Egyptian Journal of Radiology and Nuclear Medicine

REVIEW

Open Access

Two-dimensional and four-dimensional ultrasound in the diagnosis of non-cardiac fetal congenital anomalies in high risk pregnancies: a comparative study

Nada Ayman Soliman Ibrahim[1*], Kholoud Hamdy Elshorbagy[1], Abdelmonem Nooman Darweish[1] and Rania Sobhy Abou Khadrah[2]

Abstract

Background The high incidence of non-cardiac congenital anomalies in high-risk pregnancies is a major worldwide health problem. Congenital deformities represent 20–25% of perinatal deaths. The best non-invasive screening method for diagnosing congenital abnormalities is ultrasound. Four-dimensional ultrasound added additional diagnostic value to two-dimensional ultrasound in evaluating fetal prenatal conditions. Our study's goal was to compare the roles of two-dimensional and four-dimensional ultrasound in the diagnosis of non-cardiac fetal congenital anomalies in high-risk pregnancies.

Results Out of the 100 pregnant women who underwent examinations, all had high-risk pregnancies and were expected to give birth to babies with deformities, a total of 25 cases (or 25%) of fetal abnormalities were found. The two-dimensional ultrasound diagnosis's accuracy sensitivity, and specificity were 84%, 76%, and 86.67%, respectively, while they were 87%, 80%, and 89.33%, respectively, for four-dimensional ultrasound. The accuracy, sensitivity, and specificity of two-dimensional ultrasound combined with four-dimensional ultrasound were significantly higher (94%, 88%, and 96%, respectively) than those of two-dimensional ultrasound or four-dimensional ultrasound alone. This study also analyzed the risk factors leading to fetal malformations. The results showed that consanguinity, increased maternal age, past history or family history of congenital anomalies, history of medication during pregnancy, and maternal diabetes were major risk factors statistically significant for congenital anomalies.

Conclusion The diagnosis rate of fetal abnormalities can be significantly increased by combining two-dimensional ultrasound with four-dimensional ultrasound. Avoiding risk factors that raise the likelihood of fetal abnormalities should take priority for pregnant women with high risk factors. To lower the incidence of fetal abnormalities, prenatal screening and diagnosis should be standardized.

Keywords Four-dimensional ultrasound, Two-dimensional ultrasound, Non-cardiac, Congenital anomalies, High risk pregnancies

*Correspondence:
Nada Ayman Soliman Ibrahim
nadaayman430@gmail.com
Full list of author information is available at the end of the article

Background

Diagnosis of congenital abnormalities has become very important in reducing the incidence of perinatal mortality since medical advances have led to a decrease in conditions like infections and starvation [1].

Twenty to twenty-five percent of perinatal deaths are caused by congenital deformities. Presently, numerous hereditary and other medical conditions can be diagnosed early in pregnancy. Prenatal diagnosis uses different noninvasive procedures to determine any abnormality in newborn baby [2].

Ultrasound is the preferred non-invasive screening method for the diagnosis of congenital abnormalities due to its reliability, affordability, and sensitivity of detection. More congenital defects are being found antenatally than in the past due to more advanced diagnostic tools. All pregnant women should have routine prenatal ultrasound examinations to look for these anomalies. When congenital anomalies are detected early in pregnancy, mothers are better prepared to make informed decisions about their pregnancy and, if necessary, seek fetal intervention. This improves perinatal and long-term outcomes [3]. Prenatal screening can lower the birth rate of deformed fetuses, improving the quality of newborns and improving the growth of each family and society as a whole [4].

Two-dimensional ultrasound (2D-US) has been taken over as the primary and standard method for prenatal screening [5]. 3D/4D US offers multiplanar view, tomographic view, surface view, transparent view, and volume contrast imaging that are not available in conventional (2D) US, and provide a precise illustration of the normal and abnormal anatomy of the fetus by reloading volumes and browsing through them without the patient present, digital storage of volumes makes it possible for virtual exams [6, 7].

