ORIGINAL ARTICLE

Coronal approach for measuring both fetal lateral ventricles: is there an advantage over the axial view?

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ABSTRACT

Objective This study aimed to compare measurement of the lateral cerebral ventricular diameter using either the traditional axial view or the coronal plane.

Materials and methods We performed a prospective study on 144 fetuses, 77 evaluated as part of a routine fetal scan and 67 referred for a neurosonogram. Distal lateral ventricles were measured both in axial and coronal plane.

Results Good visualization of the ventricles was achieved in 91% of the cases using the coronal plane (both ventricles) and in 95% of the cases using the axial plane (only the distal ventricle) ($p > 0.001$). The mean width of the distal lateral ventricle in the axial plane was 7.9 ± 1.9 mm versus 8.2 ± 1.9 mm on the coronal plane ($p < 0.001$). This larger diameter by 0.3 mm was not dependent on the indication for the scan or the gestational age. Slight asymmetry was present on coronal images in the routine group (0.2 mm), and that was even larger in the referral group (1.6 mm) ($p < 0.001$).

Conclusion Coronal measurement of both ventricles is feasible and has the advantage over measurement in the axial view in which only the distal ventricle is clearly visible and measurable. © 2013 John Wiley & Sons, Ltd.

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INTRODUCTION

Ventricular dilatation is one of the most common, prenatally diagnosed, cerebral abnormalities.[1,2] Ventriculomegaly is defined as an atrial diameter exceeding 10 mm.[3,4] The prognosis of ventricular dilatation depends on the degree of the dilatation and the presence of associated cerebral or extracerebral abnormalities.[5] Thus, exact measurements of the lateral ventricles are extremely important. For this reason, assessment of the size of the lateral ventricles is a crucial part of the routine sonographic evaluation of the fetus.[6,7] Guidelines for these measurements have been suggested using the axial transventricular plane.[8–10] In the axial plane, typically a near-field artifact causes a technical difficulty in measuring the proximal ventricle, hindering accurate measurement of both ventricles (Figure 1). Scanning in the posterior coronal plane at the level of the atria allows simultaneous measurement of both ventricles as performed by using magnetic resonance imaging.[11]

The aim of this study was to compare the diameter of the lateral ventricles measured by traditional axial view with measurements obtained in the coronal plane.

To our knowledge, this comparison has not been addressed in the literature to date.

MATERIALS AND METHODS

We performed a prospective study, during a 1-year period (2011), in a single tertiary medical center (Sheba medical center). During this period, 144 single fetuses were examined at 19 to 38 weeks of gestational by a single operator (E. K.). The inclusion criteria were single pregnancy, gestational age confirmed by sonographic examination during the first trimester, estimated fetal weight within the 10th to 90th percentile, absence of maternal or fetal disease (e.g. diabetes, pregnancy-induced hypertension/pre-eclampsia, intrauterine growth restriction, cytomegalovirus infection, and red cell antibodies), and no known maternal or previous sibling with a neural tube defect. Seventy-seven fetuses were evaluated as part of a routine fetal scan (routine, low-risk group), and 67 were referred for a neurosonogram due to suspected mild ventriculomegaly (10–12 mm) or asymmetry (discrepancy of more than 2 mm) of the lateral ventricles (referral, high-risk group). Fetuses with other central nervous system or genetic abnormalities were not eligible.

The exams were performed on Voluson E-6 and E-8 (GE Medical Systems, Zipf, Austria) ultrasound platforms, equipped with a transabdominal, multifrequency (4–8 MHz) probe.

