ORIGINAL ARTICLE

Transverse Cerebellar Diameter as a Sonographic Parameter for Estimating Gestational Age: an Experience From Yemeni Population

Muneera A. S. Yahya[1], Husni A. Al- Goshae[2], Hameed M. Aklan[3], Maha Abdul-aziz[4] , Abdullah A. Al-Mikhlafy[5]

[1] Anatomy and Embryology Department, Faculty of Medicine & Health Sciences, University of Science and Technology, 15201, Sana'a, Yemen
[2] Neuroanatomy and Embryology Department, International Medical School (IMS), Management and Science University (MSU), Seksyen 13, 40100 Shah Alam, Selangor, Malaysia
[3] Radiology Department, Faculty of Medicine & Health Sciences, University of Science and Technology, 15201, Sana'a, Yemen
[4] Obstetrics and Gynaecology Department, Faculty of Medicine & Health Sciences, University of Science and Technology, 15201, Sana'a, Yemen
[5] Community and Family Medicine Department, Faculty of Medicine & Health Sciences, University of Science and Technology, 15201, Sana'a, Yemen

ABSTRACT

Introduction: Estimation of gestational age (GA) is clinically crucial for managing pregnancy and assessing the foetal anatomy, growth and development. Transverse cerebellar diameter (TCD) has been reported as an accurate tool for dating the pregnancy. This study aimed to determine the accuracy of foetal TCD for dating the pregnancy and to construct a reference chart for GA of Yemeni foetuses. **Methods:** We conducted this prospective cross-sectional study among 400 Yemeni pregnant women between 18 and 40 weeks of gestation provided that they were with known last menstrual period and singleton normal pregnancies. Sonographic TCDs were measured for each foetus. The mean TCD was measured for gestational weeks separately, and a polynomial regression model was then used to predict the GA by TCD. **Results:** There was a robust correlation between GA and TCD (r = 0.995, p <0.001). The coefficient of determination was 0.989, which indicates that the TCD explains 98.9% of GA change. **Conclusion:** TCD is an accurate tool to estimate the GA in second and third trimesters, including final weeks, among Yemeni pregnant women as in developed countries. The narrow range between the 5% and 95% percentiles is a significant indication of the accuracy of the TCD in estimating the GA. Therefore, clinicians are recommended to use TCD for estimating the GA and should be trained on measuring it accurately.

Keywords: Gestational age, Transverse cerebellar diameter, Dating of pregnancy, Accuracy, Yemen

Corresponding Author:
Muneera Abdulwahab Yahya, MSc
Email: dr_muneera@yahoo.com
Tel: +9671530682

INTRODUCTION

It is important to accurately estimate the gestational age (GA) in clinical practice for managing pregnancy as well as estimating foetal growth and development, especially when there is a GA uncertainty by the last menstrual period (LMP) or early ultrasonography (1, 2). Before the ultrasound era, healthcare providers have used the menstrual history and physical examination to estimate the GA. However, the date of conception cannot be as accurately predicted in most pregnancies, necessitating the estimation of GA by other methods. Ultrasonography is widely used for prenatal evaluation, where the most frequent biometric parameters to estimate GA are bi-parietal diameter, the circumferences of the head and abdomen and the femur length (3, 4). There is evidence that TCD could be a precise tool for estimating GA (5).

The cerebellum is the main structure in the hindbrain within the posterior cranial fossa beneath the tentorium cerebelli, appearing as a swelling overriding the fourth ventricle at the end of the fifth gestational week (6). It can be visualised at the end of the first trimester (7, 8). Several studies indicate that TCD is a precise parameter for estimating the GA because it is not significantly affected by the size and shape of the head, genetic disorders such as Down syndrome or extremes of the foetal growth (5-7, 9). Measurement of the posterior cranial fossa of the foetus has been routinely included as a part of ultrasound examination during antenatal care (ANC) (10). Because the growth of the foetal cerebellum parallels the GA, TCD can be used to predict the GA precisely in the second and third trimesters (2, 10).

Since the cerebellum is not affected by the shape and size of the head, TCD can be practically used to measure the GA when it is difficult or impossible to measure the bi-parietal diameter as in macrocephaly or microcephaly (9, 11). It can also be used to establish the GA in normal foetuses and early diagnosis of intrauterine growth restriction (12).