The primary goal of this study was to compare the roles of 2D-US and 4D-US in diagnosis of prenatal fetal non-cardiac congenital abnormalities, as well as the accuracy of their combined and individual diagnoses. Additionally, we assessed the risk factors for congenital defects in fetuses with abnormal development, which is essential to improving the newborn population's quality.

Methods

The current prospective study was conducted between January 2022 and January 2023 at the radiodiagnosis and medical imaging department of our university hospital. There were 100 pregnant women with high-risk pregnancies whose ages ranged between 18 and 45 years (mean age + SD = 29.03 ± 2.71), and the mean gestational age was 27.90 + 0.72 weeks, with the gestational weeks ranging from 24 to 34 weeks. In terms of parturient types, there were 57 multiparas and 43 primiparas. Inclusion criteria: high-risk pregnancy, including diabetes, pre-eclampsia, and other systemic diseases that affect pregnancy like epilepsy, thyroid disease, heart or blood disorders, poorly controlled asthma, infections, and women with bad obstetric history consanguineous marriage, prior history of fetal malformation; positive family history of fetal anomalies, and in vitro fertilization. Exclusion criteria: normal fetal biometry and pregnant women after 34 weeks. The study was approved by our university's ethical committee. All patients signed an informed consent form. And detailed medical, obstetric, past, and family histories were obtained.

A total of 100 pregnant women were examined by using Toshiba Aplio 500 ultrasound equipment with a convex abdominal probe (frequency of 3–5 MHz) and a 4D trans-abdominal probe.

Ultrasound examination

The 2D and 4D U/S examinations were done by three sonographers with at least 5 years' experience in fetal U/S, and the results were taken by consensus.

2D ultrasound examination

All patients underwent a 2D-US examination while lying on their backs with their abdomens exposed, and the fetus's various features were carefully examined. The biparietal diameter (BPD), head circumference (HC), femur and humerus lengths, abdominal circumference (AC), placenta location and grade of development, amniotic fluid index, and vertical maximum pocket depth were examined as biological markers of the fetus. The fetal face was examined in multiple planes; The lips and palate were seen in multiple planes; and the continuity of the spine was examined. The growth of the heart and lungs, among other chest organs, and abdominal organs such as the stomach, bowels, kidneys, and urinary bladder (Fig. 1).

4D ultrasound examination

To guarantee the clarity of the picture capture, the fetus' dynamic imaging was shown. The examined organ, especially the face, must be surrounded by an adequate amount of amniotic fluid to take good images. 4D examination time was 15 to 20 min (Fig. 2).

4D protocol

The following steps were used to capture a 4D picture of each fetus part: (1) Press the 4D button to begin the examination. (2) Establishing and adjusting the ROI, the 4D volume box was set to contain the whole region of interest (ROI); (3) Changing the flexible cut line and positioning the volume box's cut line in the amniotic fluid, (4)