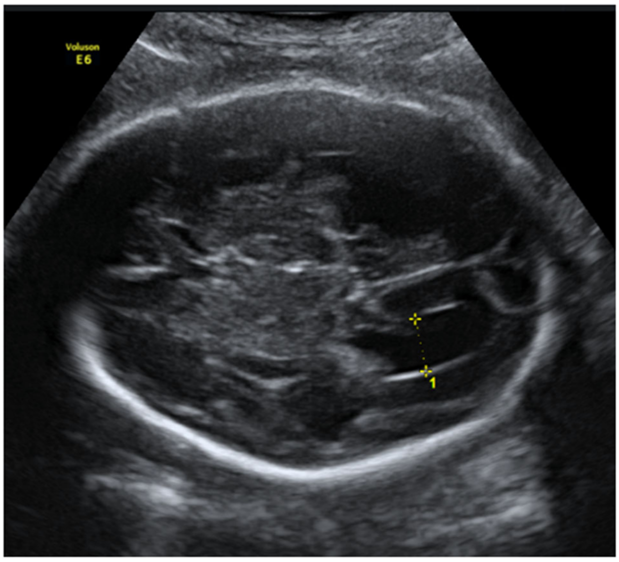

Figure 1 Axial, transventricular plane of the fetal head. The distal ventricle is well depicted, whereas the proximal one cannot be seen because of near-field artifacts

For each fetus, two-dimensional sonographic measurements of the lateral ventricles were performed in axial and coronal planes. In the transventricular axial plane, the distal lateral ventricle diameter was measured (Figure 2, plane a), whereas both ventricles were measured in the posterior coronal plane using a transcerebellar approach (Figure 2, plane b). In the axial plane, the distal lateral ventricle diameter was measured according to the recommendations of Guibaud,[9] which suggested an 'image scoring method' based on five precise criteria in the technique of measuring the distal lateral ventricle.

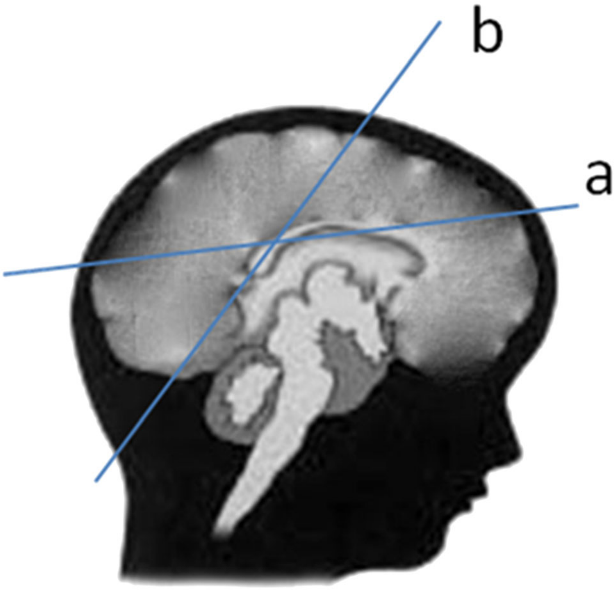

Figure 2 Axial versus coronal view of the fetal head: (a) axial transventricular plane, (b) posterior coronal plane at the level of the atria using a transcerebellar approach

In the coronal plane, to measure the trans cerebellar diameter of the cerebellum, both trigones of the lateral ventricles with the choroid plexus should be visible[12] (Figure 3). Both ventricles should be seen to be equidistant from the midline. Measurements were obtained at the level of the atria (i.e with good visibility of the choroid plexuses), on an axis perpendicular to that of the ventricle and at the mid-height of the ventricle.[11] For both planes, calipers were positioned inside the echoes generated by the ventricular walls (Figures 1 and 3) as recommended by the ISUOG guidelines for sonographic examination of the fetal central nervous system.[8]

The study was approved by the local institutional ethics committee.

Statistical analysis

The width of the measured ventricles in the different planes was compared and statistically analyzed using IBM SPSS Software version 9.0.

Continuous variables are presented as mean ± standard deviation. Kolmogorov–Smirnov tests were performed to evaluate the distribution of measurements in the study sample. To compare between the two groups (routine versus referral scans), independent *t*-tests were performed. Paired sample *t*-tests were conducted for testing the differences between the measurements of the distal ventricles on the axial and coronal planes, followed by the Pearson correlation between the two paired measurements. The linear correlation coefficients were demonstrated by a scatter plot, and the distributions of ventricular size according to the indication of scan were demonstrated by a box plot. To study concordance between two measurements in each group, the interclass correlation coefficient with 95% confidence intervals (CI)[13] was calculated on the basis of Bland–Altman analysis. The significance level (p) was set at 0.05.

