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ORIGINAL ARTICLE

Normal morphometry of fetal posterior fossa at midtrimester: brainstem–tentorium angle and brainstem–vermis angle

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ABSTRACT

Objective To standardize the evaluation of normal tentorium insertion and normal rotation of the cerebellar vermis over the brainstem, using two novel measurements: the brainstem–tentorium angle (BT angle) and the brainstem–vermis angle (BV angle). We also aimed to test the reproducibility of these measurements.

Methods Prospective observational study including normal fetuses at routine anomaly scan with confirmed normal follow-up. Three-dimensional volumes of the fetal head were acquired starting from standard trans-cerebellar views. In the sagittal plane, obtained by multiplanar reconstruction, the angle between the brainstem and the tentorium insertion in the fetal skull, and between the brainstem and the lower edge of the vermis were measured twice by two independent operators. Intraobserver and interobserver variations were calculated.

Results Eighty cases were included. The estimated BT and BV angles lie in a wide interval among normal midtrimester fetuses with a median value (min–max) of 25.65 (20.13–47.39) and 9.29 (3.87–19.36) respectively. Intraobserver and interobserver variation were good for both measurements.

Conclusion The BT and BV angle may be of help in assessing the fetal posterior fossa at midgestation and gives a standardized and reproducible measurement of normal tentorium insertion and normal rotation of the cerebellar vermis over the brainstem.

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INTRODUCTION

Congenital anomalies of the fetal posterior fossa encompass a wide spectrum of findings whose clinical implications are variable and not fully elucidated. Among them the Dandy–Walker malformation is traditionally reported as the most severe one, being responsible for perinatal death or neurobehavioral disability in a significant proportion of cases.[1–4] On the other hand, Blake's pouch cyst is common and benign with low risk of clinical implications. It is therefore mandatory to differentiate between these two conditions, which are very similar at ultrasound but carry a very different prognosis. In all posterior fossa abnormalities, a wide communication between the fourth ventricle and the posterior fossa is the common ground. However, in accordance with a recent classification,[5] the upward insertion of the tentorium on the skull and the upward rotation of the vermis have been suggested as clue findings in the differential diagnosis. Unfortunately, both sonographic and radiologic evaluation of these critical findings are usually subjective and no reference charts for normal and abnormal cases have been provided to date.[5,6] The aim of our study was to standardize the evaluation of normal tentorium insertion and normal rotation of the cerebellar vermis over the brainstem, using two novel three-dimensional (3D) ultrasound measurements, the brainstem–tentorium angle (BT angle) and the brainstem–vermis angle (BV angle), and to test the reproducibility of these two measurements.

METHODS

From December 2010 to March 2011, all pregnant women consecutively attending routine anomaly scan at 20 to 21 weeks were selected for the purpose of this prospective observational study. Patients were excluded if any of the following conditions were present: evidence or suspicion of fetal structural or chromosomal abnormality, suspected fetal infection, multiple gestation or preterm premature rupture of membranes (PROM). Cases were included in the study only if the absence of congenital anomalies was confirmed at postnatal follow-up.

A 3D-volume of the fetal head was acquired transabdominally in the study using a Voluson E8, Pro, Exp (GE, Milan, Italy) equipped with a multifrequency probe. The starting plane for 3D insonation was slightly oblique in comparison with the axial transcerebellar plane, using the mastoid fontanel as acoustic window to reduce the shadow cast by the temporal bones on the posterior fossa. A maximum quality sweep of 50° was set for each acquisition and the volume dataset stored for off-line analysis. Ultrasound scans were performed by three experienced sonographers (RC, EC, TG).

Off-line analysis of the volumes was independently performed by two operators (EC, FDM) in the multiplanar mode using the static volume contrast imaging (VCI) mode of the 4D view software (9.0 version). The volumes were adjusted to achieve the midsagittal view of the brain in the C-plane, with the reference dot positioned in the middle of the tentorium, at the level of the calcarine fissures, in the coronal plane (B plane) (Figure 1). On the magnified C plane, the calculation of the following two angles was eventually carried out, being the BT angle and the BV angle.

The BT angle was defined as the angle formed by a line tangential to the dorsal part of the brainstem and a line starting from the upper limit of the quadrigeminal plate (the posterior commissure), and following the tentorial surface down to the occipital bone (Figures 2 and 3). The BT angle was assumed as a quantitative measure of the normal tentorial insertion on the skull.

The BV angle was defined as the angle formed by a line tangential to the dorsal part of the brainstem and a line starting from the tip of the pons and crossing the lower edge of the cerebellar vermis (Figures 2 and 3). The BV angle was assumed as a quantitative measurement of the normal rotation of the cerebellar vermis over the brainstem.

Each angle was measured twice by two independent operators (EC and FDM) and for each of the above mentioned measurements, intraobserver and interobserver reproducibility was calculated.

Analysis of measurement variation

The intraobserver and interobserver repeatability of the measurements were examined by intraclass correlation coefficients and their 95% confidence intervals (CIs). The overlap between the 95% CIs of two intraclass correlation coefficients was indicative of no significant difference between them. The best measurement is the one where first, the intraclass correlation coefficients are bigger and the 95% CI between measurements are smaller.

