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Dr Dewi Anggraini has reviewed 1 submission in the journal *Risk Management and Healthcare Policy (journal Impact Factor: 2.429)* during 2020.

This contribution is greatly appreciated.

Regards

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Manuscript title:	Estimation of Gestational Age Using Neonatal Anatomical Anthropometiric Parameters in Dessie Referal Hospital, North East, Ethiopia
Article type:	Original Research
Journal:	Risk Management and Healthcare Policy
Contact person:	Mr Tiruneh
Submitted on:	15 Sep 2020
Number of authors:	1

Files:

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Article type: Original Research

Status: ACCEPTED TO REVIEW

Due Date: 14/Oct/2020

Keywords: Anatomical parameters, Gestational age, neonates, Dessie referral Hospital

Abstract: Introduction: Estimation of gestational age is a key for identification of infants of a given low birth weight is either preterm or growth retarded. Objective: To estimate gestational age from neonatal anatomical anthropometric parameters in Dessie referral hospital, Ethiopia. Methods: Prospective crossectional study design was employed in Dessie referral hospital from October, 2019 to April, 2020 with 424 consecutively live-born of 28–42 weeks gestation. After considering inclusion criteria, anthropometric parameters were measured within three days after delivery. Foot Length, Hand length, mid upper arm circumference, Head Circumference, Crown heel length, inter mammillary distance, umbilical nipple distance and Birth weight were measured and summarized using descriptive statistics and power of association was evaluated using correlation analysis. Regression equations of gestational age (GA) in completed weeks with anthropometric parameters were formulated using simple and multiple linear regression analyses. Result: Except to

hand length, all other anthropometric measurements were positively correlated with GA in completed weeks at p< 0.05. Anthropometric parameters individually, mid upper arm circumference (MUAC) and BW (birth weight) were correlated with GA at coefficient determination (r) of 0.406 and 0.334, correspondingly. A regression formula were formulated as GA (weeks) = 26.12+ [1.11×MUAC (cm)] and GA (Weeks) = 33.19 + [1.53×BW (kg)]. Multiple regression contributed well correlation with GA and used for prediction of GA as GA (weeks) = 28.12 – [0.393×HL (cm)] + [1.07×BW (kg)] + [0.87×MUAC (cm)] (r= 458). Conclusion: Overall best correlation for prediction of GA, alone and combination is found by combined parameters (HL, MUAC and BW). The best individual anthropometric parameter for GA assessment is MUAC. Hence, by using this neonatal parameter as prediction of gestational age, we can minimize the death of neonate due to preterm.

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ESTIMATION OF GESTATIONAL AGE USING NEONATAL ANATOMICAL ANTHROPOMETRIC PARAMETERS IN DESSIE REFERAL HOSPITAL, NORTH EAST, ETHIOPIA

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Abstract

Introduction: Estimation of gestational age is a key for identification of infants of a given low birth weight is either preterm or growth retarded.

Objective: To estimate gestational age from neonatal anatomical anthropometric parameters in Dessie referral hospital, Ethiopia.

Methods: Prospective crossectional study design was employed in Dessie referral hospital from October, 2019 to April, 2020 with 424 consecutively live-born of 28–42 weeks gestation. After considering inclusion criteria, anthropometric parameters were measured within three days after delivery. Foot Length, Hand length, mid upper arm circumference, Head Circumference, Crown heel length, inter mammillary distance, umbilical nipple distance and Birth weight were measured and summarized using descriptive statistics and power of association was evaluated using correlation analysis. Regression equations of gestational age (GA) in completed weeks with anthropometric parameters were formulated using simple and multiple linear regression analyses.

Result: Except to hand length, all other anthropometric measurements were positively correlated with GA in completed weeks at $p< 0.05$. Anthropometric parameters individually, mid upper arm circumference (MUAC) and BW (birth weight) were correlated with GA at coefficient determination (r) of 0.406 and 0.334, correspondingly. A regression formula were formulated as GA (weeks) = 26.12+ [1.11×MUAC (cm)] and GA (Weeks) = 33.19 + [1.53×BW (kg)]. Multiple regression contributed well correlation with GA and used for prediction of GA as GA (weeks) = 28.12 – [0.393×HL (cm)] + [1.07×BW (kg)] + [0.87×MUAC (cm)] ($r_{=}$ 458).