The statistical power of detecting clinically meaningful differences with normal measurements of 6 mm was 80% under a type 1 error of 0.05 and desired precision of ±10% (0.6 mm).

RESULTS

We collected measurements in 144 fetuses at a mean gestational week of 27.7 ± 4.6 weeks (range 19–38). The fetal presentation was breech in 32 cases (22.2%), cephalic in 107 cases (74.3%), and transverse in 5 cases (3.5%). There were 77 routine and 67 referral scans (Table 1).

Good visualization of both ventricles in the coronal plane was achieved in 131 cases (91%), whereas good visualization of the distal ventricle in the axial plane was achieved in 137 cases (95%) ($p > 0.001$). Failures were in cases with more advanced gestational age, maternal obesity, or when the fetus was in cephalic presentation with posterior position of the occiput ($p < 0.001$).

The mean width of the distal lateral ventricle on the axial plane was 7.9 ± 1.9 mm versus an average of 8.2 ± 1.9 mm on the coronal plane ($p < 0.001$). This increase of 0.3 mm using the coronal plane was constant and was not influenced by the indication for the scan (routine or referral) (Table 1).

Conversely, there was a significant difference in the atrial diameter according to the indication of the scan: In the axial

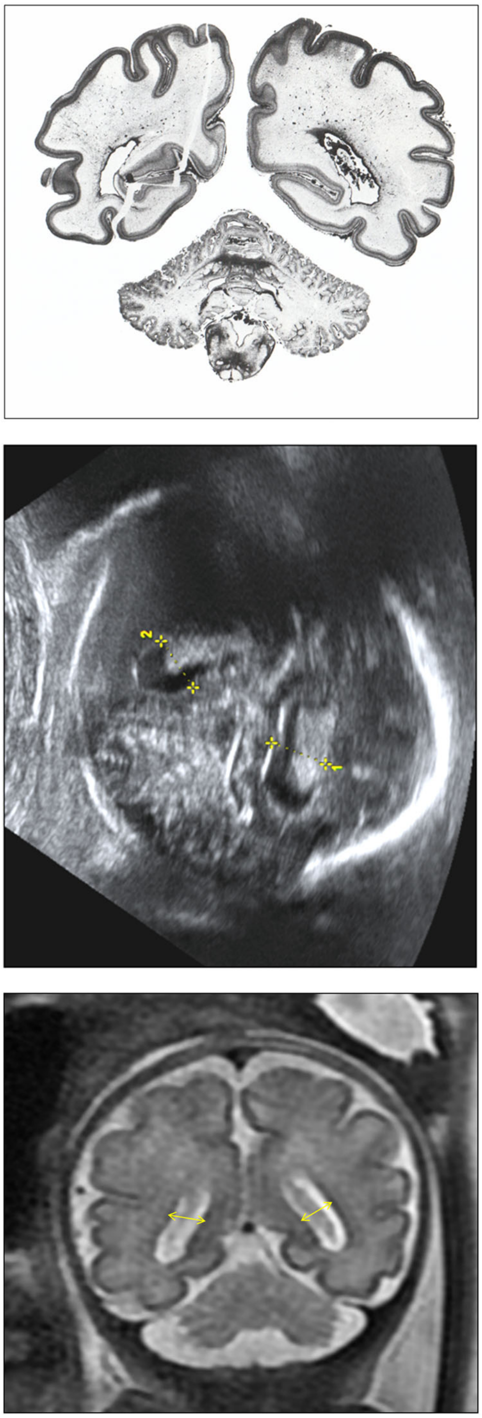

Figure 3 Landmarks for measurement of the ventricular atrial width using the coronal plane: (a) anatomical view of this coronal section[13]: For measurement of the trans cerebellar diameter of the cerebellum, both trigones of the lateral ventricles with the choroid plexus should be present. (b) Transcerebellar ultrasonographic approach: Both proximal and distal ventricles are visible and easily measured on one image. Both ventricles should be seen to be equidistant from the midline. Measurements should be obtained at the level of the atria, on an axis perpendicular to that of the ventricle and at the mid-height of the ventricle and with good visualization of both choroid plexuses. Axial transventricular plane: Only the distal ventricle is visible (Figure 1). (c) Coronal measurements of the lateral ventricles as performed by using MRI modality

