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CASE SERIES

Role of Four-Dimensional Sonography in the Assessment of Fetal Anomalies in the First and Second Trimesters of Pregnancy

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Abstract

Background: Routine ultrasound (US) study establishes itself as a major milestone of antenatal care if resources are facilitated to perform such studies in the second trimester, though routine scanning is increasingly going to begin in the first trimester nowadays, particularly in high-resource settings.

Objective: To assess the role of four-dimensional (4D) US in the evaluation of the presence of fetal congenital malformations in the first and second trimesters of pregnancy compared with 2D.

Patients and methods: The study was conducted on 50 high-risk pregnant women (first and second trimester); some of them were examined in their first trimester, whereas others were diagnosed in their second trimester as part of fetal anomaly scan. Part of routine maternal care, suspected cases were advised to undergo 4D US, and data were collected mainly from the 4D unit at Al-Hussien University Hospital.

Results: The study compared 2D US and 4D US in the detection of fetal anomalies. A total of 50 women with 56 fetuses were checked by 2D and 4D US, and 52 showed anomalies. Results showed an advantage of 4D US over 2D US in 13% of the examined fetuses, equal findings noted in 30%, and limited information in 17% of the examined cases. 4D US is more useful in some anomalies of the face and extremities only.

Conclusion: According to our results, 3D/4D US appears beneficial over 2D US in demonstrating facial and MSK anomalies.

Keywords: Anomalies, Fetal, Four dimensional, Sonography

1. Introduction

The routine ultrasound (US) study is considered a part of antenatal care if resources are facilitated and easily obtained to do in the second trimester, although routine scanning is increasing to begin through the first trimester nowadays. Ongoing advancements in procedures and instrument, including high-frequency transvaginal US, have allowed detailed assessment and monitoring of early fetal development.¹ The second-trimester '18–22-week' examination remains the familiar period for anatomical assessment of the fetus, in both high-risk and low-risk pregnancies.²

NT early anatomy scanning is once again gaining popularity owing to aneuploidy screening in the 11–13-week window. According to reports, benefits

include early discovery of many important medical conditions, an early assurance for high-risk women, early genetic diagnosis, and early pregnancy termination when necessary.³

This work aimed to examine and identify prenatal congenital abnormalities using 4D US in the first and second trimesters of pregnancy compared with 2D.

2. Patients and methods

The study was conducted on 50 high-risk pregnant women (first and second trimester); some of them were examined in their first trimester, whereas others were diagnosed in their second trimester as part of fetal anomaly scan. Part of routine maternal care, suspected cases were advised to undergo 4D US, and data were collected mainly from the 4D unit at Al-Hussien University Hospital.

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Inclusion criteria included high-risk pregnant women such as consanguineous marriage, history of fetal malformation, positive family history, and multiple pregnancies, whereas exclusion criteria included normal fetal biometry, third trimester pregnant women, and pregnant women with massive oligohydramnios. During the period between November 2021 and June 2022, pregnant women participated in US screening for major anomalies, including anomalies of the central nervous system, urinary tract, abdominal wall, and long bones. It was not anticipated that heart abnormalities would be included. Transvaginal approach was used for first-trimester pregnant women except those who have first visit in their second trimester time or who declined the use of the vaginal route; they were also examined by transabdominal US to enhance the visualization of the fundal part of the uterus.

Requirements: real-time, gray-scale, two-dimensional (2D) transabdominal US (3–5 MHz) was used. After the 2D US, transvaginal and 4D US transducers are used to determine whether the outcomes of the 2D scans and the data from 4D imaging were in agreement. Next, 3D US was used to evaluate the patients. The abnormalities were grouped according to eight bodily systems: central nervous system, musculoskeletal, gastrointestinal, head and neck, miscellaneous, and genitourinary. A three-score system was applied to determine the clarity of US findings using 2D or 4D methodology: (a) not seen, (b) faintly seen, and (c) excellent visibility of details. The protocol and technique of heart examination by gray scale and color Doppler used in all included cases were as follows: there were no detectable congenital heart anomalies in fetuses included in the research. We used 2D transducers (3–5 MHz). 2D US is more accurate than 4D US in heart evaluation.

