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CORRELATION OF FOOT AND HAND LENGTH MEASUREMENTS WITH GESTATIONAL AGE IN NEONATES

Community Medicine

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ABSTRACT

INTRODUCTION: Neonatal mortality is still high in India. Gestational age helps identify high risk preterm babies and is crucial while performing neonatal autopsy.

OBJECTIVES: To find correlation between foot and hand length measurements with gestational age in neonates and to derive formulae to show the same.

METHOD: Gestational age of 100 live neonates was found using the New Ballard Score and length of hands and feet on both the sides were measured.

RESULTS: Correlation coefficients for hand and foot lengths were 0.974 and 0.981 respectively. P value in both cases was <0.05.

CONCLUSIONS: This simple, economic and non-invasive method can be carried out by basic medical doctors, paramedics or even the ASHAs, Anganwadi workers or the midwives in rural areas to identify the high risk preterm neonates. This method can also be used by forensic pathologists for age determination in cases of fragmented body parts, macrocephaly and short limb dwarfism.

KEYWORDS

gestational age, foot length , hand length, neonates

Introduction

The number of neonatal deaths is high all over the world. The neonatal period—the first 28 days of life—carries the highest risk of mortality per day than any other period during the childhood.[1]

Nearly, 0.75 million neonates died in India in 2013, the highest for any country in the world.[2] Given the infant and under-five child mortality rates of 40 and 49 per 1000 live births, respectively, 70% of total infant deaths and more than half of under-five deaths fall in the neonatal period. Indeed, with the early NMR of 22 per 1000 live births, deaths in the first week alone account for ~ 45% of total under-five deaths.[3]

A systematic analysis of global, regional and national causes of child mortality in 2013 identified preterm birth complications and infections to be the two major causes of neonatal deaths in India.[4] The review, which included the data from the Million Death Study from India,[5] found perinatal asphyxia and malformations to be the other two significant causes of neonatal mortality.

However, incidents of sex determination, sex selective abortion and feticide methods prenatally and neonaticide and infanticide methods, neglect and abandonment of child postnatally, are not unheard of.[6] A majority of such neonates are females due to preference of birth of male child.[7] In India, despite the introduction of PNDT Act, efforts to increase awareness, literacy rates as well as access to health care, neonatal mortality still remains high.

Gestational age is necessary to identify the high risk preterm babies. Conventionally, gestational age is calculated by Naegele's formula or antenatal ultrasonography (USG) or by using New Ballard Score (NBS) in neonates.[8] In the rural areas, identifying preterm newborns is a challenge. Rural areas with low literacy levels, application of Naegele's rule and non-availability of antenatal USG and other equipment and trained personnel are the limiting factors. According to Naegele's rule, nine months and seven days are added to the first day of the last menstrual period. This rule requires the correct menstrual period dates, is influenced by changes in ovulation and the use of oral contraceptives. Ultrasound to assess gestational age, is a limiting factor, particularly in developing countries, like India where a majority of women do not go for the recommended number of antenatal visits, do not undergo ultrasonography and many home deliveries still take place in the rural areas. Also, ultrasound estimation of gestational age in the first trimester is more accurate than later in pregnancy.[9] New Ballard Score helps determine the gestational age by assessing 6 criteria for physical maturity and 6 criteria for neuromuscular maturity.

Application of NBS requires handling of newborns, is time consuming and requires the expertise of a pediatrician who may not be available in remote areas.

Establishing the age is crucial for a forensic pathologist while performing neonatal or fetal autopsy. In forensic medicine, anthropometric parameters like birthweight, crown heel length, head-circumference, foot length, hand length, intermammary distance, umbilical nipple distance, etc. have been used to predict the age of neonates.[10] Age of fetus can also be determined from physical and morphological features and ossification centers. These parameters cannot always be used like in cases of animal attacks, macrocephaly or short limb dwarfism.

As measuring foot and hand length to determine the age of newborns is a simpler, less time-consuming method which requires less handling of newborns, we decided to correlate these measurements with gestational age.

Methodology

This was a cross sectional study on 100 live neonates over a period of 4 months, at a tertiary care hospital, after the approval of the Institutional Ethics Committee. Prior to taking the measurements, the mother's consent was obtained as well.

Live neonates for whom the consent was given by mothers and NBS was calculated were included. Still births, neonates with hand and foot oedema, congenital deformities like congenital talipes equino varus, etc. and other congenital anomalies were excluded and those for whom NBS wasn't calculated were excluded.[8]

Figure 1. Measurement of hand length using a Vernier caliper

Figure 2. Measurement of foot length using a Vernier caliper

The gestational age estimation was done using the NBS. The lengths of both the right and left foot was measured using Vernier caliper, parallel to the long axis of foot from the posterior most prominence of foot to the tip of the longest toe, which may be the big toe or second toe.[8, 11] The length of both the right and left hand WAS measured using Vernier caliper with the wrist extended and measurement done from the distal crease of the hand and tip of the middle finger.[12] All the measurements were taken within 48 hours after birth. To reduce error due to movement the lengths were measured after breastfeeding when the neonates were asleep and if at all there were movements three readings were taken and their mean was obtained. These values were noted along with the sex and age determined for each neonate.

