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Interobserver Reproducibility of Intracranial Anatomy Assessment During Second Trimester Sonographic Scan

Erkan Kalafat[1*], Tuncay Yüce[2], Batuhan Aslan[3], Esra Ozkavukcu[4], Acar Koc[3], Feride Söylemez[3]

[1]*Department of Obstetrics and Gynecology, School of Medicine, Koc University, Istanbul, Turkey*
[2]*Private Clinic, Gaziantep, Turkey*
[3]*Ankara University Faculty of Medicine, Department of Obstetrics and Gynecology, Ankara, Turkey*
[4]*Ankara University Faculty of Medicine, Department of Radiology, Ankara, Turkey*

ABSTRACT

To evaluate the reproducibility of mid-trimester intracranial anatomy assessment.
Women undergoing mid-trimester scan (between 18th to 25th gestational weeks) for fetal anatomy assessment were included in the study. Measurements of lateral ventricle (LV), cisterna magna (CM) and transverse cerebellar diameter (TCD) were obtained for reproducibility analyses. Inter-observer reproducibility analysis was made with correlation coefficients.
A total of 162 women were included in the analysis while one woman was excluded from the study due to diagnosis of vermian agenesis. Correlation coefficient (CC) of cisterna magna measurements have shown weak to moderate interclass correlation (r=0.28, P=0.001). Measurements of lateral ventricle have shown moderate to strong interclass correlation (r=0.73, P<0.0001). Transverse cerebellar diameter measurements have shown the best interclass correlation (r=0.88, respectively P<0.0001). Mean difference between different observers were -0.4 mm (95% CI: -3.0 to 2.1 mm), 0.7mm (95% CI: -1.0 to 2.5 mm) and 0.53 mm (95% CI: -2.5 to 3.6 mm) for measurements of cerebellum, lateral ventricle and cisterna magna, respectively. When grouped according to BMI (Over 30 kg/m2 and lower than 25 kg/m2) and presentation (cephalic and breech), there were no differences between groups regarding the prevalence of an absolute difference greater than 1 mm between paired measurements by different observers.
Measurements of TCD, LV and CM during mid-trimester scan have good interobserver reliability with the exception of CM measurements. Methods used for measuring these structures have shown good consistency between different BMI categories and different fetal presentations during ultrasound scans.

Keywords: Reliability, scan, rescan, lateral ventricle, atrium, cisterna magna, routine, correlation, agreement

Introduction

The routine mid-trimester ultrasound scan is an important part of antenatal screening and many countries offer the scan to all pregnant women regardless of perceived individual risk(1). For purposes of standardization and performance improvement of mid-trimester scans, the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) issued a guideline on the subject(2).

The ISUOG guideline on routine mid-trimester ultrasound scan describes the anatomical structures that should be routinely assessed. According to the guideline anatomical structures of cavum septi pellucidi, midline falx, thalami, cerebral ventricles, cerebellum and cisterna magna should be assessed(2). Among five of these structures, quantitative assessment of lateral ventricle, cerebellum and cisterna magna are recommended and methods of measurement have been described(3). However, despite wide acceptance of utilizing these measurements for recognition of intracranial anomalies, studies on interobserver reliability of measurements are lacking.

The aim of the present study is to document interobserver reliability of measurements of lateral ventricle width, cisterna magna depth and transverse cerebellar diameter. A secondary objective of the study is to investigate possible factors effecting the reproducibility of measurements such as BMI and fetal presentation.

***Corresponding Author:** Erkan Kalafat, Topkapı, Koç Üniversitesi Hastanesi, Davutpaşa Cd. No:4, 34010 Zeytinburnu/İstanbul
E-mail: mail@erkankalafat.com
ORCID ID: Erkan Kalafat: 0000-0003-0658-138X, **Tuncay Yüce:** 0000-0002-7085-5878, **Batuhan Aslan:** 0000-0002-0785-0919, **Esra Ozkavukcu:** 0000-0002-2202-7760, **Acar Koc:** 0000-0003-2482-7478, **Feride Söylemez:** 0000-0002-0816-5577
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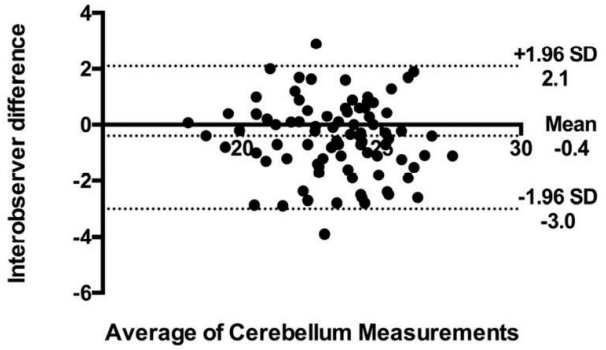