Table 1 Descriptive statistics of the study population

	Mean ± SD			
	Total $n=144$	Routine $n=77$	Referral $n=67$	p-value
Week of gestation	27.7 ± 4.6	26.1 ± 4.2	29.5 ± 4.2	<0.001
Distal ventricle – axial measurement	7.9 ± 1.9	6.6 ± 1.1	9.3 ± 1.6	<0.001
Distal ventricle – coronal measurement	8.2 ± 1.9	6.9 ± 1.1	9.6 ± 1.6	<0.001
Proximal ventricle – coronal measurement	7.3 ± 1.4	6.7 ± 1.0	8.0 ± 1.5	<0.001

measurement, the diameter was 6.6 ± 1.1 mm in the routine group versus 9.3 ± 1.6 mm in the referral group ($p < 0.001$). Coronal measurements of the distal ventricle showed the same difference (6.9 ± 1.1 vs 9.6 ± 1.6) ($p < 0.001$) (Table 1).

There was a strong correlation (0.98) between the measurements of the distal ventricles in the axial and coronal planes (Figure 4), even when we divide the groups according to the indication for the scan (Table 2). No correlation was found between the measurements of the distal lateral ventricle and the week of gestation (Table 2).

The interclass correlation coefficient for referral group was equal to 0.95 with 95% CI 0.92 to 0.97 and for routine group 0.92 (CI 0.88–0.95), indicating high level of agreement between two measurements.

The ventricular size measurements had almost a symmetrical distribution. The distributions of ventricular size according to the indication of the scan were not similar. In the referral group, the average atrial diameter was greater when compared with the routine group ($p < 0.001$). Coronal measurements in the routine

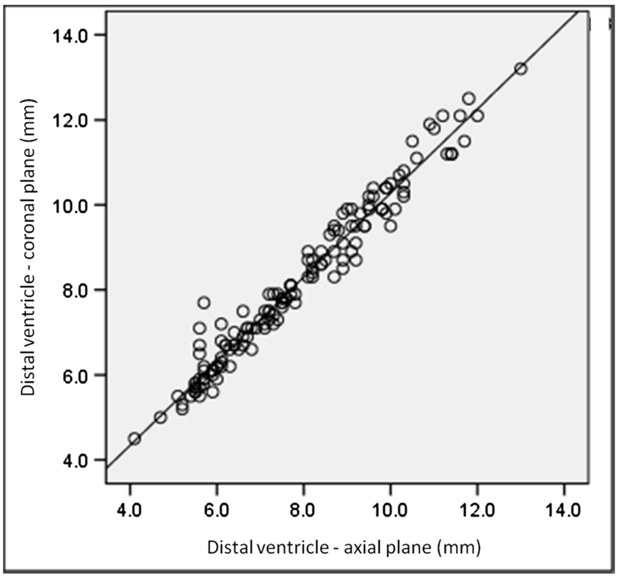

Figure 4 A scatter plot, which demonstrates the correlation between the measurements of the distal ventricles diameter on both planes

Table 2 Pearson correlation between the measurements of the distal ventricle on the axial plane, to coronal measurements of the same ventricle, and to the week of gestation ($p < 0.01$)

	Total	Routine	Referral
Correlation coefficient between axial and coronal measurements of the distal ventricle	0.98	0.95	0.97
Correlation coefficient between axial measurements of the distal ventricle and the week of gestation	0.36	0.25	0.05

group revealed slight asymmetry of the ventricles (0.2 mm), whereas in the referral group, the asymmetry was more significant (1.6 mm) ($p < 0.001$) (Figure 5).