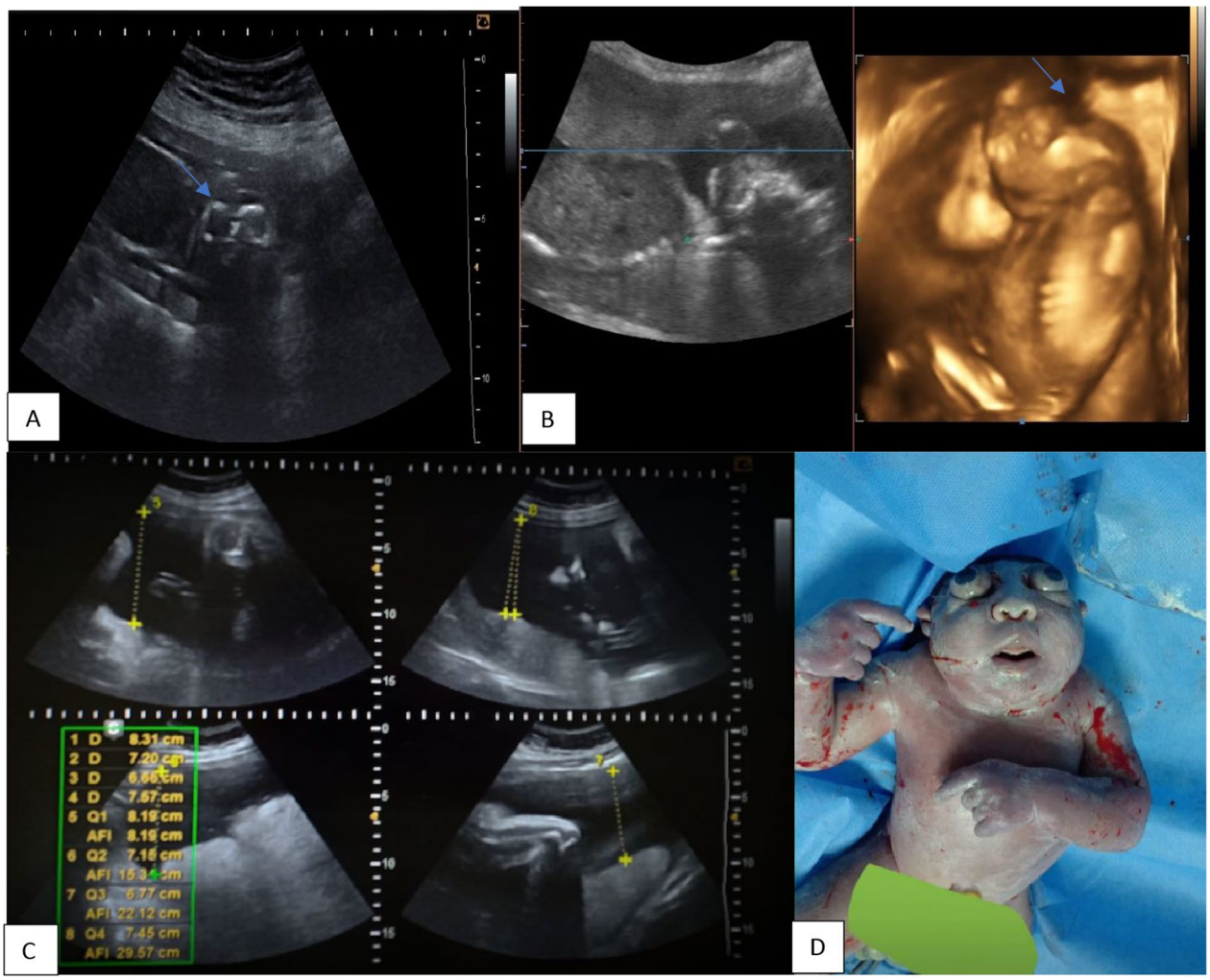

Fig. 1 A pregnant female aged 28 years primigravida presented at 24 weeks of gestation and was diabetic. She had a history of medication during pregnancy with a positive history of consanguinity without any prior antenatal checkup. **A** 2D US axial and coronal images of the fetal head revealed an absent cranium; the eyes are pronounced, giving a typical froglike appearance (blue arrow). **B** Reconstructed 4D US image of fetal head with absent cranium and rudimentary brain, giving a frog-like appearance to the fetal face (blue arrow). **C** Increase amniotic fluid (polyhydramnios (AFI = 29)). **D** Post-termination image confirming the diagnosis of anencephaly

By pushing the 4D button, the volume was captured in the axial view (Fig. 3).

The organ was next examined in the three orthogonal planes (sagittal, axial, and coronal) using the multiplanar mode. Additionally, Multiview mode was used, which presented up to 16 planes of a volume simultaneously and was similar to CT or MRI scans with multilevel slices every 1 mm or fewer. The facial structures, including the eyes, nose, lips, ears, and limbs, were examined using the 4D surface rendering method. In order to assess the fetus' skeletal structure, 4D maximal mode was applied. Adjusting the image through the use of options like panning, zooming, rotating, and removing the 4D image's undesirable area (Fig. 4).