Fig. 1. Bland-Altman plot of inter-observer difference of cisterna magna measurements (SD, standard deviation)

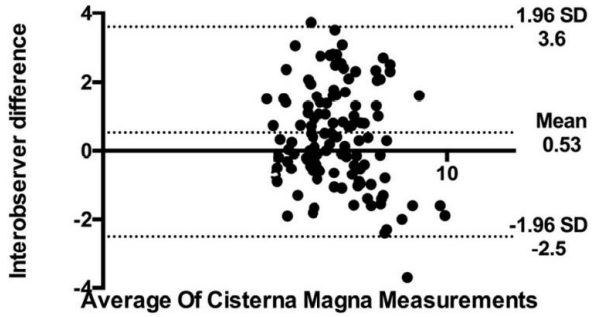

Fig. 2. Bland-Altman plot of inter-observer difference of lateral ventricle measurements (SD, standard deviation)

Materials and Methods

This was a retrospective cohort study conducted between December 2015 and April 2015. Women with singleton pregnancies who were scheduled for routine mid-trimester ultrasound scan between 18 and 25 weeks of gestation were included in the study. Fetuses diagnosed with severe congenital anomalies that would interfere with the measurements (i.e. holoprosencephaly, cerebellar agenesis etc.) and twin pregnancies were excluded from the study. Measurements of cisterna magna depth, transverse cerebellar diameter and lateral ventricle width were obtained from stored DICOM images for interobserver reliability analyses. Measurement were taken by one radiologist (EO) during detailed second trimester anatomy scan and one perinatology fellow (TY) during second trimester biometry scan as per institutional protocol. All examiners were qualified sonographers with a good record of successfully performed mid-trimester ultrasound scans.

Measurements of cisterna magna depth and transverse cerebellar diameter were obtained in the transverse cerebellar plane. Cisterna magna depth were measured between the cerebellar vermis and the

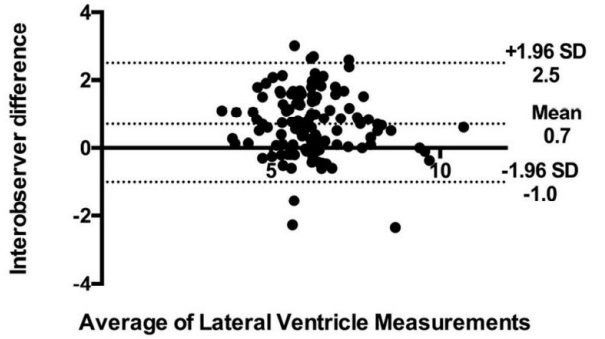

Fig. 3. Bland-Altman plot of inter-observer difference of transverse cerebellar diameter measurements (SD, standard deviation)

internal table of occipital bone. Transverse cerebellar diameter were measured in a straight line perpendicular to the line of falx cerebri. The lateral ventricle was measured in the transventricular plane with the technique described by L. Guibaud(4). The biparietal diameter was also measured to ensure the measurements were performed within the appropriate gestational week. All measurements were recorded in millimeters. Ultrasound examinations were performed and recorded with the Voluson E6 System using a 2 to 5 MHz convex probe (GE Healthcare Austria GmbH, Zipf, Austria).

Reliability of measurements were documented with interclass correlation coefficient (inter -CC) analyses. Correlation coefficient demonstrates the consistency of measurements between different examiners (inter-CC). Correlation coefficient documents the consistency on a scale of 0 to 1.00, where 0 means no consistency and 1.00 means perfect consistency. Bland-Altman plots were used to demonstrate the repeatability of measurements(5). Bland-Altman plots calculate a mean difference between measurements using the scan and rescan data from the same examiner. A mean difference of 0 between measurements documents perfect reproducibility.

Effects of presentation and body-mass index of patients on absolute differences of inter-observer measurements were analyzed. Absolute differences in each set of measurements were calculated as absolute value of difference between two paired measurements. Effects of BMI and presentation on relative difference of each set of measurements were analyzed with Chi-Square test. Women were categorized into two regarding their BMI (Obese; Over 30kg/m2, Normal; Below 25kg/m2). A cut-off of 1mm was used arbitrarily as a clinically significant absolute difference between measurements. Statistical analyses of inter-CC, intra-CC and chi-square tests were performed with R for Windows (Version 3.1.3, https://www.r-project.org/) and Bland-Altman plots were obtained with MedCalc software (Version 11.6,