DISCUSSION

Ventriculomegaly is an excess of fluid in the ventricles of the brain.[10] It is the most common brain abnormality found on prenatal ultrasound[14] with a reported incidence that varies from 1.48 per 1000 births in a low-risk population to 22 per 1000 births in a high-risk population.[15]

Ventriculomegaly can have various causes such as spina bifida, obstructive disorders, congenital infections, and intracerebral hemorrhage and can occur without any evident etiology. Ventriculomegaly can be associated with agenesis of the corpus callosum, Dandy–Walker complex, neuronal proliferation/migration disorders, and chromosomal abnormalities.[5]

Over 20 years ago, it was already established that the normal atrial diameter remains relatively constant throughout gestation and has a normal distribution.[10,16] Since these pioneer studies, 10 mm is considered to be the upper limit of the normal range for lateral ventricular measurement in an axial plane.[17–20] Normal ranges for cerebral ventricular width are usually based on parametric methods, which define cut-off values on the basis of mean value and their standard deviation. The 10-mm cut-off is derived from several series that established this cut-off as being +3 or 4 SD above the mean, depending on the study.[3,17,21]

When the axial diameter, measured across the atrium of the ventricle at any gestational age, exceeds 15 mm, ventriculomegaly is considered to be severe.[10,17–20] Ten to 12 mm and 12 to 15 mm, respectively, are considered mild and moderate ventriculomegaly with a different prognosis for each.[22–24] The prognosis of ventricular dilatation depends on the degree of the dilatation along with the presence of associated cerebral, extracerebral, and/or chromosomal abnormalities.[5,25,26] Thus, exact measurements of the lateral ventricles are extremely important.

Asymmetry of the lateral ventricles with unilateral ventriculomegaly was found to be a significant risk factor for developmental delay[27]; therefore, both lateral ventricles (proximal and distal) should be measured carefully.

Clinically, assessment of the atrial diameter of the lateral ventricles is recommended for screening for ventriculomegaly.[6,7]

The diagnosis of ventriculomegaly will prompt further investigation of the brain (neurosonogram), which eventually may lead to the detection of other pathology.[28]

Currently, also when a neurosonogram is indicated, the axial approach is recommended for measurements of the lateral ventricles, although only the distal part is clearly visible.[8]

Historically, there have been variations in technique for measurement of the lateral ventricules in the axial plane. In the methodology of Cardoza,[10] the atrium is measured at the level of the smooth posterior margin of the choroid plexus. However, the margin of the choroid plexus may change depending on the degree of ventricular dilatation and the shape of the ventricle. In the 2007 ISUOG guidelines,[8] measurement is obtained at the level of the glomus of the choroid plexus, perpendicular to the ventricular cavity, positioning the calipers inside the echoes generated by the lateral walls. Guibaud[9]

