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ORIGINAL ARTICLE

The Role of 2D and 3D Ultrasonography in Detection of Central Nervous System Anomalies in 2nd Trimester

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Abstract

Background: **Central nervous system (CNS) defects are the most frequent malformations and can be detected with conventional prenatal ultrasonography (US). 3D imaging allows for the simultaneous assessment of the fetal central nervous system in three orthogonal planes, better defining the spatial relationship of CNS components and abnormalities.**

Objective: **The value of traditional 2D and modern 3D ultrasound in the diagnosis of CNS anomalies during the second trimester of pregnancy (18–22 weeks of gestation) is evaluated, and the importance of fetal neurosonogram in the detection of CNS anomalies is highlighted.**

Methods: **This was a prospective descriptive study, conducted at Al-Hussein and Bab El-Sheirya (Sayed Galal) Hospitals, Al-Azhar University on 40 pregnant females with CNS anomalies who were examined and evaluated sonographically. They came for routine antenatal screening or for confirmatory advice from another place during the period from November 2021 to May 2022.**

Results: **There was no statistically significant difference between 2D and 3D ultrasonography in the detection of all studied fetal CNS anomalies. The sensitivity of 2D was 83.33%, specificity was 62.5%, and accuracy was 80% and the sensitivity of 3D was 88.09%, specificity was 71.8%, and accuracy was 85.5%.**

Conclusion: **This study concluded that conventional 2D had a comparable and accurate screening and diagnostic validity in the diagnosis of CNS anomalies during the second trimester of pregnancy compared with modern 3D ultrasound.**

Keywords: Central nervous system anomalies, Second trimester, Three-dimensional, Two-dimensional, Ultrasonography

1. Introduction

Congenital malformations are anatomical, behavioural, functional, and metabolic problems that arise during intrauterine life and can be identified during pregnancy, at birth, or later in infancy. They have a significant impact on neonatal morbidity and death. 7.9 million children are thought to be affected each year by major congenital abnormalities, which are defined as anomalies that have a significant influence on life expectancy and affect 2–3% of live births and 20–30% of stillbirths.[1]

More than 90% of congenital abnormalities occur in LMICs, which have higher death rates and poor incomes. Numerous survivors also experience permanent disabilities.[2]

20–25% of perinatal deaths are caused by congenital abnormalities. About 15% of baby deaths in Egypt are attributable to congenital abnormalities, which has an adverse effect on neonatal morbidity.[1]

Ultrasound screening of structural fetal malformations is mainly based on the utilization of ultrasound during the second trimester of pregnancy.[3]

While the Royal College of Obstetricians and Gynecologists advises performing the second-

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trimester fetal anatomical exam between 20 and 23 weeks into pregnancy, other sources advise waiting until after 18 weeks and before 22 weeks to perform the second-trimester ultrasound.[4]

Neurosonograms, including 2D scan performed by an expert ultrasonographer in a tertiary center had an accuracy of 91.3%, while MRI obtained an accuracy of 94.4%.[5]

2. Methods

This was a prospective descriptive study, conducted at Al-Hussein and Bab El-Sheirya (Sayed Galal) Hospitals, Al-Azhar University on 40 pregnant females with CNS anomalies who came for routine antenatal screening or for confirmatory advice from another place during the period from November 2021 to May 2022.

2.1. Inclusion criteria

Women aged 19–39 years old with body mass index ≤30 kg/m^2 on the second trimester of pregnancy suffering from CNS diseases with ultrasound findings suggestive of fetal anomalies.

2.2. Exclusion criteria

Pregnant women on CNS medications or had risk factors of fetal malformations as family history, positive consanguinity or medical disorders as diabetes mellitus were excluded from the study.

2.3. Study procedures

All study participants were introduced to the researcher, who then requested their participation after briefly outlining the study's objectives.

All participants got thorough information on the study's goal and anticipated advantages. The entire project was conducted with the utmost ethical consideration.

All participants provided verbal consent after being informed, and information confidentiality was guaranteed.

A formal written administrative permission letter was given by the administrators of Al-Hussein and Bab El-Sheirya (Sayed Galal) Hospitals, the dean of the faculty of medicine at Al-Azhar University, and the head of the department of obstetrics and gynecology.

To ensure their cooperation, the study's title and goals were explained to them.