The latest development of new software, such as volume contrast imaging, has contributed to a more accurate assessment of posterior cranial fossa anomalies and biometric measurements of the cerebellum (13, 14). High women illiteracy, ignorance of the importance of ANC and inadequate ANC services contribute to delayed pregnancy follow-up and failure of sonographic dating of pregnancy in developing countries, including Yemen. Therefore, this study aimed to determine the accuracy of TCD in the estimation of GA and to construct a reference range for GA by TCD of Yemeni foetuses.

MATERIALS AND METHODS

This prospective cross-sectional study was conducted in the Anatomy and Embryology Department of the University of Science and Technology (UST) and the Radiology Department of the University of Science and Technology Hospital (USTH) in Sana'a-Yemen, between June 2014 and January 2016. Four-hundred consecutive Yemeni pregnant women who attended the ultrasound unit of the USTH's Diagnostic Radiology Department and met the inclusion criteria were included. Inclusion criteria were Yemeni pregnant women aged 18-40 years with a gestational age of 14-40 weeks, with known first day of the LMP, single pregnancy, no maternal diseases (chronic hypertension, diabetes mellitus, or renal disease) and absence of foetal abnormalities at the time of the scan.

TCD was measured by scanning the pregnant women using the Siemens Acuson X700TM ultrasound system (Siemens Healthcare GmbH, Erlangen, Germany) with a linear array of 3.5 MHz transducer. Transverse scans of the foetal intracranial anatomy were taken for each foetus. To view the cerebellum, the probe was put on the abdominal skin surface of the pregnant women to identify the landmarks of the thalami, the cavum septum pellucidum, and the third ventricle followed by rotating the transducer below the thalamic plane (15). The TCD was measured by placing the ultrasound machine callipers at the outer-to-outer edges of the cerebellum (Fig 1), according to McLeary et al. (16) and Goldstein et al. (17). Each woman was scanned only once during the study. A consultant radiologist performed all the measurements in millimetres. For the dating of pregnancy, days were rounded to the nearest week, with days < 4 days rounded to the fewer weeks and days ≥4 rounded to the higher weeks (18).

Data were analysed using the SPSS program, version 21 (IBM Corp., Armonk, NY, USA). The categorical data were displayed as frequencies and percentages, while the quantitative data were displayed as means and standard deviations. The GA nomogram was constructed based on a suitable cubic polynomial regression of TCD, by modelling the means and SDs separately (17, 19). To model the mean, it was fitted to the raw data. The cubic curve gave the best fit to the data (p value= 0.00013). After that, residuals between the observed and fitted values were plotted against TCD to study the variability changes with gestation. The SD was modelled by a suitable regression model (19). The residuals were converted into absolute residuals, which were then regressed on the TCD. The quadratic curve gave the best fit to the data (p-value <0.001).

The values fitted from this model were multiplied by 1.235 to obtain the age-specific estimated SD. These values ±1.645 SD were superimposed on the plot of the residuals to see how the SD would be modelled. The standard residuals (Z scores) or SD scores (SDS) were calculated by dividing the observed value minus fitted mean by the fitted SD. The distribution of SDS was assessed using a normal plot and Shapiro-Wilk test. The 5th and 95th percentiles were reported as the mean ± 1.645 SD, and the 10th and 90th percentiles were calculated as the mean ± 1.28SD (19-22).

The protocol of this study was reviewed and approved by the Medical Ethics Committee of the Faculty of Medicine and Health Sciences at the UST, Sana'a, Yemen. Permission was obtained from the Department of Radiology at the USTH, and informed consent was obtained from the participating pregnant women after explaining the objectives of the study. The confidentiality of the pregnant women was also assured.

RESULTS

The mean age of the participating pregnant women was 25.9 ± 5.4 years (range: 18-40), and their mean GA was 31.2 ± 5.6 weeks (range: 18-40). Table I shows that the 18-24 age group was the most frequent (183; 45.8%), while the women aged 35 years or older were the least frequent (29; 7.3%).

There was a robust correlation between GA and TCD (r = 0.995, p <0.001). The coefficient of determination (R^2) was 0.989, which indicates that TCD explains 98.9% of GA change. Besides, there was a strongly significant curvilinear relationship between the GA and TCD. The best regression model for the mean was cubic (Fig. 1).

The GA was calculated using the following regression equation: GA = 7.377 + (0.470 × TCD) + (0.009 × TCD^2) - (0.000133 × TCD^3). For SD, the quadratic model was the best fit, and it was calculated using the following regression equation: SD = 0.470 + (0.00453 × TCD) - (0.000035 × TCD^2)

Fig. 3 shows the standardised residuals plotted against TCD, where their distribution did not exceed mean ± 3.