Conclusion: Overall best correlation for prediction of GA, alone and combination is found by combined parameters (HL, MUAC and BW). The best individual anthropometric parameter for GA assessment is MUAC. Hence, by using this neonatal parameter as prediction of gestational age, we can minimize the death of neonate due to preterm.

Key words: Anatomical parameters, Gestational age, neonates, Dessie referral Hospital

Introduction

Gestational age estimation is crucial for medical besides numerous public health functions, including the assessment of intrauterine growth curves and related tricky in populations, such as delineating whether infants of a given low birth weight are either preterm or growth retarded, the adjustment for prematurity when assessing gross motor milestone attainment and determining at risk status for potential developmental delay related to targeting populations in need of follow up and intervention services (1).

Theoretically, "gestational age (GA) denotes to the length of time between conception and delivery; because the timing of conception cannot be easily ascertained, GA is commonly estimated as the difference between the first day of the last normal menstrual period (LNMP) and the delivery date" (2). However, in low-resource settings GA estimation is difficult because of late came for antenatal care, challenges of LNMP recall because of hormonal contraceptives usage or maternal diseases and educational label of women, and unavailability of ultrasonography (2,3).

"Preterm birth is a main cause of neonatal mortality, accountable for 28% of neonatal deaths overall" (4). According to study, one of the contributing factors to neonatal mortality is duration of pregnancy (5). As prematurity is a primary cause of neonatal death, timely estimation of gestational age is vital for early identification of infants in need of specialized care. Thus, gestational age estimation at birth and identification and prompt care of premature babies provides us with an opportunity to not only reduce neonatal mortality but also under-five

mortality rate. Gestational age and Birth weight as predicted from last menstrual period have traditionally been used as strong indicators of prematurity and neonatal death (6).

"Globally, about one million babies die every year because of prematurity" (7). "As stated by the United Nations mortality estimate in 2013, the neonatal mortality rate in Ethiopia was 28 per 1000 live births. Even though there is an achievement observed in the reduction of neonatal mortality by 48%, still neonatal mortality is high" (8). In 2017 alone, an estimated 6.3 million children and young adolescents died, mostly from preventable causes. Of all, about 2.5 million deaths occurred before celebrating their 28^{th} days. Among children and young adolescents, the risk of dying was highest in the first month of life with average rate of 18 deaths per 1000 live births (9).

So, the above problems specifies that their a need of another model development which is new simple, cost effective, reliable, easy to use and uniform method for estimation of gestational age especially in developing countries for immediate identification of preterm neonate and referral of preterm neonates, and the delivery of potentially life-saving management. Thus, alternative measurements of neonates at time of delivery have a good correlation with gestational age in new-born. Foot length, hand length, mid upper arm circumference, umbilical nipple distance, Intermamilary distance, crown heel length and weight have been studied for their correlation with gestational age. All of these neonatal parameters can be measured with simple and easily available equipment 'measuring tape' and does not require any special training for use. Therefore, the study was aimed 1) to examine the correlation between gestational age and Birth weight, Head Circumference, Intermammary distance, Umbilical nipple distance, Mid-upper arm- circumference, hand length, Foot length, and crown-heel length 2) to find the better parameter for gestational age assessment by calculating regression equation of the best

anthropometric parameter alone and/or in combination 3) to develop regression models to estimate gestational age from these neonatal anatomical anthropometric parameters in Dessie referral hospital delivered neonates.

MATERIALS AND METHODS

This institutional based prospective cross sectional study was carried in the period of October, 2019 to April, 2020 at Dessie Referral Hospital in gynecology and obstetrics department, which is found in Amhara region North East Ethiopia. The Hospital is located in Dessie town serving 2.4 million peoples including neighboring zones. It has more than five wards including the obstetrics and gynecology ward and the hospitals monthly delivery report is above 500 mothers.