All cases were given a thorough history, which included maternal age, gestational age, a history of consanguinity, a positive family history of fetal anomalies, a history of diabetes, and any other risk factors.

All cases underwent fetal biometry, which measured the femur length, head circumference, abdominal circumference, and biparietal diameter (BPD), among other anatomical features.

A Doppler study of the umbilical and middle cerebral arteries, as well as the ductus venosus, was performed.

2.4. Equipment and technique

The device used in the study for 2D and 3D ultrasound was Volsun E6 and traditional 2D ultrasound scans was performed to evaluate fetal brain in the axial plane through trans thalamic, trans ventricular, and trans cerebellar views.

The following parameters were measured: BPD, HC, lateral ventricle width, third ventricle width, cerebellar diameter, and cistern magna diameter.

The shape of the skull was investigated, as well as the presence of the cavum septum and corpus callosum in the sagittal or coronal planes.

Three-dimensional and four-dimensional ultrasound scans are evaluated using a multiplanar view: it examines the brain in three spatial planes (axial, sagittal, and coronal), yielding an infinite series of images useful for a thorough evaluation of the brain's complex structure.

Preliminary diagnoses were made based on the findings discovered following the completion of the 2D scan, and 3D ultrasound was performed for instances that required further investigation.

When a 2D ultrasound discovered or suggested a problem, a 3D ultrasound volume was taken to scan the head areas as well as the area of interest.

The 2D images were compared to the 3D images, and the results were analyzed to see if equal, additional, or conflicting data was obtained.

2.5. Statistical analysis

Version 20.0 of the statistical software for social sciences was used to evaluate the recorded data (SPSS Inc., Chicago, Illinois, USA). The mean and standard deviation were used to convey quantitative data (SD). Frequency and percentage were used to express qualitative data.

3. Results

Mean ± SD of maternal age was 29.35 ± 7.92 years, gestational age was 20.75 ± 5.60 weeks and BMI was 26.01 ± 2.47 kg/m^2 (Table 1).

Three (7.5%) cases had a history of previous cytomegalovirus infection, 2 (5.0%) cases had previous toxoplasmosis infection, 1 (2.5%) case had previous chickenpox and the other had previous rubella infection (Table 2).

There was no statistically significant difference between 2D and 3D ultrasonography in detection of all studied fetal CNS anomalies (Table 3).

The sensitivity of 2D was 83.33%, specificity was 62.5%, and accuracy was 80% (Table 4).

Table 5.

4. Discussion

This study showed that there was in significant difference between both groups as regard maternal age or gestational age.

All pregnant women who were referred to the fetal medicine unit at Sheba Medical Center between 2005 and 2011 as a result of fetal CNS anomalies discovered at the end of the second and beginning of the third trimester after a normal anatomy scan at 21–24 weeks of gestation were the subjects of a retrospective cohort study by Yinon et al. (2013). At a median gestational age of 31.1 weeks during the study period, fetal CNS anomalies were discovered in 47 patients.[6]

In a research by Egbe et al. (2015) carried out in the USA, the cardiovascular (35.5%) and genitourinary (27.7%) systems were the most often impacted.[7]

This study demonstrated that there were no appreciable differences in CNS anomalies between the two groups.

Using ultrasound imaging, Dulgheroff et al.[8] gathered information during gestational weeks 11–13 + 6, 20–24, and 32–36 to check for fetal abnormalities before, during, and after delivery. The primary outcome measures were sensitivity, specificity, positive predictive value, and negative predictive value for the diagnosis and prevalence of congenital anomalies. In total, structural abnormalities were discovered during pregnancy and delivery in the amounts of 2.95% (79/2678) and 7.24% (194/2678), respectively. Ultrasounds were used to identify structural abnormalities in the first, second, and third trimesters at rates of 1.2% (13/1102), 4.4% (30/683), and 4.0% (36/893), respectively.

Table 1. Demographic data distribution among study group.

Demographic data	Total (n = 40)
Age (years)	
Range	19–39
Mean ± SD	29.35 ± 7.92
GA (wks)	
Range	13–28
Mean ± SD	20.75 ± 5.60
BMI [wt/(ht)^2]	
Range	23–29
Mean ± SD	26.01 ± 2.47

Table 2. History of exposure to infection distribution among study group.