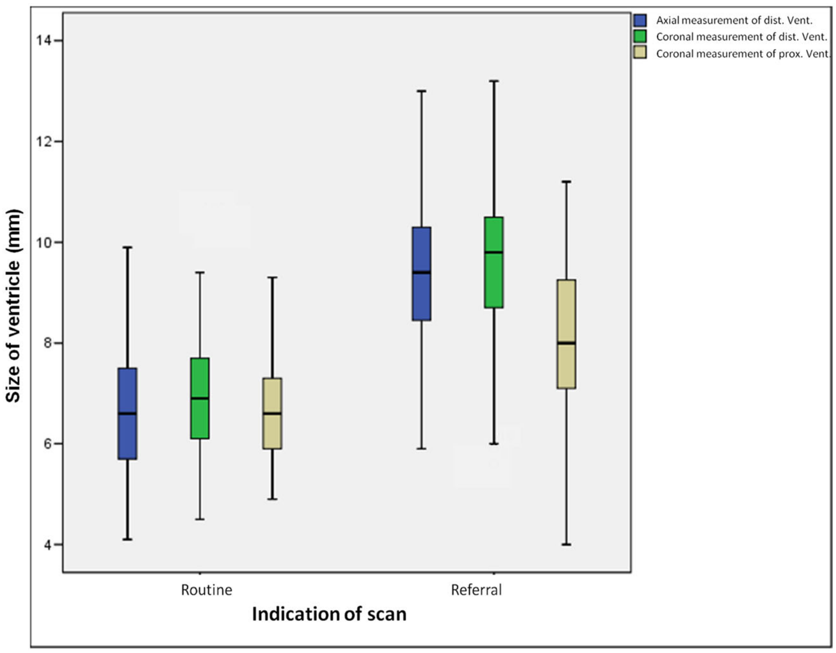

Figure 5 A box plot, which demonstrates the distribution of ventricular size according to the indication of scan

published criteria for high quality measurement; it has been shown that the internal parieto-occipital sulcus is a precise anatomical landmark for atrium measurement because it is located at the convergence of the parietal and occipital horns, which precisely defines the atrium.

Using the axial plane for measuring atrial width often results in a typical technical obstacle, that is, the presence of near-field artifacts, which permit measuring only the more distal ventricle (Figure 1).

Browning *et al.*[29] have described a technique to visualize and measure the proximal ventricle using an oblique view, which does not visualize both ventricles simultaneosaly. Hilpert *et al.*[19] compared coronal and axial measurements and discovered that the discrepancy between the two measurements was ≤2 mm in 98% of the cases. In that study, an accurate description of how the lateral ventricle was measured in the either plane was missing. Garel *et al.*[11] showed that when atrial diameter is measured on a coronal slice by ultrasound imaging and magnetic resonance imaging, the two techniques are in close agreement.

Herein, we have compared measurements of the lateral ventricular diameter by using coronal and axial planes, in low-risk and in high-risk patients, in order to determine whether the coronal plane could serve as a reliable additional plane for measuring both atria at the same time.

As far as we know, an ultrasonographic study comparing coronal and axial measurements of the lateral ventricles using precise criteria has yet not been reported.

Our study shows that measurement by either techniques correlates very well, irrespective of the indication and the gestational age. The study sample was sufficient to reveal statistically significant correlation between the two approaches. Coronal plane measurements were on average 0.3 mm larger compared with the axial plane measurements, which is probably without clinical significance. It should be noted that good visualization of both ventricles was achieved in 91% of cases using the coronal plane.

As expected, the atrial diameter was larger both in the coronal and in axial planes in the referral group compared with the routine group. In addition, asymmetry between the proximal and distal ventricles was evident in the referral group.

CONCLUSION

Clinically, measurement of both proximal and distal ventricles is very important in the diagnosis of ventriculomegaly and is essential for diagnosis ventricular asymmetry. We have shown that coronal measurement of both proximal and distal ventricles are feasible, which is an advantage over the axial view, in which only the distal ventricle is clearly visible and measurable. Coronal measurements can serve as additional approach to the axial view when both ventricles are not visible.

Ethics approval

The study was approved by the local institutional ethics committee (Sheba Medical Center) No. 8813-11-SMC from 25/08/2011.

Authorship

Eldad Katorza, Nir Duvdevani, conception, design, acquisition of data, analysis, and writing; Jeffrey-Michael Jacobson, analysis, writing, and revision; Yinon Gilboa, conception, design, and analysis; Chen Hoffmann, Reuven Achiron, conception, design, and revision.

All the authors approved the final version to be published.

WHAT'S ALREADY KNOWN ABOUT THIS TOPIC?

- Measurement of both proximal and distal ventricles is very important in the diagnosis of ventriculomegaly and ventricular asymmetry. So far, only the distal ventricle is measured routinely using an axial plane.

WHAT DOES THIS STUDY ADD?

- Coronal measurement of both ventricles is feasible and has the advantage over measurement in the axial view in which only the distal ventricle is clearly visible and measurable.

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