Table II shows the constructed GA nomogram based on TCD with 5%, 10%, 50%, 90% and 95%. The range between the 5% and 95% percentiles was narrow and did not exceed three weeks at its maximum value, and it exceeded two weeks against three values of TCD only.

On comparing our results with those of some Western studies (Fig. 4), we found a great match, especially with the findings of Hill et al. among American pregnant women (3).

Table I : Frequency distribution of pregnant women by age

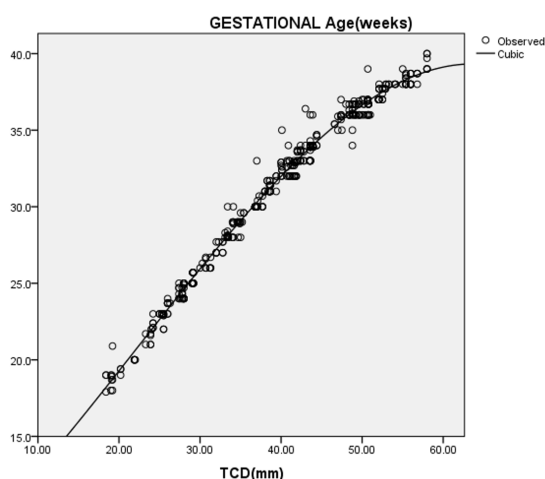| Age group (years)	n (%)
18-24	183 (45.8)
25-29	112 (28.0)
30-34	76 (19.0)
≥35	29 (7.3)
Total	400 (100.0)

Figure 1 : Gestational age vs. transverse cerebellar diameter (TCD) with cubic polynomial fit.

DISCUSSION

Although several studies indicate the accuracy of the TCD in estimating the GA, they have been mostly conducted in developed countries. Therefore, this study is the first to determine the applicability of using TCD to estimate the GA among Yemeni women as a model of developing countries. Using advanced statistical reference methods, we explored whether the results of using TCD in a developing country did not differ from those in developed countries and constructed a nomogram for the expected GA based on the TCD.

The present study revealed a strong correlation between TCD and GA, where the relationship between them was of a polynomial degree (cubic regression), and the slope was curvilinear. Therefore, TCD is an accurate tool for estimating the GA among Yemeni women in the second and third trimesters, even in the final weeks of
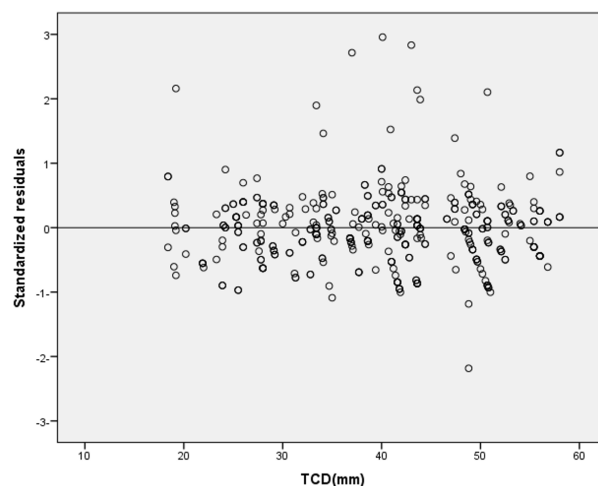

Figure 2 : Scatter plot of standardized residuals from the model describing mean vs. transverse cerebellar diameter (TCD).
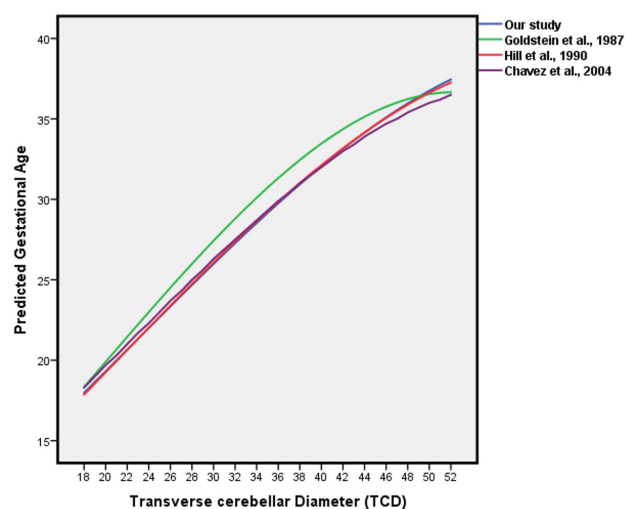

Figure 3 : Comparison of predicted GA of the present study with those of previous studies.

pregnancy. Our findings are very consistent with those of other studies (3, 7, 23), and a near-perfect match was observed among American pregnant women (3).