Interpretation and outcome measures

The accuracy, sensitivity, and specificity of 2D-US and 4D-US as well as their combined examinations in the detection of fetal abnormalities were established by postnatal follow-up on all patients. Postnatal findings and the abnormality diagnosed by an obstetrician were considered the gold standard for the accuracy of 2D and 4D US results (Fig. 5).

Statistical analysis

The data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp.) Qualitative data were described using numbers and percents. The Kolmogorov–Smirnov

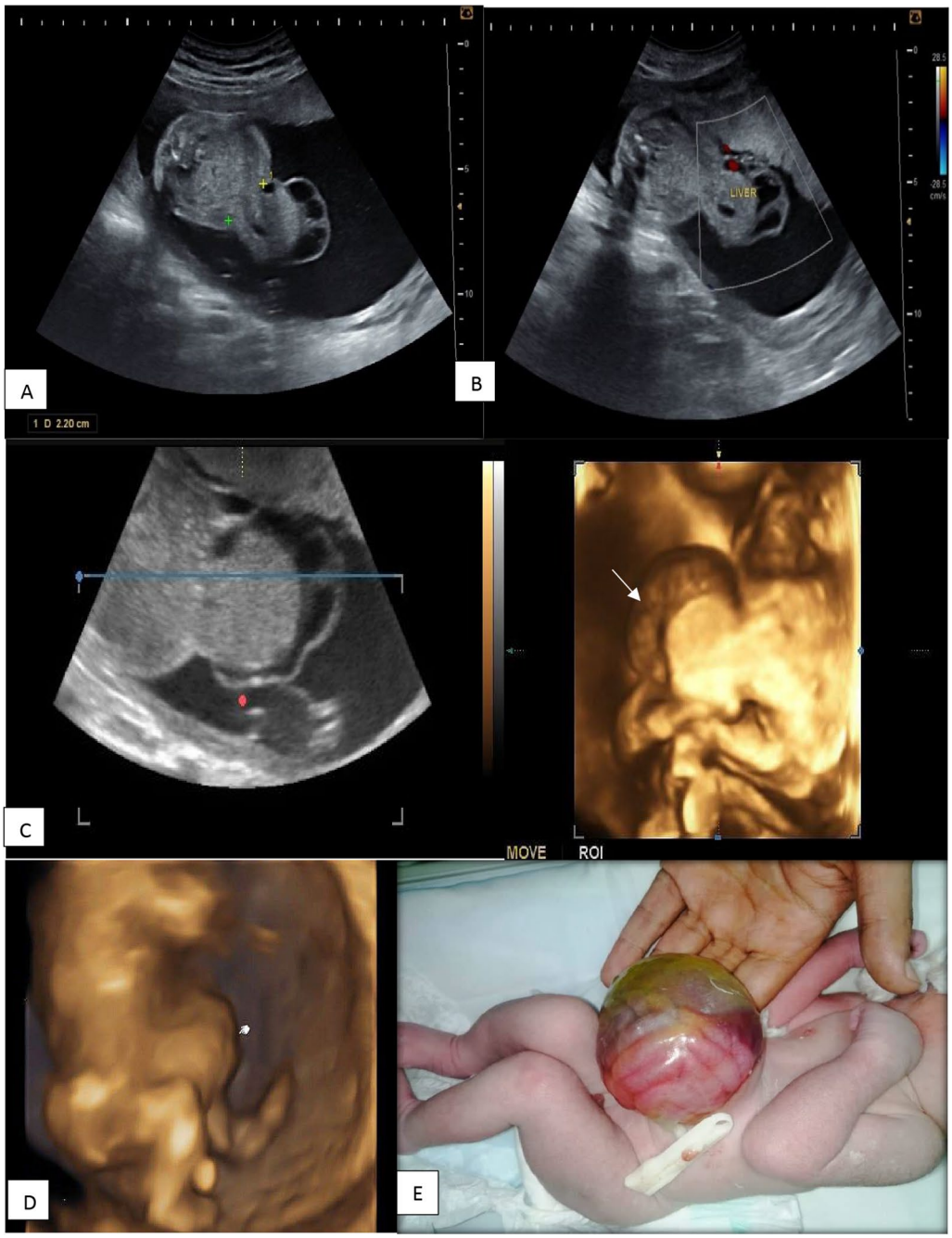

Fig. 2 A pregnant female aged 38 years, multigravida, presented at 25 weeks of gestation. She had a history of medication during pregnancy and a family history of previous congenital anomalies that referred her for an anomaly scan. **A** A 2D US axial image of the fetal abdomen with a minor abdominal wall defect measures 2.2 cm, passing a sac containing part of the liver and some bowel loops with an overlying membrane covering the content. **B** Color Doppler image showing insertion of the umbilical cord into the sac. **C**, **D** 4D US images showing herniation of abdominal content through the abdominal wall defect (arrow). **E** Postnatal image confirming the diagnosis of omphalocele

test was used to verify the normality of the distribution. Quantitative data were described using range means and standard deviations. The significance of the obtained results was judged at the 5% level. The Chi-square test was used for categorical variables to compare between different groups, and Fisher's Exact was used for correction for the chi-square when more than 20% of the cells had an expected count less than 5. Accuracy: rate of agreement = (true positives + true negatives)/total tested × 100%. Sensitivity: Positivity in