RESULTS

In the study period a volume dataset of the brain was sonographically obtained from 80 normal fetuses. Postnatal follow-up was normal in each case. Offline volume analysis by either examiner never exceeded 5 min for any single dataset, and lead to calculation of both BT and BV angle in all cases.

Both the variables for two the independent operators failed to display a normal distribution at Kolmogorov–Smirnov test and *p*-plot graphic. Therefore a nonparametric approach was used for comparison of mean values (Mann–Whitney *U*-test).

The estimated BT angle and the BV angle lie in a wide interval among normal midtrimester fetuses with a mean value (SD) of 25.65 (20.13–47.39) and 9.29 (3.87–19.36), respectively. No significant difference between males and females for both measurements was noted ($p < 0.005$).

Intraobserver and interobserver variation was good for both measurements as displayed in Table 1.

The two ultrasound measurements showed approximately the same intraobserver variation whereas the BV angle presented a higher interobserver reproducibility in comparison with the BT

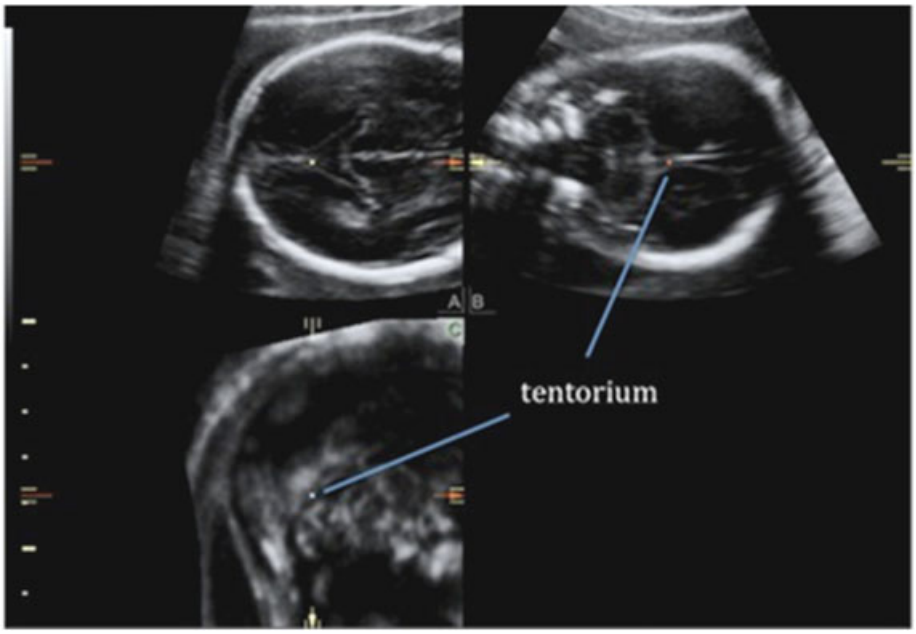

Figure 1 3D mutiplanar mode visualization of the tentorium in a normal fetus at 21 weeks

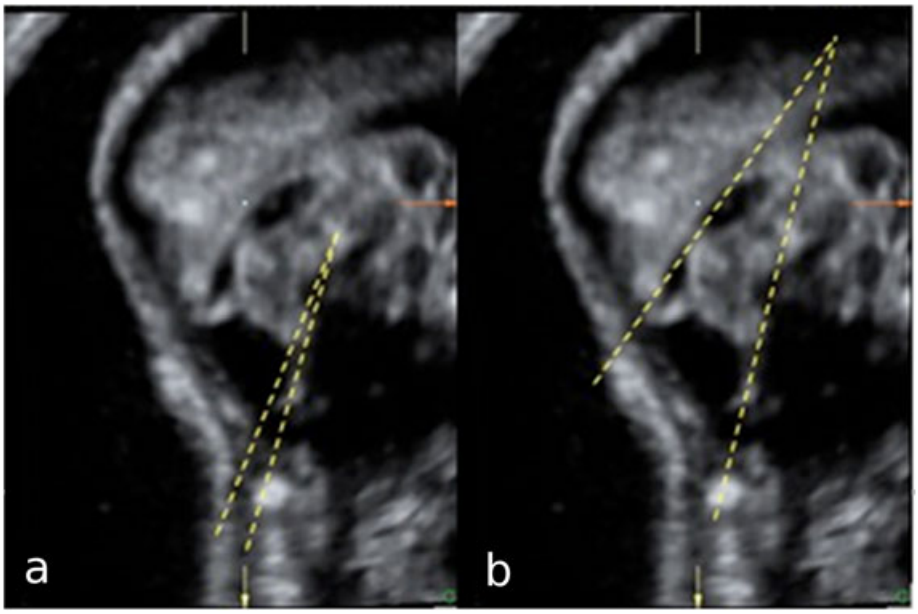

Figure 2 Magnified sagittal view of the fetal head reconstructed with three-dimensional multiplanar mode in a normal fetus at 21 weeks. (a) BV angle and (b) BT angle

angle, with the largest intraclass correlation coefficients (0.968 vs 0.909) and the smallest 95% CIs (0.955–0.978 vs 0.871–0.938).