Our findings are also consistent with the curve of Goldstein et al. (7), which between the gestational weeks of 18 and 22 weeks; however, it began to increase slightly until the cerebellum diameter of 50 mm, where it became flat. The authors attributed this to the fact that the growth of the cerebellum becomes flat in the final weeks of pregnancy (7). In contrast, studies conducted on foetal corpses showed continued growth of the cerebellum until the final weeks (2), which is consistent with the results of the present study and those of Hill et al. (3).

The findings of Chavez et al. (23) among American women were almost identical to ours up to the cerebellum diameter of 47 mm, where they became slightly less. In contrast, the findings of Altman et al. (24) were significantly different from our results and those of other studies, where they found that the TCD is suitable for estimating GA for up to 20-25 weeks only (up to 30

Table II : Predicted percentiles of GA by TCD of Yemeni fetuses

TCD	Percentiles of GA					TCD	Percentiles of GA				
	5th	10th	50th	90th	95th		5th	10th	50th	90th	95th
18	17.27	17.48	18.2	18.99	19.2	39	30.79	30.92	31.4	31.82	31.94
19	17.66	17.89	18.7	19.53	19.76	40	30.78	31.07	32.1	33.07	33.35
20	18.72	18.88	19.4	20.0	20.16	41	31.61	31.82	32.6	33.33	33.54
22	19.62	19.83	20.6	21.36	21.58	42	32.17	32.38	33.1	33.79	33.99
23	20.7	20.88	21.5	22.16	22.34	43	32.15	32.47	33.6	34.66	34.97
24	21.52	21.63	22.0	22.42	22.53	44	33.27	33.44	34.0	34.59	34.76
25	22.46	22.53	22.8	23.06	23.13	47	34.81	34.98	35.6	36.16	36.33
26	22.48	22.63	23.2	23.74	23.9	48	35.38	35.52	36.0	36.53	36.67
27	23.44	23.62	24.3	24.9	25.08	49	35.33	35.55	36.3	37.06	37.28
28	23.79	23.97	24.6	25.23	25.41	50	35.87	36.05	36.7	37.26	37.43
29	24.61	24.79	25.4	25.99	26.16	51	36.1	36.3	37.0	37.66	37.86
30	25.91	25.94	26.1	26.19	26.23	52	36.64	36.81	37.4	38.06	38.24
31	25.67	25.88	26.6	27.34	27.54	53	37.04	37.18	37.7	38.14	38.28
32	26.61	26.76	27.3	27.82	27.97	54	37.98	37.99	38.0	38.07	38.09
33	27.57	27.68	28.0	28.41	28.52	55	37.63	37.79	38.4	38.93	39.09
34	27.63	27.82	28.5	29.21	29.41	56	37.69	37.87	38.5	39.17	39.35
35	28.48	28.61	29.1	29.55	29.69	57	38.02	38.17	38.7	39.21	39.36
37	29.54	29.71	30.3	30.86	31.03	58	37.95	38.17	38.9	39.66	39.88
38	30.12	30.29	30.9	31.5	31.67						

GA, gestational age; TCD, transverse cerebellar diameter.

mm diameter). This difference could be attributed to several factors, including the different statistical methods used, where the latter study used a different logarithmic equation. Altman et al. (24) reported that measuring the TCD in the third trimester had been challenging and unreliable.

Although this study was based on a single hospital and its sample may not be representative of pregnant women at the community level in Yemen, it was conducted in a referral hospital that receives cases from the capital Sana'a and other governorates of the country.

CONCLUSION

TCD is an accurate tool to estimate the GA in the second and third trimesters, including final weeks, among Yemeni pregnant women as found in developed countries. The narrow range between the 5% and 95% percentiles, which does not exceed three weeks at maximum, is a significant indication of the accuracy of the TCD in estimating the GA. Therefore, clinicians are recommended to use TCD for estimating the GA and should be trained on measuring it accurately.

ACKNOWLEDGEMENT

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