2.1. Statistical analysis

Data were captured using Excel spreadsheets. To minimize potential errors, we used validation checks for numerical variables and an option-based data entry mechanism for categorical variables. Analysis was carried out using the program Statistical Package for the Social Sciences (SPSS, version 24; SSPS Inc., Chicago, Illinois, USA). To ascertain whether the data were normal, the Shapiro–Wilk test was used. Numerical data were presented as mean and SD if normally distributed or median and interquartile range if not normally distributed. Frequency tables with percentages were used as categorical variables.

3. Results

Our results agreed with the study by Kurjak et al.,⁴ as they showed that structural and functional fetal-facial evaluation is superior with 3D/4D US compared with 2D. Cleft palate, lip,⁵ neural tube, skeletal,⁶ and brain problems can all be identified in addition to facial defects, according to studies (Tables 1–4, Figs. 1–5).

4. Discussion

Structural abnormalities of the fetus complicate 2.3% of all pregnancy cases. US screening for fetal structural anomalies is a main part of routine prenatal care in countries with advanced facilities. The early chance for pregnant parents to learn about the problem, including its nature, cause, prognosis, and the possibilities of perinatal therapy, is made possible by the prenatal diagnosis of structural defects. The anatomical scan of the second trimester, usually carried out through 18 and 22 weeks of gestation, has been the norm for discovering fetal abnormalities for several decades.²

The reported prenatal percentage of fetal anomalies has far variability (15–85%) and depends on multiple factors: the gestational age at which the mother is examined, the expertise of the US facility and operator skills, the BMI of the woman, and the particular organ system being interrogated.⁷ High detection rates are seen in obstetric US practices and tertiary care facilities. Detection rates are also increased in high-risk populations where anomalies are higher in women with higher risk factors for abnormalities than in women without risk factors.⁸

The principal findings of the ongoing study were as follows: the mean age of the included women was 30.54 ± 6.3 years and the mean gestational age was 19.7 ± 4.4 weeks. Most of the women (36%) were G1P0, 20% were G2P1, and 12% were G3P2. Almost 26% women had positive consanguinity. Our findings were consistent with the study by Khambalia et al.,⁹ who reported that the age of most groups studied was between 25 and 34 years. In the review

Table 1. Accuracy of four-dimensional ultrasound compared with two-dimensional ultrasound of the included women.

	4D US			P value
	Accurate	Less	More	
Women (N = 50)				
2D US [n (%)]				
Accurate	7 (30.4)	0	0	0.001
Less	4 (17.3)	0	11 (73.3)	
More	3 (13)	12 (100)	0	
No role	9 (39.1)	0	4 (26.7)	

2D, two-dimensional ultrasound; 4D, four-dimensional ultrasound; US, ultrasound.

Table 2. Comparison between four-dimensional and two-dimensional ultrasound regarding central nervous system anomalies.

Variables	4D US	2D US	P value
Spine anomalies [n (%)] (N = 7)			
Accurate diagnosis	5 (71.4)	1 (14.3)	0.03
Indefinite diagnosis	2 (28.6)	6 (85.7)	
Head anomalies [n (%)] (N = 17)			
Accurate diagnosis	11 (64.7)	4 (23.5)	0.015
Indefinite diagnosis	6 (35.3)	13 (76.5)	

2D, two-dimensional ultrasound; 4D, four-dimensional ultrasound; US, ultrasound.

Table 3. The comparison between four-dimensional and two-dimensional ultrasound regarding face anomalies.

Variables	4D US	2D US	P value
Face anomalies [n (%)] (N = 11)			
Accurate diagnosis	7 (63.6)	0	0.001
Indefinite diagnosis	4 (36.4)	11 (100)	

2D, two-dimensional ultrasound; 4D, four-dimensional ultrasound; US, ultrasound.

Table 4. Upper and lower extremity anomalies of the included women.