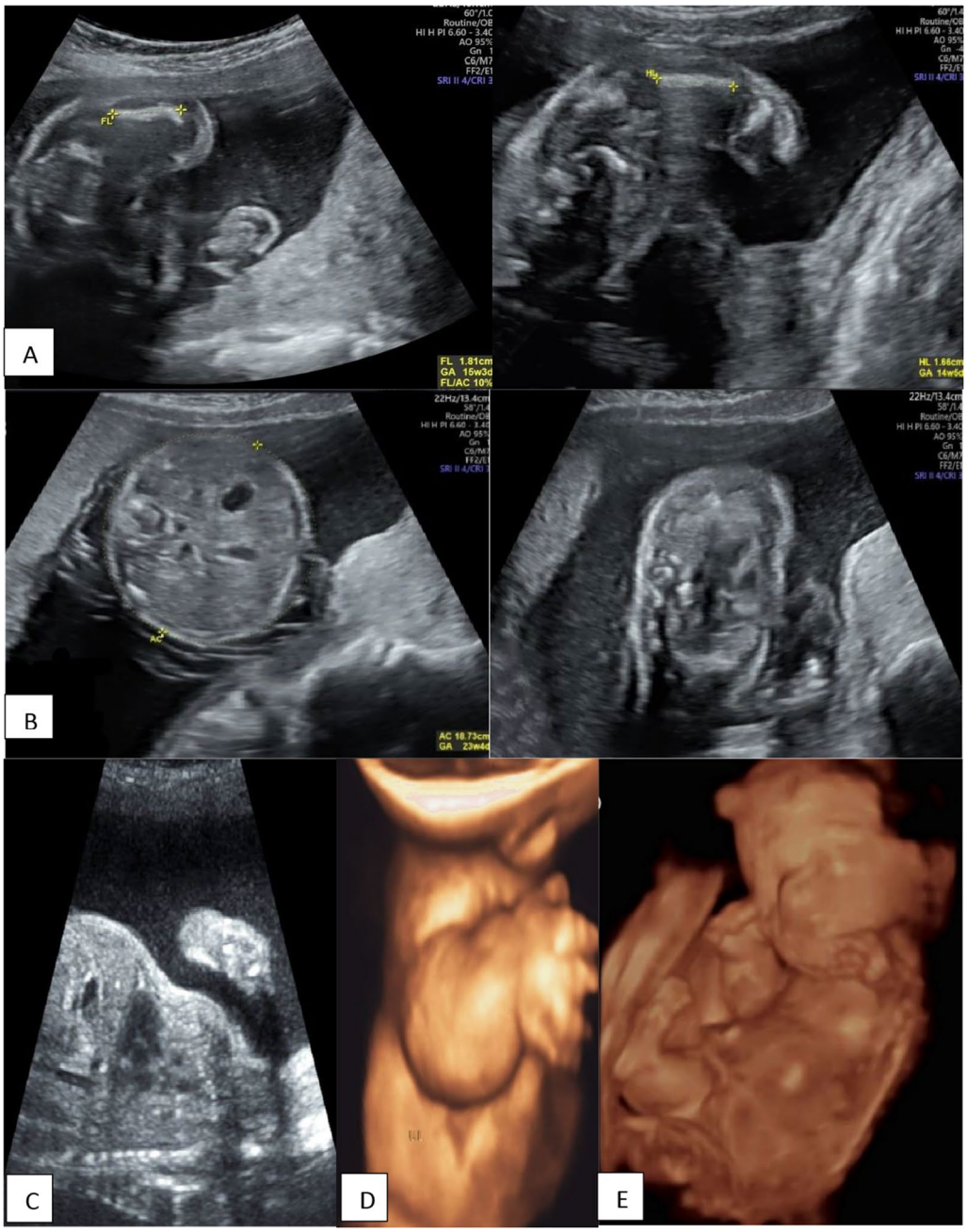

Fig. 3 A pregnant female aged 20 years, primigravida, presented with 24 weeks of gestation, was hypertensive, and had a positive history of consanguinity. She had a previous US examination that revealed abnormal measurements. Referred for an anomaly scan. **A** 2D US axial and longitudinal images showing shortening of the length of the femur and humerus (aged about 16 weeks) in comparison to head and abdominal circumference and amenorrhea (about 24 weeks). **B** Small chest in comparison to abdomen shown in axial sections of the chest and abdomen. **C** 2D US sagittal image of the chest and abdomen showing a narrow chest. **D** A 4D US surface rendering image of a hand showing a small hand with the 2nd, 3rd, and 4th fingers appearing separated and similar in length (trident hand). **E** 4D US revealed shortening of the proximal bones of the upper and lower limbs (rhizomelia) and a protruding forehead (frontal bossing) with a depressed nasal bridge. A case of skeletal dysplasia (Achondroplasia rhizomelia) confirmed by genetic testing

diseased patients = true positives/true positives + false negatives × 100%. Specificity: Negativity in non-diseased patients = true negatives/true negatives + false positives × 100% (Fig. 6).