Four hundred twenty four sequentially alive delivered neonates within three days of life and in the range 28-42 weeks of gestational age were included in the study.

Exclusion Criteria

- Neonates born from mothers not knowing LMP exactly
- Twin neonates
- New born with gross congenital anomalies
- Severe perinatal asphyxia
- Neonates borne from women with known chronic maternal disease - hypertension, diabetes mellitus, cardiac disease and severe anemia, TORCH infections positive mothers
- Women with obstetrical complications known to compromise fetal growth – eclampsia, smoking history, alcohol consumption or drug abuse.

Source and study population

The Source Population was all neonates who were delivered in Dessie referral hospital during the study period. The study population all alive delivered neonates in Dessie referral hospital who fulfill inclusive criteria.

Sample Size Determination

There was no published data on estimation of gestational age from neonatal anatomical parameters in Ethiopia. Therefore, the minimum number of sample required for this study was determined using single population proportion formula (p=50 %, CI=95%) and then 10% was added for none response rate. Thus, the ultimate sample size was set at 424.

Sampling Procedure

After checking the medical card of cases and taking informed consent from the parents, based on the inclusive and exclusive criteria of study, purposive sampling technique was employed till the total sample size was achieved.

Operational Definitions

Gestational age - It is measured in weeks, from the first day of the woman's last menstrual cycle to the current date. A normal pregnancy can range from 28 to 42 weeks.

Vertex: It is the highest point on the head in the mid-sagittal plane (10).

Anatomical anthropometric parameters:

Head circumference: It is "just above the supercilliary arch on the anterior aspect, just above the auricle on the lateral aspect and at the level of external occipital protuberance on posterior aspect" (11).

Umbilical nipple distance: "it is measured between the 12 o'clock positions of the rim of the umbilicus to the right nipple" (12).

Intermamilary distance: it is the distance between the nipples at the end of expiration.

Middle upper arm circumference: The midpoint circumference between acromion end of clavicle and olecranon process of ulna.

Hand length: it is measured from the distance between the heel of the hand and tip of the middle finger, with the wrist held in extension and the palm and fingers extended against the hand of the assistant, using a slide caliper (12).

Foot length: "The maximum length between the most prominent posterior point of the heel and the tip of hallux and the tip of the second toe if it is larger than the hallux" (13).

Crown-heel length: it is measured from vertex of skull to the heel of foot (supine position).

Anthropometry Equipment

- ✓ Weight scale and
- ✓ Flexible, Non elastic measuring tape meter

Methods of Data Collection

To conduct this research checklist was prepared. This check list contains socio demographic character (mother's age, occupation, levels of education, residence and neonate sex) and study variables (gestational age of the mother prior to delivery and neonatal anatomical parameters like HC, CHL, FL, HL, IMD, UND and birth weight).

The GA of the study participants was calculated from the history sheets of their women, by the use of "Naegele's formula" (i.e. count back 3 months from the first day of the LNMP and add a year and 7 days).

Neonatal anatomical parameters were measured to near 0.1 centimeters (cm). Birth weight was measured by weight scale in kilogram (kg).

Head circumference was measured by non-elastic measuring tape meter which encircle head just above supercilliary arch on anterior aspect, just above auricle on lateral aspect and at the level of external occipital protuberance on posterior aspect (12).

Foot length was measured with non-elastic measuring tape meter as the maximum length between the most prominent posterior point of heel and the tip of hallux and the tip of the second toe if it was larger than the hallux (13). Hand length was measured from the distance between the heel of the hand and tip of the middle finger (12). Both foot length and hand parameters were measured from right side of the body.

Crown-heel length: it was measured from vertex of skull to the heel of foot (supine position).

Umbilical nipple distance: "it was measured between the 12 o'clock positions of the rim of the umbilicus to the right nipple" (12). Intermamilary space was measured between the nipples.

Middle upper arm circumference: it was measured at midpoint circumference of humerus between acromion end of clavicle and olecranon process of ulna. The right side arm was used.

Data Quality Control

The data was collected by 3 BSc Midwifery staffs who work in delivery room and I was supervisor of them. The data collection was accomplished within three day of postpartum period.