Statistical analysis was done using the software on the computer called Statistical Package for Social Service.

The same software would be used to derive a linear regression equation of the form -
Gestational Age (GA) = (Regression Coefficient) x Foot Length + Constant

Gestational Age (GA) = (Regression Coefficient) x Hand Length + Constant

Results

This study was done on 100 live neonates of gestational ages ranging from 29 to 37 weeks. 47 females and 53 males were included.

Table 1. Mean hand and foot lengths corresponding to neonates varying from ages 29 to 37 weeks.

| Gestational Age In weeks	No. of babies N = 100	Mean Hand length in c.m. ± S.D.	Mean Foot Length in c.m. ± S.D.
29	4	4.800 ± 0.50	5.400 ± 0.17
30	9	5.250 ± 0.21	5.500 ± 0.24
31	4	5.000 ± 0.11	6.050 ± 0.29
32	8	5.100 ± 0.15	6.080 ± 0.13
33	18	5.257 ± 0.16	6.375 ± 0.25
34	20	5.470 ± 0.25	6.623 ± 0.24
35	26	5.595 ± 0.12	6.75 ± 0.32
36	8	5.617 ± 0.27	6.816 ± 0.35
37	3	6.100 ± 0.28	7.400 ± 0.07

With the p value greater than 0.05 no significant statistical difference was seen between the observations for males and females, and between the lengths for both right and left side.

In both the cases of hand and foot lengths, the Pearson correlations were 0.97 and 0.98, showing a positive correlation and the p value was less than 0.05 thus statistically significant.

R square values showed that the foot length accounts for 96.3% of variation and hand length accounts for 94.8% of variation in gestational age.

The standard error of estimate is low in both the cases being 0.564 in case of foot length and 0.669 in case of hand length.

Graph 1. Graph showing linear association with gestational age and foot length

GA = 4.159 x Foot Length + 6.663
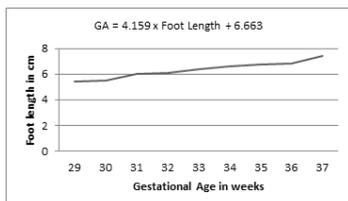
Graph 2. Graph showing the linear association between gestational age and hand length

GA= 6.383 x Hand Length − 0.928
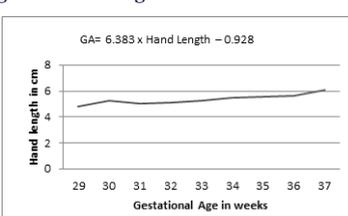
The linear regression equations derived from this study are:
Gestational Age (GA) = 4.159 x Foot Length + 6.663
Gestational Age (GA) = 6.383 x Hand Length – 0.928

Discussions

The findings in the present study are concordant with the results of other workers.[10,11,13,14] Not as many studies have been done using hand length as a parameter, as have been done using the foot length.

Table 2. Comparison of present study results with previous studies

	Foot length	
Study	R* value	Equation (GA[†] = Regression Coefficient x Foot Length + Constant)
Present study	0.98	GA = 4.159 x Foot Length + 6.663
Goldstein's study	0.90	GA = 3.87 × Foot length + 8.29
Kumar and Kumar's study	0.97	GA = 3.48 × Foot length + 8.86
Thawani et al's study	0.76	GA = 1.20 × Foot Length + 27.45
B. Manjunatha et al's study	0.98	GA = 5.60 × Foot Length + 4.11

	Hand length	
Study	R* value	Equation (GA[†] = Regression Coefficient x Hand Length + Constant)
Present study	0.97	GA= 6.383 x Hand Length – 0.928
Goldstein's study	-	-
Kumar and Kumar's study	0.97	GA = 4.88 × Hand Length + 8.05
Thawani et al's study	0.76	GA=1.28×Hand Length + 28.76
B. Manjunatha et al's study	-	-

* : correlation coefficient †:gestational age

Variations seen could be due to differences in methodology. Goldstein used sonographic measurement of fetal foot length of fetuses between 10 and 36 weeks.[13] In Thawani et al's study, neonates were categorized as 'small', 'large', and 'appropriate' for gestational age, using Lubchenco's reference charts.[10] In B. Manjunatha et al's study, foot lengths of both live and dead fetuses were included.[11] Also, personal errors in measurement, movement of babies, nutritional, socioeconomic, genetics, maternal and environmental factors are contributory to the variations.