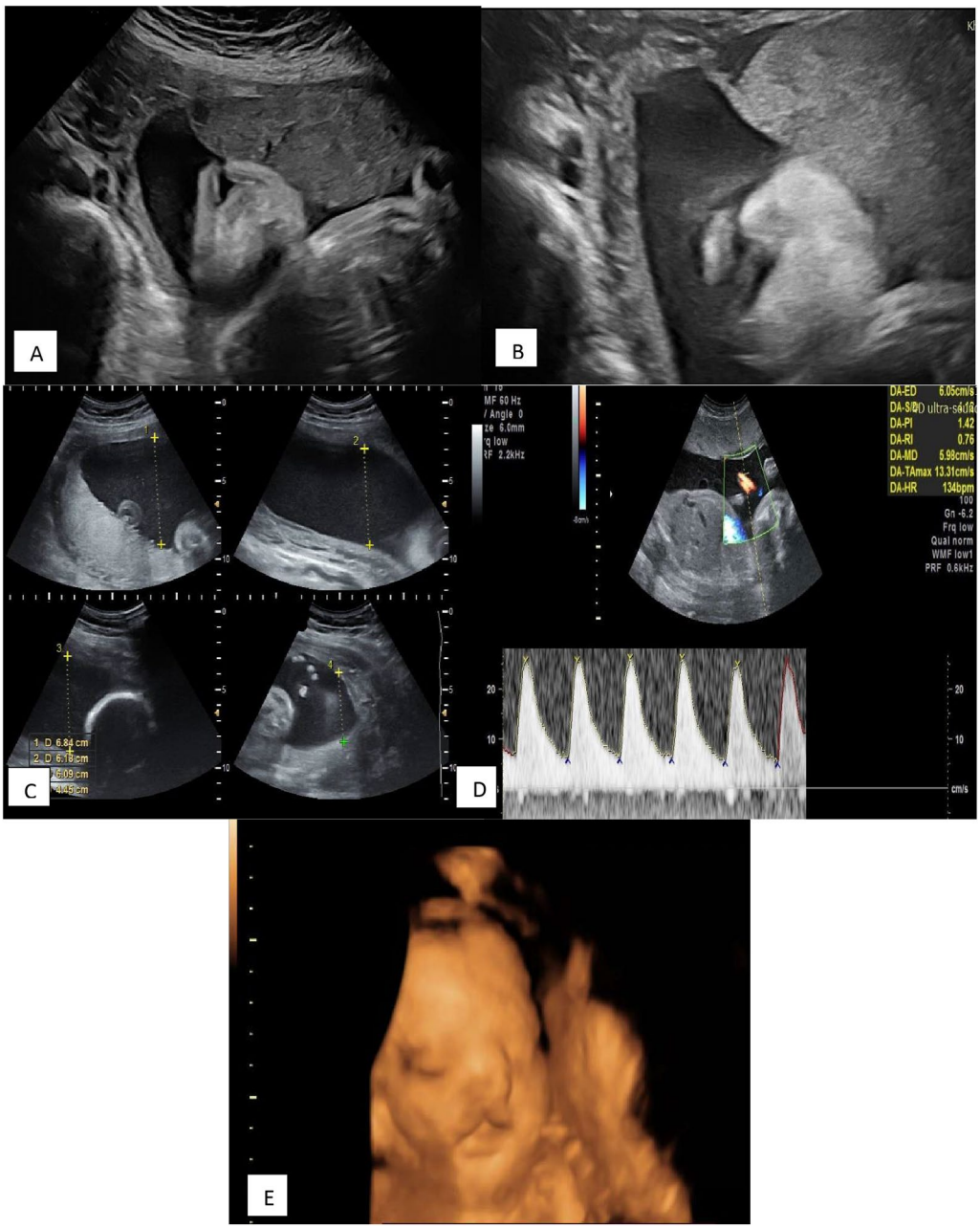

Fig. 4 A pregnant female aged 22 years, multigravida, presented with 26 ± 2 weeks of gestation, was hypertensive, presented with eclampsia, had a positive history of consanguinity, and had a past history of a fetus with facial anomalies. She had one previous US examination that revealed polyhydramnios and referred her for an anomaly scan. **A**, **B** 2D US coronal images of the fetal face showed a loss of integrity of the upper lip. **C** 2D US showed an increase in amniotic fluid (polyhydramnios). **D** Doppler examination revealed an increase in the resistive index of the umbilical artery (RI = 0.76) with low diastolic flow. **E** A surface-rendering 4D US image of the fetal face revealed loss of integrity of the upper lip, confirming the diagnosis of cleft lip. A case of paramedian cleft lip was confirmed postnatally

Results

This study was carried out on 100 pregnant women with high risk pregnancy who expected to give birth to deformed newborn babies. Among the 100 pregnant women with high-risk pregnancy, there were 75 cases who had normal fetus and 25 cases had fetuses with non-cardiac congenital anomalies, including 6 cases (24%) of neurological malformations, 4 cases (16%) of abdominal malformations, 4 cases (16%) of genitourinary system malformations, 4 cases (16%) of skeletal system