Variables	4D US	2D US	P value
Upper limb [n (%)] (N = 8)			
Accurate diagnosis	6 (75)	4 (50)	0.3
Indefinite diagnosis	2 (25)	4 (50)	
Hand [n (%)] (N = 5)			
Accurate diagnosis	3 (60)	0	0.03
Indefinite diagnosis	2 (40)	5 (100)	
Lower limb [n (%)] (N = 9)			
Accurate diagnosis	6 (66.7)	4 (44.4)	0.34
Indefinite diagnosis	3 (33.3)	5 (55.6)	
Feet [n (%)] (N = 5)			
Accurate diagnosis	2 (40)	2 (40)	
Indefinite diagnosis	3 (60)	3 (60)	

2D, two-dimensional ultrasound; 4D, four-dimensional ultrasound; US, ultrasound.

of Bodnar et al.,¹⁰ it was found that most of their studied women had aged between 20 and 34 years.

Prenatal testing enables high-risk pregnant women to assess the most common aneuploids. Cases that are considered at 'high-risk' condition have the choice of additional diagnoses (invasive) testing. Before the 1980s, prenatal screening was considered a risky assessment according to the age of the mother; however, with the arrival of biochemical analysis of the maternal serum, prenatal screening has developed considerably.⁷

An US without a thorough anatomical examination is appropriate for fetal–maternal assessment of the number of fetuses; amniotic/chorionic sacs; surveys of intracranial, spinal, and abdominal anatomy; evaluation of a four-chamber heart view; determining the site of insertion of the umbilical cord; estimating AFI; and, if possible, evaluation of

the mother's adnexa. 3D US can speed up scanning times in obstetric US while maintaining clear fetal view.¹¹

Our results were supported by the study by Blaas et al.,¹² who reported an early spina bifida diagnosis using 2D and 3D US before the 10th week of pregnancy. It showed early diagnosis of spina bifida in a case of OEIS complex (Omphalocele, bladder exstrophy, imperforate anus, and spina bifida) at the ninth week of gestation. Anencephaly is considered as a rare condition of neural tube defect, which combines extreme retroflexion of the head as well as several defects of the spine, associated with acrania, encephalocele, and anencephaly. There is an extremely poor prognosis for those with anencephaly.

According to Cicero et al.,¹³ 87 (62.1%) of the 140 fetuses with Trisomy 21 and 113 (0.6%) of 20, 165 phenotypically or chromosomally normal fetuses lacked a nasal bone. A midsagittal slice of the fetal face can be obtained by using 3D US's three orthogonal planes. It avoids the pitfall of obtaining a para-sagittal view, which could lead to false-negative results. This stays away from the trap of getting a para-sagittal view, which can produce wrong negative outcomes. By analyzing closely parallel slices, tomographic US imaging also enables the detailed depiction of facial midline structures. It is essential to realize that the initial acquisition plane has a significant effect on the quality of the orthogonal planes or tomographic imaging.¹³

Rembouskos et al.¹⁴ reported that the routine application of 3D scanning for the nasal bone in screening for trisomy 21 is probably associated with a very high false-positive rate owing to the possible limits of 3D technology.

Benoit and Chaoui¹⁵ described the detection of bilateral or unilateral hypoplasia or the lack of nasal bones during the second-trimester Down syndrome screening by using 3D US through maximal mode rendering.

Skupski et al.¹⁶ studied 860 fetuses in 854 pregnancies. The anomalies were found in 5.35% (46/860); 1.16% (10/860) had major anomalies and 4.19% (36/860) had minor anomalies.

Our results agreed with the study by Kurjak et al.,⁴ as they showed that structural and functional fetal-facial evaluation is superior with 3D/4D US compared with 2D. Cleft palate, lip, neural tube, skeletal, and brain problems can all be identified in addition to facial defects, according to studies.^{5,6}

In a study by Gonçalves et al.¹⁷ done on 99 pregnancies, 54 normal and 45 abnormal fetuses (82 abnormalities) were found by 2D US after being first assessed with 3D/4D imaging. Compared with 3D/