Table 1. Baseline Characteristics of Study Population

Variables	Values
Gestational week at scan	22 weeks (17 to 25 weeks)
Body-mass index	25.99 kg/m2 (18.29 to 37.60 kg/m2)
Presentation (Breech/Cephalic)	80/78
Cisterna magna depth (Examiner A)	7.12 mm (1.23 mm)
Cisterna magna depth (Examiner B)	6.59 mm (1.38 mm)
Lateral ventricle width (Examiner A)	6.58 mm (1.21 mm)
Lateral ventricle width (Examiner B)	5.83 mm (1.32 mm)
Transverse cerebellar diameter (Examiner A)	23.11 mm (1.98 mm)
Transverse cerebellar diameter (Examiner B)	23.72 mm (2.21 mm)

Table 2. Inter and Intraobserver Correlation Coefficients of Intracranial Structures

Variable	Interclass CC(95%)	P value
Cisterna magna	0,28 (0,11 to 0,43)	0.001
Lateral ventricle	0,73 (0,63 to 0,80)	<0.0001
Transcerebellar diameter	0,88 (0,80 to 0,93)	<0.0001

Mariakerke, Belgium). Quantile-quantile plots were used to test normality assumptions of variables and P values below 0.05 were considered statistically significant. Study was started following departmental approval and only used anonymized DICOM images of patients.

Results

A total of 162 women were included in analysis. During the inclusion period two fetuses were diagnosed with agenesis of corpus callosum, one fetus was diagnosed with septa-optic dysplasia and one fetus was diagnosed with mega cisterna magna. Only one fetus who was diagnosed with vermian agenesis was excluded from the study. Baseline characteristics of study population can be seen in Table 1.

Correlation coefficients have shown measurements of cisterna magna have weak to moderate inter-observer reliability (r=0.28, P=0.001). Measurements of lateral ventricle have shown moderate to strong inter-observer reliability (r=0.73, P<0.0001). Measurements of cerebellum have shown strong interobserver reliability (r=0.88, P<0.0001). Inter-CC values with 95% confidence interval of each parameter are shown in Table 2.

Bland-Altman plots of interobserver difference of cisterna magna measurements (Figure 1), interobserver difference of lateral ventricle measurements (Figure 2), interobserver difference of transverse cerebellar diameter measurements (Figure 3) are shown in their respective figures.

Discussion

In this study we aimed to assess the interobserver reliability of intracranial anatomy assessment during mid-trimester scan. Our analysis have revealed measurement methods of lateral ventricle and transverse cerebellar diameter are both reliable between different operators. Measurements of cisterna magna have weak to moderate inter-observer reliability. Until a better method of assessment is available, a careful reevaluation of cisterna magna should be performed when a patient is referred for abnormalities in cisterna magna measurements. After that initial assessment, the same operator should perform subsequent scans to avoid misinterpretation of clinical status.

Our study has an advantages of being a blinded assessment (anonymized images) with a good sample size to determine the reliability of intracranial anatomy scan. We have also investigated potential confounders that would have affected the reliability of the methods. A short coming of our study is that we didn't measure the exact time elapsed between the examinations. Arguably, this would have affected the measurements but the time interval between the measurements less than a day in most cases. Another weak point of our study is that only a few of the measurements we obtained were within abnormal range. This limits the extent that we can generalize our findings to abnormal range.

Studies on reliability of intracranial assessment are sparse. A study on reliability of these measurements via magnetic resonance imaging were conducted by

Tilea et al. in 2009(6). Authors reported interclass correlation coefficients and mean bias between measurements with 95% limits of agreements. Between that study and ours, only measurements of transverse cerebellar diameter and lateral ventricle atrium were similar. In their study, Tilea et al. reported an ICC of 0.93 (95% CI: 0.88 to 0.96) for TCD measurements and an ICC of 0.66 (95% CI: 0.46 to 0.79) for lateral ventricle measurements. These results are very similar to our findings but we have observed a higher ICC for measurements of lateral ventricle. This may be due to different methodology employed by the authors compared to the method we have used(4, 7). Future studies should be performed to compare two methods of lateral ventricle measurements to determine which method has better reproducibility. A steep angle in transverse cerebellar plane has been described as a potential pitfall while evaluating posterior fossa. Increasing angle of the plane is associated with increasing cisterna magna depth. We suspect this was the principal reason behind the observed poor correlation coefficient in between different observers. Also another method of assessment for cisterna magna is desirable as current method has very weak interobserver reproducibility.

Results of our study demonstrate methods used in assessing intracranial anatomic structures during mid-trimester scan are most reliable. Future studies should focus on establishing a new method of measurement for cisterna magna which is less dependent on the scanning angle.

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