History of exposure to infection	No. (%)
Cytomegalovirus	3 (7.5%)
Toxoplasmosis	2 (5.0%)
Chickenpox	1 (2.5%)
Rubella	1 (2.5%)

According to **Onkar *et al.* (2014),** ultrasonography was able to identify CNS malformations in 24 fetuses, either with or without accompanying anomalies. There were 0.31% cases of CNS abnormalities. With a mean age of 21.3 years, the mother's age ranged from 19 to 32 years. The average gestational age at which CNS abnormalities were diagnosed was 23.54 weeks. The distribution by trimester was accurate. Four of the patients have experienced miscarriages in the past. None had a history of CNS abnormality at birth or in their family. Three were undetected and three were still pregnant. There were 18 autopsies done.[9]

Comparing 2D and 3D ultrasonography revealed that the latter was superior in 60.8% of the anomalies, according to Merz et al.[10] The advantage of 3D scans was related to the accurate tomographic survey using the multiplanar view in 69.9% of the cases, to a more accurate demonstration of the defect in the surface view in 25.2% of the cases, to a distinct demonstration of the defect in the transparent view in 3.9% of the cases, and to a well-defined demonstration of the defect in the combined transparent and color view in 1.0% of the cases. 42 of the 1012 malformations (4.2%), using 3D ultrasound, had defects; the 2D method was unable to definitively identify the defects.

At the Obstetrics and Gynecology Department, Bab el-Sheria, Al-Azhar University Hospital, a prospective study was conducted on a total of 100 patients with gestational ages ranging from 18 weeks to 24 weeks. These patients underwent 2D ultrasounds before being examined by 3D ultrasound. Holoprosencephaly and Anencephaly were the most common neurological malformations.[11]

Intracranial cysts (19%), significant ventriculomegaly (15%), corpus callosum absence or dysgenesis (10%), and intracerebral hemorrhage (10%) were the four most prevalent anomalies, according to Yinon et al. (2013). Other CNS abnormalities in this group of people included hydrocephalus, Dandy-Walker deformity, massive cysterna magna, microcephalus with lissencephaly, craniosynestosis, periventricular pseudocysts,

Table 3. Comparison between 2D ultrasonography and 3D ultrasonography according to anomalies' among study group.

Central Nervous System Anomalies' History	2D Ultrasonography No. (%)	3D Ultrasonography No. (%)	x2	*P* value
Complete agenesis of corpus callosum	1 (2.5%)	2 (5.0%)	0.342	0.559
Microcephaly	5 (12.5%)	5 (12.5%)	0.000	1.000
Hydrocephalus	4 (10.0%)	4 (10.0%)	0.000	1.000
Cerebellar hypoplasia	1 (2.5%)	2 (5.0%)	0.342	0.559
Schizencephaly	1 (2.5%)	1 (2.5%)	0.000	1.000
Ventriculomegaly	2 (10.0%)	2 (12.5%)	0.124	0.725
Holoprosencephaly	3 (12.5%)	3 (12.5%)	0.000	1.000
Spina bifida	4 (10.0%)	6 (15.0%)	0.451	0.502
Encephalocele	3 (7.5%)	5 (12.5%)	0.549	0.459
Intracranial hemorrhage	1 (2.5%)	1 (2.5%)	0.000	1.000

global brain ischemia, cerebellar hypoplasia, and sub-ependymal nodule.

This study demonstrated that the Sensitivity of 2D was 83.33%, Specificity was 62.5%, Accuracy was 80%. The Sensitivity of 3D was 88.09%, Specificity was 71.8%, and accuracy was 85.5%.

According to Hassan et al.,[11] there was a considerable yet modest agreement between 2D and 3D regarding the identification of neurological anomalies. In terms of the diagnosis of Holoprosencephaly, there was a relatively high degree of agreement between 2D and 3D. With reference to the diagnosis of Chiari malformation, there was a substantial level of perfect agreement between 2D and 3D. Between 2D and 3D, there was a significant but modest degree of agreement regarding the diagnosis of hydranencephaly.

