Gestational age estimation using transcerebellar diameter with grading of fetal cerebellar growth

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Abstract

Background: The transverse cerebellar diameter (TCD) serves as a reliable predictor of gestational age (GA) of the fetus and is a standard against which aberrations in other fetal parameters can be compared, especially when the GA cannot be determined by the date of the last menstrual period or an early pregnancy scan. Aim: The aim of this study was to derive a regression equation and evaluate the relationship between transverse cerebellar diameter and gestational age, which will be helpful in assessing the fetal gestational age and also to evaluate the grades of cerebellum and to see its growth. Materials & methods: The prospective study was carried out in 292 pregnant women between 14-40 weeks of pregnancy attending the Konaseema Institute of Medical Sciences & Research Foundation, Amalapuram for routine ultrasound examination. Transverse cerebellar diameter was measured and cerebellum was graded using ultrasonography. Results: Fetal cerebella were found to be in 29%, 10% and 61% cases as grade I, II and III respectively. The grade changed from I to III progressively with advancing gestation. The median GA and TCD were 20 wks and 22 mm for grade I, 32 wks and 30 mm for grade II and 36 wks and 38 mm for grade III. Conclusion: Regression analysis indicated a strong relationship between TCD and gestational age indicating TCD is a good marker for estimation of gestational age. Keywords: transverse cerebellar diameter, gestational age, ultrasound, cerebellum, regression equation.

Introduction

The transverse cerebellar diameter (TCD) serves as a reliable predictor of gestational age (GA) of the fetus and is a standard against which aberrations in other fetal parameters can be compared, especially when the GA cannot be determined by the date of the last menstrual period or an early pregnancy scan. Erroneous menstrual GA estimates leads to unnecessary induction, dysfunctional labor and unnecessary Caesarean section, and resultant neonatal and maternal morbidity. These indicate accurate GA estimation is of greatest clinical importance. Moreover, it is essential to ensure appropriate management of newborns and to distinguish pre-term from term infants, identify low birth weight, diseases due to short gestational period like hyaline membrane disease, infection, asphyxia and hypoglycemia. In addition, post-maturity problems may arise when mothers are not aware of last menstrual period (LMP) and appropriate care is not provided to reduce complications such as asphyxia or hypoglycemia. Sonographic determination of gestational age (GA) is becoming increasingly important. Out of the many sonographic parameters used, the transverse cerebellar diameter (TCD) is a reliable parameter for estimating gestational age.

TCD can predict GA especially in cases where there is variation of fetal head shape. Cerebellum, the largest part of the hind brain lying in the posterior cranial fossa dorsal to pons and medulla intervened by fourth ventricle, is not liable to change in its form owing to the dense petrous ridges and occipital bones; hence it can withstand
more deformation than the parietal bones and its size correlates well with GA. The maximum measurement of this organ is its transverse dimension. Fetal transcerebellar diameter in normal gestation is highly correlated with fetal growth indices. It is least affected in cases of growth retardation and hence has proved itself a better marker for gestational age estimation as compared to other clinical and biometric parameters.

Cerebellum develops from dorsolateral part of alar lamina of the metencephalon and appears as a swelling overriding the fourth ventricle around the end of 5th week of intrauterine life. The aim of this study was to derive a regression equation and evaluate the relationship between transverse cerebellar diameter and gestational age, which will be helpful in assessing the fetal gestational age and also to evaluate the grades of cerebellum and to see their progression.

Material & methods

Fetal TCD data from ultrasound examinations of pregnant mothers attending Konaseema Institute of Medical Sciences and Research Foundation for routine ultrasound examination and seeking antenatal care between 14 to 40 weeks was recorded prospectively between September to December 2011. Analysis was restricted to normal singleton pregnancies with sonographically estimated GA confirmation of last menstrual period (LMP) dating and with no medical or obstetrical complications. The previous USG report of pregnant mother (14 to 40 weeks), who had already their 1st USG done at 1st trimester was consulted; if the ultrasound GA was within seven days, LMP was retained for assigning GA. If the initial ultrasound was in the second trimester, the pregnancy was included only if the biometry was within two weeks of the LMP. For these fetuses, the GA was assigned using the LMP. Fetuses that had discordant LMP and ultrasound biometry dating (> seven days in the first trimester and >14 days for second and third trimester) were excluded.