To keep data quality, preparation was assumed for data collectors. A properly designed data collection material was prepared. Anatomical parameters were measured by non-stretchable tape and recorded to near 0.1 cm. The principal investigator was carried out supervision during data collection period to check comprehensiveness and reliability. The consistency and representativeness of data was maintained by including merely complete data of study subjects with in the study period.

Data Processing and Analysis

Data was checked after collection from each participant for its completeness. The data was entered in EPI data version 3.1 and then for analysis it was exported to SPSS version 23 statistical software. The correlation among different anatomical anthropometric measurements with gestational age was tested. $P< 0.05$ was considered as statistically significant. Correlation coefficients were calculated and linear regression equations were formulated to estimate gestational age from measurements taken. Fitness of regression models was assessed using coefficients of determination and residual plots. Finally, the data was presented by using statements, tables, charts and graphs.

Ethical Considerations

Ethical clearance was obtained from institutional research review board of Wollo University, and then the letter of cooperation was written to Dessie Referral Hospital. Next, it was communicated with Head of Obstetrics and Gynecology department and other concerned bodies. The purpose and importance of the study was clarified to each study participant and oral consent was gained from each participant. Privacy was kept by taking the data anonymously and also participants had the right to excluded from study if they were not voluntary to participate.

Results

Descriptive statistics of sociodemographic Variables

A total of 424 women, who gave birth were participated in the study. About 262 (61.8%) and 162 (38.2%) study participants were came from urban and rural, respectively. The age of them were ranges from 16-38 with the mean age of 26.8 (±5.2). The gestational age of the women while they delivered ranges from 31- 42 weeks with the mean weeks of (38.1±1.8). The proportions of cases in each gestational week were not evenly divided. The largest proportions of delivery were occurred at 38 weeks followed by 39 weeks and accounted 134 (31.6%) and 98 (23.1%), respectively. Conversely, the smallest proportions of delivery were occurred at 42 weeks 1 (0.2%). Status of newborn were term 360 (84.9%) followed preterm 64 (15.1%) (table 1 and figure 1 and 2).

Descriptive statistics of gestational age, anatomical anthropometric parameters and weight of neonates

Descriptive statistics of neonatal anatomical measurements of study participants are provided in tables 2. It was observed that different neonatal anatomical parameters had different measurement quantities. It was also observed that weight ranged from 2.2 kilogram (kg) to 4.5 kg and mean weight was 3.2 (± 0.4 kg).

Correlation between gestational age and neonatal anatomical anthropometric measurements

Pearson's correlation coefficient (r) between gestational age and neonatal anatomical anthropometric measurements are provided in table 3. The r- value between gestational age and anthropometric parameters ranges from -0.018 to 0.406. Except to the hand length, all anatomical anthropometric parameters were revealed positive statistically significant correlation with gestational age ($p < 0.05$). The highest correlation was observed on mid upper arm circumference ($r_{=}$ .406). Conversely, the lowest correlation was detected on hand length ($r_{=}$ -.018) and these parameter was not significantly correlated ($p > 0.05$). It also observed that weight had positive significant correlation ($r=.344$, $p<0.05$) (table 3).

Gestational age estimation from anatomical anthropometric measurements and weight of neonate

To estimate gestational age, simple and multiple linear regression analyses were made from each neonatal anatomical anthropometric measurements and weight. It was evident that maximum significant correlation coefficient was obtained when all anthropometric parameters was entered in multiple linear regression model. As a result, better significant correlation coefficient was obtained on (MUAC, BW and HL) (r=0.458) followed by simple linear regression model entry, MUAC (r=0.406). Hence, better predictor regression equation for gestational age was formulated as:

GA (in weeks) = 28.12 – [0.393×HL (cm)] + [1.07×BW (kg)] + [0.87×MUAC (cm)] and

GA (in weeks) = 26.12+ [1.11×MUAC (cm)] (table 4).