3D ultrasonography is helpful in evaluating fetal CNS abnormalities, with ultrasound identification of CNS malformations at 90%, according to Fatma et al. (2019).[12]

These findings support prior study by Fatma et al.,[12] which discovered that holoprosencephaly (13.33%) was the most prevalent abnormality, followed by anencephaly (10%), Dandy-Walker malformation (10%), and hydrocephalus (6.66%).[12]

These results supported Liu et al.'s[13] (2005) study, which demonstrated that 3D US has an improved capacity to view the corpus callosum and the intracranial midline structures when compared to 2D US. 3D US visualised these structures in 78.1% of examinations while 2D US only did so in 3.1% of examinations.

These results supported a research by Xu et al. (2002)[14] that demonstrated the superiority of 3D US over 2D US, notably in the identification of the spine/extremities, cranium/face, deformities, and body surface. This is due to the fact that certain curved abnormalities usually accompany anomalies of the spine and skull and cannot be fully depicted on a single cross-sectional scan. It is difficult for conventional 2D US to depict these abnormalities in 3D shape and their connections to neighboring structures as a result. Misdiagnosis and ambiguous diagnoses are therefore frequent.

Wang et al.[15] discovered that 3D US did not significantly provide more data than 2D US did.[14]

These findings were in line with those of Sioudi and Mohamed,[16] who reported that a case of small spina bifida was missed on a routine 2-D ultrasound examination of the low-risk women and that spina bifida was suspected and confirmed by 3D imaging after 26 weeks of pregnancy.

According to Dyson et al.,[17] 3D US imaging offers benefits over 2D US imaging in terms of diagnosing some anomalies and data storage. To localize the appropriate site for 3D scanning, however, it is imperative to perform 2D US before 3D US scanning; as a result, 3D US performance cannot be performed without the prior use of 2D ultrasound.

Using postnatal transcranial ultrasound as a reference standard, Abd El Salam et al.[18] showed that the prenatal 2D ultrasound had a sensitivity of 75.0%, specificity of 100.0%, PPV of 100.0%, NPV of 98.7%, and overall accuracy of 99.0%. Other than that, the prenatal 4D ultrasound was 100% sensitive and specific.

With the advancement of 3D technology over the past several years, acceptance of 3D ultrasound has increased. Better picture resolution, quicker volume acquisition and rendering speeds, interactive displays with enhanced user interfaces, and the

Table 4. ROC curve of 2D techniques regarding neurological anomaly diagnosis.

	Roc Curve		PPV	NPV	Accuracy
	Sensitivity	Specificity			
2D	**83.33%**	**62.5%**	92.1%	41.66	80

Table 5. ROC curve of 3D techniques regarding neurological anomaly diagnosis The sensitivity of 3D was 88.09%, specificity was 71.8%, and accuracy was 85.5%.

	Roc Curve		PPV	NPV	Accuracy
	Sensitivity	Specificity			
3D	**88.09%**	**71.8%**	93.6%	54.76	85.5

use of harmonic imaging and color Doppler method are just a few of these advancements. Furthermore, real-time (4D) viewing of the fetal surface is possible because to the technology that is now accessible.[18]

In addition to conventional 2D ultrasound, a 3D ultrasound examination was employed in this investigation. For the diagnosis of fetal abnormalities, 3D exams were shown to be preferable to 2D ultrasound scans in 60.8% of the instances. These findings closely match those of Merz et al. (1995)[10] 's earlier study (62%), as well as those of Bonilla et al. (1998) (25)'s (65%), and Dyson et al. (2000)'s (51%) findings.

Using 3D ultrasound has the advantage of making the areas of interest visible in a number of perspectives, such as the surface view, the multiplanar view, the transparent view, and the combination of transparent + color views.[10]

Starting with the matching landmark, the recorded volume can be tomographically separated millimeter by millimeter from any of the three planes. The ideal slice showing the fault in the greatest size can be discovered by rotating or scrolling approaches. Timor-Tritsch et al.[19] demonstrated that in cases of mild ventriculomegaly, an oblique section plane known as the 'three horn view,' which displays the anterior, posterior, and inferior horns in the same image, provides diagnostic and clinically useful information comparable to that obtained by neonatal transfontanelle ultrasound imaging.[19]

4.1. Conclusion

This study concluded that conventional 2D had a comparable and accurate screening and diagnostic validity in diagnosis of CNS anomalies during the second trimester of pregnancy compared with modern 3D ultrasound.

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Ethical approval

The study was approved by the Institutional Ethics Committee.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article.

Conflict of Interest

Authors declare that there is no conflict of interest.

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