303 neonates between 28 weeks and 42 weeks of GA, with 51.6% being preterm and 48.1% being term. The mean MUAC varied from 6.20±0.5 cm among the preterm newborns to 10.27±0.5 cm among newborns born after the 40^{th} week of gestation. The highest percentage of newborns was found to be between 38 and 40 weeks having a mean value of MUAC 9.38±0.6 cm. The difference was found to be statistically significant with F statistics 986.005 and $p<0.01$. The mean birth weight and MUAC were significantly less in preterm neonates than in the full-term newborns, as shown in Table 1.

The mean value, standard deviation, and different centile of MUAC were evaluated with GA (Table 2). The maturity of the newborn could be identified using different centiles of MUAC and the high-risk newborns were assessed. Pearson's r was found to be 0.903 ($p<0.01$), which suggested a good strength of correlation between MUAC and GA. A linear regression analysis was done and the regression equation was derived to predict the GA of newborn by the formula: GA (weeks)=2.362 (MUAC)+15.295 ($r^2=0.8217$). To determine the optimal cutoff along with sensitivity and specificity, receiver operating characteristic curve analysis of MUAC and GA was done (Fig. 1).

DISCUSSION

Conventionally, GA of newborn is calculated by the recall of LMP using Naegele's formula, ultrasound scan, and postnatally using NBS [6]. Inability of the patients to recall the date of LMP, due to the low level of literacy or conception during lactation, hinders the estimation of GA [7]. Ultrasound, as a tool to assess GA, is a limiting factor, particularly in developing countries like India, where only 51% of women undergo the recommended number of at least four antenatal visits. Around 17% of women have no antenatal visit and only 61% of pregnant women undergo ultrasonic evaluation during pregnancy [2].

The principal method used to estimate GA is the NBS, which combines physical and neurologic criteria. The Dubowitz scoring system used earlier incorporated 21 physical and neurologic assessments [8]. The Ballard system shortened the Dubowitz method to depend on six physical and six neurologic criteria. The examination is most reliable when it is

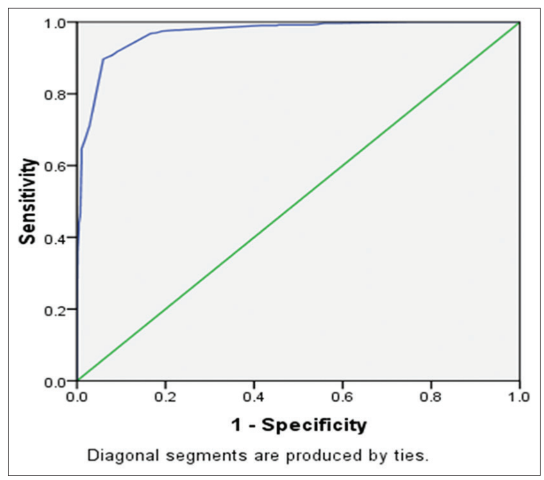

Figure 1: Receiver operating characteristic curve. Mid-upper arm circumference: Area under curve: 0.969, cutoff: 8.3, sensitivity: 97.5%, specificity: 80.8%

Table 1: Gestational age and anthropometric parameter of newborns

Gestational age	Number (%) of newborns	Birth weight (Mean±SD)	Mid-upper arm circumference (Mean±SD)
<37 weeks	673 (51.6)	1854.80±387.3 g	7.47±0.9 cm
37–42 weeks	628 (48.1)	2818.95±328.1 g	9.58±0.7 cm
>42 weeks	2 (0.3)	2750.00±70.7 g	9.50±0.0 cm
F statistics, p value		1.17, <0.01	1.09, <0.01

SD: Standard deviation

Table 2: Mean values, standard deviation, and their centile for mid-upper arm circumference with gestational age

GA	No. of cases	Mean±SD	Mean+2 SD	Mean−2 SD	5^{th}	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	95^{th}
28	32	6.197±0.474	7.145	5.249	5.5	5.5	5.8	6.2	6.5	7.0	7.0
30	182	6.642±0.505	7.652	5.632	5.8	6.0	6.2	6.6	7.0	7.2	7.5
32	161	7.306±0.583	8.472	6.140	6.2	6.5	7.0	7.3	7.8	8.0	8.2
34	180	8.038±0.540	9.118	6.958	7.0	7.0	8.0	8.0	8.4	8.7	8.9
36	118	8.448±0.617	9.682	7.214	7.5	7.9	8.0	8.5	9.0	9.2	9.5
38	486	9.383±0.592	10.567	8.199	8.5	8.6	9.0	9.5	9.8	10.0	10.3
40	144	10.274±0.527	11.328	9.220	9.4	9.5	10.0	10.3	10.6	11.0	11.0

GA: Gestational age, SD: Standard deviation

performed between 30 and 42 h of age. The Ballard system was modified as the NBS to improve the assessment of infants as premature as 20 weeks [5]. Problems with the implementation and accuracy of neurological methods have been reported. They are more difficult, especially for non-pediatricians to perform, and interobserver reliability is poor. Assessment of GA of newborns using NBS may not be reliable as its accuracy depends on the skill of examiner and the condition of the neonate. It cannot be used in asphyxiated neonates. In addition, it is a complex score, which requires the skills of a pediatric specialist [6].

In the present study, it was observed that mean MUAC of a preterm newborn was found to be 7.47±0.9 cm as compared to 9.58±0.7 cm in full-term newborn. Similar findings were observed by Das, in 2012 [9]. However, Kumar *et al*. observed a higher mean value of MUAC both in preterm (8.69) and full term (9.62). Kabir *et al*. found the mean MUAC in preterm as 8.97 in females and 9.02 in males and in a term neonate (female 9.41 and male 9.45) [10]. In the present study, MUAC showed a linear correlation with GA (Pearson's r=0.903, p<0.01). This was in accordance with the findings observed by Kumar *et al*. [11].

MUAC has been found to have a significant correlation with GA in neonates in the previous studies also [12-15]. Sasanow *et al*. found a significant (p<0.001) linear correlation between MUAC (r=0.93) with the estimated GA between 25 and 42 weeks. Excler *et al*. also found a significant (p<0.001) linear correlation between MUAC and GA in appropriate for GA (r=0.850) as well as small for GA (r=0.76) neonates. The strength of the study is a large sample size. The major limitation of this study is that being a hospital-based study, results obtained might not be representative of the whole population.

CONCLUSION

We found that MUAC was significantly associated with the GA of newborn; therefore, it can be used as its surrogate. Assessment of MUAC should be an integral part of examination, as it is an inexpensive, non-invasive method and does not need expertise and can be used as an alternative to NBS in a low resource setting.

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Funding: None; Conflicts of Interest: None Stated.

How to cite this article: Agrawal A, Gaur A, Ambey R. Newborn mid-upper arm circumference as valid proxy marker of gestational age. Indian J Child Health. 2020; 7(2):54-56.

Doi: 10.32677/IJCH.2020.v07.i02.003