Discussion

This study was intended to estimate gestational age from neonatal anatomical anthropometric measurements including head circumference, crown heel length, mid upper arm circumference, hand length, foot length, Intermamilary distance, umbilical nipple distance and weight in 424 consecutively delivered neonates of Dessie referral hospital. The study was conducted in the gynecology and obstetrics department of postpartum ward within 72 hours of delivery.

Though prematurity is a major determinant of neonatal survival, there was no study finding entitled on gestational age estimation from neonatal anatomical anthropometry in developing country including Ethiopia. This countries they rely on LNMP for determination of gestational age to assess the delivered neonate weather they were term or preterm. However, LNMP may not be recall due to irregularity, hormonal contraceptive usage and low literacy in low income countries. As a result, this study might have significance for the early management of prematurity and then lessening under five mortality rates.

In the current study, head circumference, crown heel length, mid upper arm circumference, foot length, Intermamilary distance, umbilical nipple distance and weight had positive significant correlation with gestational age. This finding was in line with study conducted in India by Thawani R et al (12). However, hand length had insignificant correlation in the current study with gestational age as compared to study conducted by Thawani R et al. This discrepancy may be due to difference in sample size usage. This study also had in agreement with study conducted by Ritesh Yadav et al in India (14), showed that Birth weight, Foot Length , Head Circumference and crown-heel length had positive correlation with gestational age.

Regarding the strength of association on the current study, mid upper arm circumference (r=0.406) had strong correlation with gestational age in complete weeks followed by birth weight (r= 0.335). This finding was inconsistence with study conducted by Ritesh Yadav et (14), where foot length (r= 0.878 p<0.0001) had maximum correlation followed by birth weight (r=0.799). These contradictions might be due to demographic profile and sample size difference. Another study conducted by Niloy Kumar Das, et al (15), HC had strong association (r= 0.863) followed by CHL(r= 0.859) This inconsistence might be due to the use of only two variables for estimation of gestational age as compared to the current study.

In the present study, the regression equation was formulated in complete weeks and found that strong association was obtained in combination of (MUAC, BW, HL) (r=0.458), and formulated as GA in weeks= 28.12 - [0.393×HL (cm)] + [1.07×BW (kg) + [0.87×MUAC (cm)], followed by a simple linear regression equation on mid upper arm circumference(r = 0.406), GA in weeks = 26.12+ [1.11×MUAC(cm)]. This finding was consistent with study carried out by Ritesh Yadav et al (15), he revealed that using combination of neonatal parameters had better prediction for gestational age as compared to individual parameters.

Conclusion

Except to hand length, all other neonatal anatomical parameters had positive correlation with gestational age. The general best correlation for estimation of gestational age, alone and in combination is found by combined mid upper arm circumference, hand length and Birth weight. The best individual neonatal parameter for GA prediction is mid upper arm circumference.

The best regression model was formulated by combined parameters of mid upper arm circumference, hand length and birth weight. These simple and multiple linear regression model

are simple, quick. As a result, it can be used at any primary health care by basic health care providers with the help of ordinary measuring tape. Hence, basic health care personnel can identify preterm cases easily and then quickly refer them for further treatment.

Recommendations

Based on the finding of this study, the following are recommended for future researchers:

- A similar large scale and multi-center study should be conducted.
- It would be ideal to carry out a similar study on other neonatal anatomical parameters.
- Further studies should be conducted on bilateral neonatal anatomical parameters to detect the difference for prediction of gestational age.

Declarations

Ethical Approval and Consent to participate

Ethical clearance was obtained from Department of Research Ethics Review Committee (DRERC) of Wollo University. Then this ethical clearance and cooperation letter was sent for Dessie referral hospital director to obtain consent to perform data collection. The purpose and objective of the study were explained to the director of Dessie referral hospital and card room workers as well. Finally, data were collected and Confidentiality of patient information was maintained through taking the data anonymously.

Consent for publication

Not applicable

Availability of supporting data

The datasets used and/or investigated during the current study are available from the corresponding author on reasonable request.

Competing interests

The author affirms that there is no conflict of interest regarding the publication of this paper.

Funding

No fund was received to conduct this study.

Acknowledgements

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