The resulting cross sectional data for 292 pregnant mothers were used for deriving regression equation and percentiles were also computed. The measurement was obtained with commercially available, curvilinear array real time, B-mode ultrasound, equipped with a 3.5 MHz transducer. Participants were explained about the procedure and it was performed in supine position with hips and knees in extension. The probe was held with right hand and the same observer performed all the measurements in millimeters. Specific methods regarding imaging criteria, caliper placement, and averaging of at least two measurements for each was followed. Transverse views of the fetal intracranial anatomy was obtained. The landmarks of the thalami, cavum, septum pellucidum and third ventricle were identified followed by rotation of the transducer below the thalamic plane to view the butterfly like structure in the posterior cranial fossa which is cerebellum, as mentioned by McLeary et al (1984) and Goldstein et al. The measurement was obtained by placing the calipers of the ultrasound machine at the outer-to-outer margins of the cerebellum (figure 3). A single measurement was used for each case. Only last TCD measurement was considered in case of fetuses with multiple measurements at different gestational ages. To decrease the inter-observer variability, a single radiologist performed the measurements. To decrease the intra-observer variability, the average value of the two measurements was used. The data collected was statistically analysed to calculate the mean TCD, standard deviation and regression equation was framed.

In our study the cerebella were grouped into three categories according to the following ultrasonographic features:

Grade I - The cerebellar hemispheres appear as two cystic globules, on either side of the midline and the vermis is not developed.

Grade II - The vermis is seen as an echogenic rectangular tissue connecting the two hemispheres with...
the cerebellum resembling a dumbbell with the echoic margins.

Grade III - The appearance of the cerebellar hemispheres change to that of a triangular structure, which is homogeneously echogenic and looks more solid.

Results

The mean TCD was 16.7 mm at 14-20 weeks, 23.2 mm at 21-27 weeks, 30.6 mm at 28-34 weeks and 35.2 mm at 35-40 weeks. (Table 1). When individual observation of mean transverse cerebellar diameter was studied in relation to gestation age in weeks, linear relationship was found between gestation age and TCD. At 14-20 weeks of gestation age, the minimum

### Table 1: Mean TCD During Different GA

<table>
<thead>
<tr>
<th>Gestation Age (weeks)</th>
<th>n</th>
<th>Mean TCD (mm)</th>
<th>SD</th>
<th>Co-efficient of variation</th>
<th>TCD range</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-20</td>
<td>34</td>
<td>16.7</td>
<td>1.7</td>
<td>10.2</td>
<td>13-20</td>
</tr>
<tr>
<td>21-27</td>
<td>50</td>
<td>23.2</td>
<td>2.2</td>
<td>9.5</td>
<td>20-28</td>
</tr>
<tr>
<td>28-34</td>
<td>83</td>
<td>30.6</td>
<td>2.5</td>
<td>8.2</td>
<td>24-35</td>
</tr>
<tr>
<td>35-40</td>
<td>125</td>
<td>35.2</td>
<td>1.7</td>
<td>4.8</td>
<td>30-40</td>
</tr>
</tbody>
</table>

![Figure 1: Showing maximum & minimum TCD, 1st & 3rd quartile & median values in different gestational age groups.](image1)

### Table 2: Transverse Cerebellar Diameter (TCD) Percentiles By Gestational Age

<table>
<thead>
<tr>
<th>Gestational Age (weeks)</th>
<th>5th percentile</th>
<th>10th percentile</th>
<th>25th percentile</th>
<th>50th percentile</th>
<th>75th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-20</td>
<td>14.5</td>
<td>15</td>
<td>15</td>
<td>17</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>21-27</td>
<td>20</td>
<td>20</td>
<td>21</td>
<td>24</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>28-34</td>
<td>26</td>
<td>28</td>
<td>30</td>
<td>30</td>
<td>32</td>
<td>34</td>
</tr>
<tr>
<td>35-40</td>
<td>32</td>
<td>34</td>
<td>34</td>
<td>36</td>
<td>36</td>
<td>38</td>
</tr>
</tbody>
</table>

![Figure 2: Relationship Between TCD & GA (Scatter Diagram)](image2)

### Table 3: Coefficients: Dependant Variable = TCD (mm)

<table>
<thead>
<tr>
<th>UNSTANDARDIZED COEFFICIENT</th>
<th>B</th>
<th>CONSTANT</th>
<th>GA</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD ERROR</td>
<td>0.392</td>
<td>11.201</td>
<td>6.119</td>
</tr>
<tr>
<td>BETA</td>
<td>0.946</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIGNIFICANCE</td>
<td>0.000</td>
<td>49.959</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4: Gradation Of Cerebellum

<table>
<thead>
<tr>
<th>SERIAL NO</th>
<th>GA</th>
<th>NUMBER OF CASES</th>
<th>GRADE I</th>
<th>GRADE II</th>
<th>GRADE III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14-20</td>
<td>34</td>
<td>33</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>21-27</td>
<td>50</td>
<td>48</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>28-34</td>
<td>83</td>
<td>3</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>35-40</td>
<td>125</td>
<td>0</td>
<td>5</td>
<td>120</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>292</td>
<td>84</td>
<td>28</td>
<td>180</td>
</tr>
</tbody>
</table>
TCD was 13 mm and maximum TCD was 20 mm, at 21 to 27 weeks of gestation, it was 20 mm and 28 mm, at 28 to 34 weeks, it was 24 mm and 35 mm and at 35 to 40 weeks, it was 30 mm and 40 mm respectively (Table 1). The predicted TCD for the 5th, 10th, 50th, 90th and 95th percentiles are reported in Table 2 & Fig. 1.