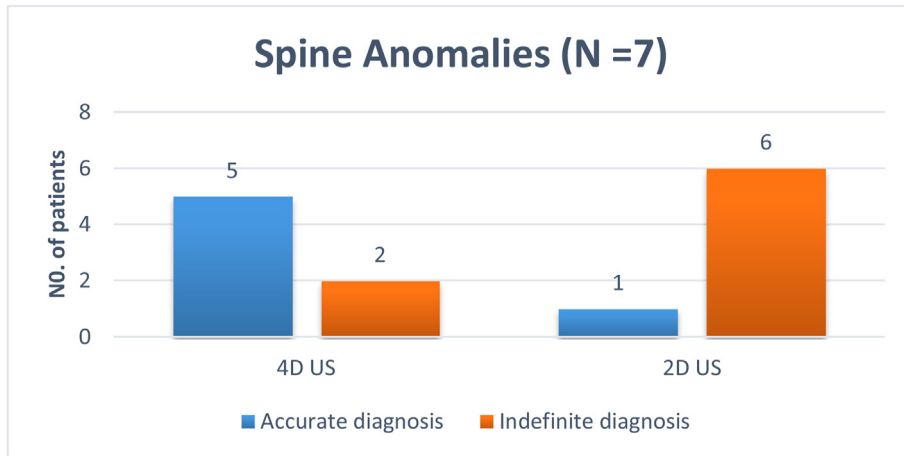


Fig. 1. Distribution of spine anomalies.

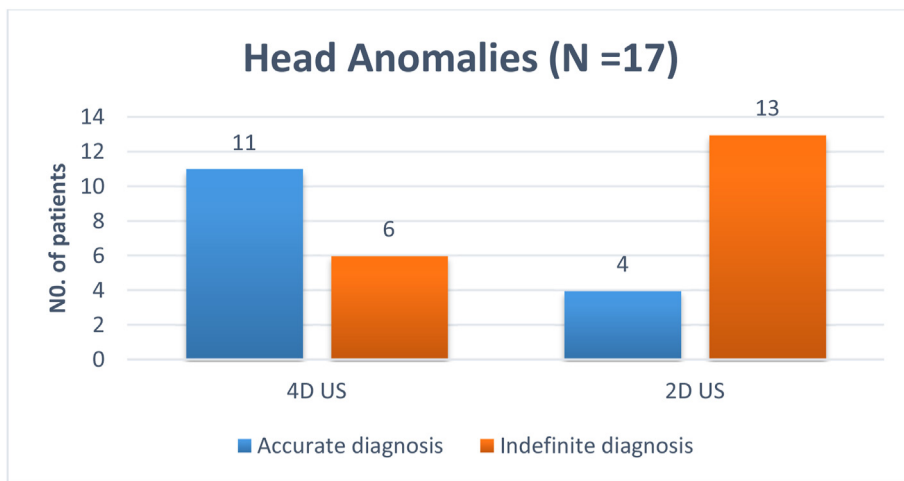


Fig. 2. Distribution of head anomalies.

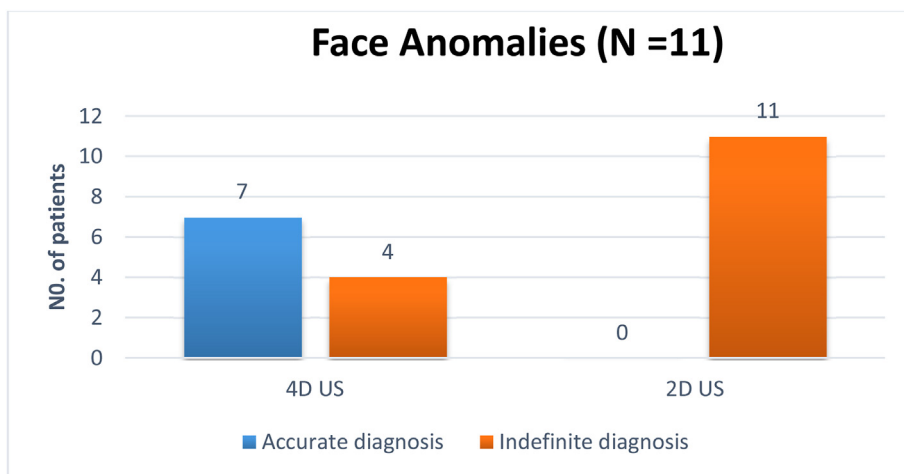


Fig. 3. Distribution of facial anomalies.