DISCUSSION

The evaluation of the BT angle and the BV angle may be of help in assessing the fetal posterior fossa at midgestation and gives a standardized measurement, with good reproducibility, of normal tentorium insertion and normal rotation of the cerebellar vermis over the brainstem. On the basis of our results, measuring these two angles on static volume ultrasound appears feasible.

The measurements obtained at midtrimester for both BT and BV angle appear fairly constant with a narrow interval of values. Moreover, the intraobserver and interobserver agreement for both seems very good, with high intraclass correlation coefficient (ICC) and very small 95% CI. In particular, the interobserver reproducibility of the BV angle seems excellent.

These results may have useful implications in clinical practice. Indeed, our measurements of the BT and BV angles may be now looked at as a reliable reference when assessing the anatomy of the posterior fossa at midtrimester scan.

Prenatal detection and classification of posterior fossa abnormalities of the fetus is extremely difficult because sonographic visualization of an opened fourth ventricle does not allow to differentiate between the classical Dandy–Walker malformation and more benign conditions such as Blake's pouch cyst. In the differential diagnosis, the morphologic and biometric assessment of cerebellar vermis in the sagittal plane has been suggested.[7–10] In addition, the level of tentorium insertion and the degree of vermis rotation over the brainstem have been proposed as the clue findings for the differential diagnosis in posterior fossa abnormalities.[2] In particular, the supraelevation of the tentorium has been introduced as a major criterion for diagnosis of Dandy–Walker malformation,

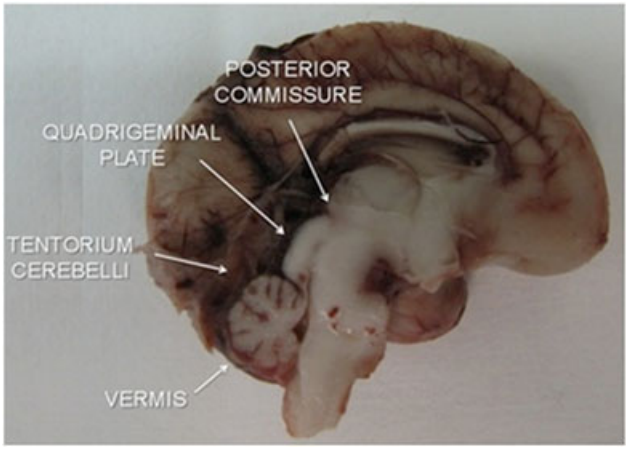

Figure 3 Anatomical specimen of a normal fetal brain at 21 weeks showing left hemisphere and midline structures

Table 1 Interclass correlation coefficient (ICC) for BT angle and BV angle to test intraobserver and interobserver reproducibility

Measurement	ICC	95% CI	*p*
BT angle	—	—	—
Intraobserver operator 1	0.911	0.864–0.942	<0.0001
Intraobserver operator 2	0.916	0.872–0.945	<0.0001
Interobserver	0.909	0.871–0.938	<0.0001
BV angle	—	—	—
Intraobserver operator 1	0.918	0.875–0.947	<0.0001
Intraobserver operator 2	0.911	0.865–0.942	<0.0001
Interobserver	0.968	0.955–0.978	<0.0001

while the upward rotation of the vermis seems to be a prognostic factor in the fetuses with Blake's pouch cyst.

To date, prenatal assessment of these parameters still remains mainly qualitative and based upon the subjective experience of the sonographer. A good effort to standardize the evaluation of fetal posterior fossa has been previously published.[11] These authors used the tentoroclivus angle, tentorovermian angle, and clivovermian angle obtained by 3D ultrasound at 18 to 37 weeks in a group of fetuses with normal and abnormal posterior fossa findings. However, we believe the anatomical landmarks involved in our series are easier to recognize and more reproducible, as shown by our results.

In conclusion, we have proposed two simple and reproducible sonographic parameters to quantify the level of tentorium insertion and vermis rotation in a normal midtrimester fetus. We strongly believe that BT and BV angle may represent a practical and objective tool in the sonographic assessment of suspicious findings of posterior fossa at midtrimester. It would be interesting to evaluate if and how the BT and BV angles would vary among normal and abnormal fetuses and this is actually the subject of a forthcoming paper from our group. Significant differences in the angle values have been found at preliminary assessment of data and if this will be confirmed on the whole series, the sonographic measurement of both BT and BV angle may become a critical tool in the differential diagnosis of posterior fossa abnormalities.

WHAT'S ALREADY KNOWN ABOUT THIS TOPIC?

- The level of tentorium insertion and the degree of vermis rotation over the brainstem seem to be the clue findings for the differential diagnosis in posterior fossa abnormalities but prenatal assessment of these parameters is mainly qualitative and based upon the subjective experience of the sonographer.

WHAT DOES THIS STUDY ADD?

- This study has proposed two simple and reproducible sonographic parameters (BT and BV angle) to quantify the level of tentorium insertion and vermis rotation in a normal midtrimester fetus.

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