The correlation coefficient (Table 3) between period of gestation and TCD was found to be +0.946, which was statistically significant (p < 0.001), indicates a high degree of correlation between Transcerebellar diameter and Gestational Age. The $R^2 = 89.6\%$ indicates, 89.6% of the Transcerebellar diameter, can be explained by gestational age, which is very large. The model applied is significantly good enough in predicting the outcome variable (P < 0.0001).

From regression analysis, a strongly significant relationship has been observed between fetal TCD and gestational age.

**TCD = 6.119 X GA + 11.201**

Both the constant and GA contribute significantly to the model. When individual observation of mean transverse cerebellar diameter was studied in relation to gestation age in weeks, linear relationship was found between gestation age and TCD. The relationship has been shown in the scatter diagram. (Fig. 2)

The 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles of TCD measurements based on week of gestation were then derived using the relationship of mean $\pm z$(SD), where $z$ is the standard normal deviate with values $\pm 1.645$ for the 5th and 95th percentiles, $\pm 1.28$ for the 10th and 90th percentiles, $\pm 0.68$ for the 25th and 75th percentiles and 0 for the 50th percentile. (The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.)

We found that cerebella in 29%, 10% and 61% cases were grade I, II and III respectively (Table 4). The grade changed from I to III progressively with advancing gestation. The median GA and TCD were 20 wks and 22 mm for grade I, 32 wks and 30 mm for grade II and 36 wks and 38 mm for grade III.

**Discussion**

If expected date of delivery is not known higher perinatal mortality is the obvious outcome. Hence,
determination of gestational age is of crucial importance in obstetrics. Indeed, prematurity and post maturity is the result of inaccurate estimation of gestational age. Though LMP is known to correlate best with the gestational age, it may act as a false guide when a woman is ignorant about her menstrual status. Hence, ultrasonography plays a central role in modern obstetric practice and that ultrasonographic examination should be recommended when indicated and performed with women's consent. Campbell et al (1994) established that ultrasonographic measurement of GA between 12-18 weeks is superior to an optimal menstrual history in predicting the date of delivery. The American Institute of Ultrasound in Medicine assessed theoretical harms in its safety assessment and concluded that “the benefits to patients of the prudent use of diagnostic ultrasound far outweighs any potential risk”14. Many traditional biometric parameter usage in determination of gestational age is in vogue, viz. bi parietal diameter, femur length, head circumference etc. but they have their own limitations and gradually usage of transverse cerebellar diameter in estimating gestational age is emanating in the field of radiology and it has already been well established in ultrasound literature as a reliable parameter.

Fetal studies have demonstrated the close relationship between the TCD and GA1,2,3,4,5,6,7,8,9,10 with linear growth of the TCD during the second trimester. The measurement of TCD in the fetus continues to be a useful indicator for GA even in the presence of abnormal skull shapes5,10 fetal growth restriction5,6 multiple pregnancies6,10 and large-for-dates foetuses10. Therefore, the TCD measurement of the fetus is resistant to these effects on other fetal measurements. Moreover, fetal head shape alteration does not affect this parameter. The transverse cerebellar diameter therefore represents an independent biometric parameter that can be used in both singleton and multifetal pregnancies to assess normal and deviant fetal growth16.

In our study linear relation of transverse cerebellar diameter with gestational age was established indicating the reliability of this new parameter in estimating gestational age & monitoring fetal growth. Moreover, progressive histological development, Purkinje cell differentiation in the cerebellum18 and progressive decrease in cerebellar water content19 with advancing gestational age was aptly reflected by the progressive change in cerebellar grade with advancing gestational age.

Conclusion

Gestational age of fetus of pregnant mothers not sure of their last menstrual period may be faithfully and reliably estimated by measuring transverse cerebellar diameter because a good correlation (r = -0.946; r² = 89.6% and p <0.001) has been shown. Apart from the fact that these values may allow intrauterine assessment of development of cerebellum, the increase in TCD along with the gestational age and progressive change of cerebellar grade also indicates that the utility of this study in assessing the development of fetus by measuring transverse cerebellar diameter.

References

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