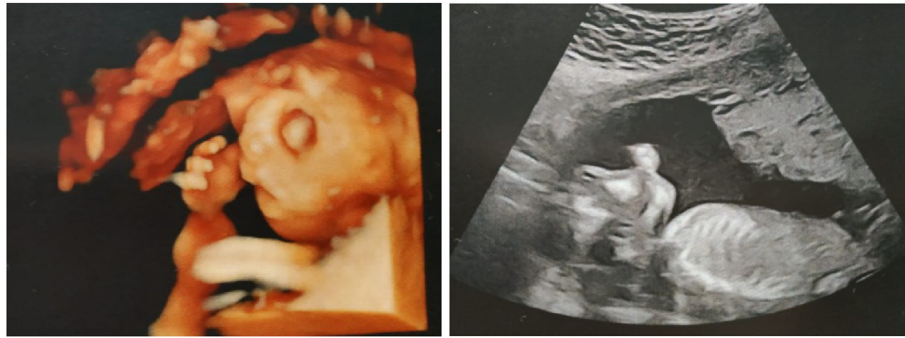


Fig. 4. Left image is a 4D image and right image is a 2D image for a case of anencephaly. 2D, two dimensional; 4D, four dimensional.

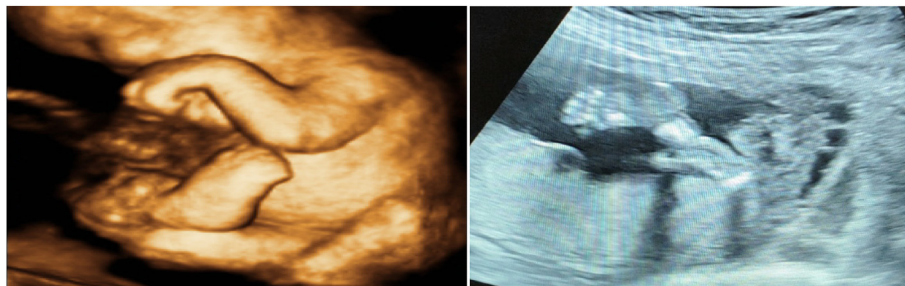


Fig. 5. The left image is a 4D image and the right image is a 2D image for a case of talipes equinovarus. 2D, two dimensional; 4D, four dimensional.

4D, 2D US found six more abnormalities (VSD, IVC blockage, Fallot Tetralogy, renal anomaly, and cystic adenomatoid malformation). A fetal hemivertebra and a small occipital encephalocele existing in the cases were not observed with either of the US techniques. Sensitivity was 96% in 2D and 92% in 3D/4D whereas specificity was 73% in 2D and 76% in 3D/4D comparing postnatal diagnosis. There was no statistically significant difference.

Öcal et al.¹⁸ reported that 194 abnormalities were diagnosed in 174 pregnancies out of 1379 pregnant women evaluated (18), and 2D US was identified to be more effective at finding anomalies than 4D ($P = 0.001$). The use of 4D US was found to be more effective for identifying prenatal malformations of the face, extremities, spine, and abdomen wall. It has been stated that 15% of all cases and 50% of all anomalies have better-quality images. In another study involving 204 patients, 3D US demonstrated 62% advantage in detecting prenatal anomalies; 36% of patients received the same information from 2D US, and 2% of patients were found to benefit more from 2D evaluation compared with 3D.

Fetal anatomy was assessed using 2D US in a different study of 159 uncomplicated pregnancies carried out by Merz et al.,¹⁹ followed by 3D examination of all pregnancies. Complete anatomy was obtained in 93.7% with 2D imaging and 80.5% with 3D. Morphometry, volumetric, and functional

analyses of the fetus's anatomical structure were all carried out using 3D/4D US. The use of 3D/4D US fetal imaging has several benefits, and it helps 2D fetal screening become more accurate.²⁰

5. Conclusion

3D/4D US has demonstrated various facial and extremity deformities more clearly than 2D US. There are conflicting results from large studies comparing 2D US and 4D US for the diagnosis of congenital abnormalities. This modality has advantages over 2D US, having positive psychological effects and increasing interest among experts and the public. With 3D/4D US serving as an adjunct, 2D US assessment continues to be the gold standard for fetal anomaly evaluation.

Conflict of interest

None declared.

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