The limitation of this study was that it was a pilot study at an institutional level and included a small sample size of 100. Above mentioned factors responsible for variation, like personal errors in measurement, movement of babies, nutritional, socioeconomic, genetics, maternal and environmental factors are contributory. Moreover, this test would not help distinguish between small-for- age and appropriate-for-age newborns. Another limitation of this study would be the factors affecting NBS irrespective of the skills of the pediatrician. The parameters included while measuring NBS could be affected due to the intrauterine fetal distress or if the examination was carried out the tests too soon without giving ample rest period to the muscles of the neonate.

Similar studies including both live and dead cases must be carried out on a larger scale in India at the community level using standard measuring techniques as providing a ready mathematical formula to assess gestational age seems to be a viable option. Furthermore, these equations can also help us draw charts which would do away with the time spent for calculations. Given the demerits of each USG, Naegele's Formula and the New Ballard Score, using accurate techniques or at least two parameters for estimation of age instead of just one parameter is advisable. The newborns could be categorized into groups: small-for gestational age, appropriate-for-gestational age and large-for-gestational age: to see if the results hold true for each of these categories. Standard measuring devices could provide precise results instead of the use of flexible tape or foot prints which might result in the curves of extremities not getting included and thus underestimation of values. All this precision and uniformity so that a strong base is formed for the larger studies and further the influence of maternal, genetics and environmental factors can be assessed. If this method is popularized, we expect the use of a simple ruler to determine age to be an economical tool, provided it is kept parallel to the plane of extended hands and feet.

In conclusion, this method if implemented will have many implications. This simple, economic and non-invasive method can be used in rural settings and in case a newborn is found abandoned or there is a home delivery by the paramedics or Asha workers or the midwives in the rural areas for early identification of the high risk preterm neonates so that prompt basic care can be provided until they are referred to the higher centers. This can also be used by forensic pathologist for age determination in infanticide, concealment of birth and abandonment of child cases.

References

1. Sankar MJ, Neogi SB, Sharma J, et al. State of newborn health in India. Journal of Perinatology. 2016;36(Suppl 3):S3-S8. doi:10.1038/jp.2016.183.
2. Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE et al. Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet 2015; 385(9966): 430–440.
3. Registrar General of India. Sample registration system (SRS) statistical report 2013. New Delhi: 2013.
4. Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet 2012; 379: 2151–2161.
5. Bassani DG, Kumar R, Awasthi S, Morris SK, Paul VK, Shet A et al. Causes of neonatal and child mortality in India: a nationally representative mortality survey. Lancet 2010; 376: 1853–1860.
6. Hesketh T, Xing ZW. Abnormal sex ratios in human populations: causes and consequences. Proc Natl Acad Sci U S A. 2006;103(36):13271-13275. doi:10.1073/pnas.0602203103.
7. Chowdhury R, Taneja S, Mazumder S, Bhandari N, Strand TA. Gender differences in infant survival: a secondary data analysis in rural North India. BMJ Open. 2017;7(8):e014179. doi:10.1136/bmjopen-2016-014179.
8. S.R. Sateesha. H.R. Niranjan, A.S, Jagdish, Naveen Benakappa; Correlation of foot and hand length measurement with gestational maturity in neonates; Int J Pharm Bio Sci 2015 July; 6 (3): (B) 1050-1054
9. Caughey, A.B., Nicholson, J.M. and Washington, A.E. (2008) First vs Second Trimester Ultrasound: The Effect on Pregnancy Dating and Perinatal Outcomes. American Journal of Obstetrics & Gynecology, 198, 703705.
10. Rajat Thawani, Pooja Dewan, M.M.A. Faridi. Shilpa Khanna Arora, Rajeev Kumar. Estimation of Gestational Age, Using Neonatal Anthropometry: A Cross-sectional Study in India. J Health Popul Nutr 2013 Dec; 31(4): 523-530.
11. Manjunatha B, Nithin MD, Sameer S. Cross sectional study to determine gestational age by metrical measurements of foot length. Egypt J Forensic Sci. 2012;2(1):11-17. doi:10.1016/j.ejfs.2011.11.003.
12. Srivastava A et al. To study correlation of foot length and gestational age of new born by new Ballard score. Int J Res Med Sci. 2015 Nov; 3 (11):3119-3122
13. Goldstein Israel, Reece EAlbert, Hobbins John C. Sonographic appearance of the fetal heel ossifications centers and foot length measurements provide independent markers for gestational age estimation. Am J Obstet Gynecol 1988;159:923–7.
14. Kumar GP, Kumar UK. Estimation of gestational age by hand and foot length. Med Sci Law 1993; 33:123-8.