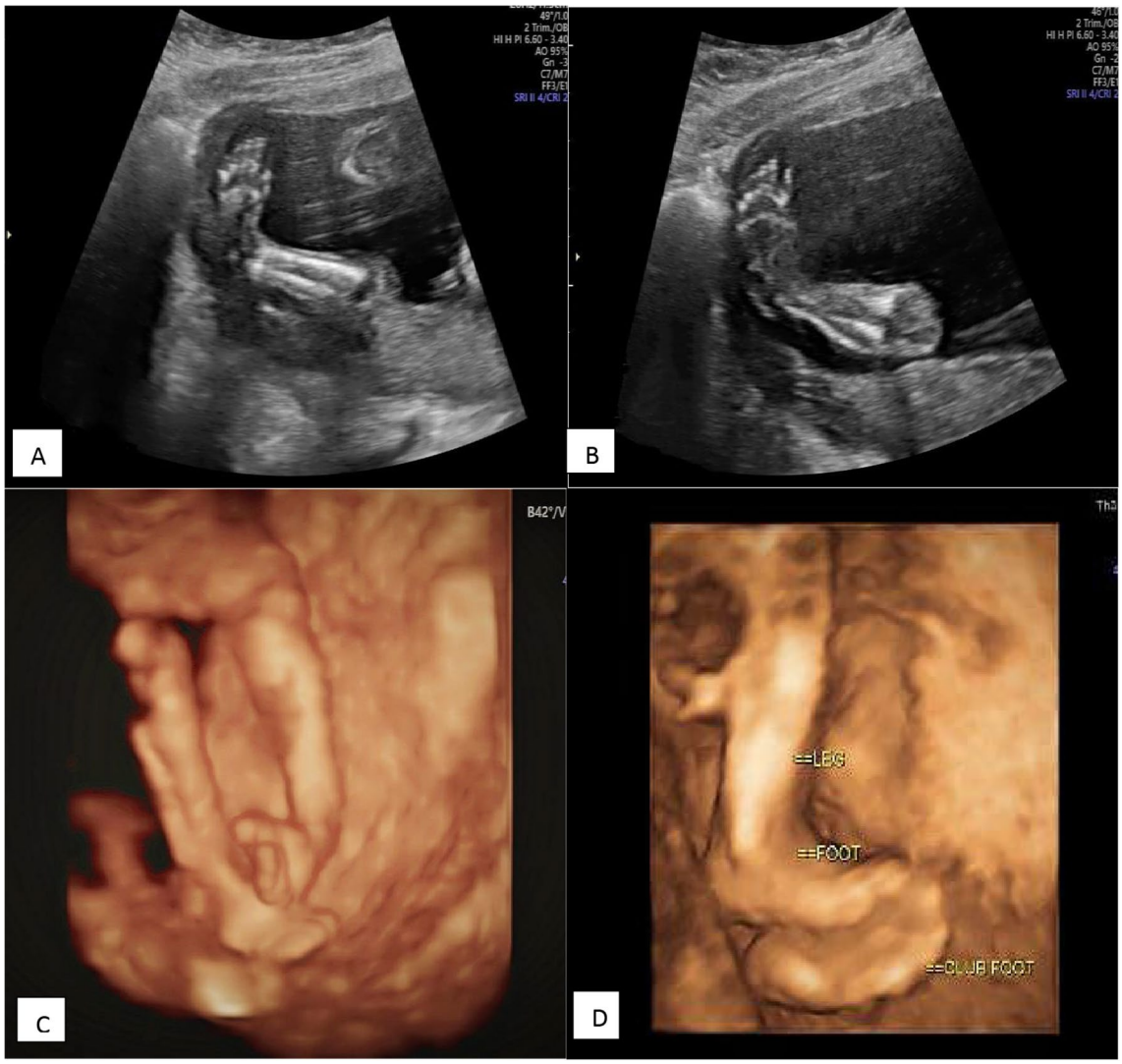

Fig. 5 A pregnant female aged 40 years with multigravida presented at 27 weeks of gestation, was hypertensive, and had a past history of babies with congenital anomalies. Without any previous ultrasonographic examination. **A**, **B** 2D US images of the fetal leg in the longitudinal plane revealed the tibia, fibula, and foot were seen in the same plane, and the foot appeared medially deviated; this abnormal positioning persists during the duration of the scan. **C**, **D** Surface rendering 4D US images of the fetal foot showed a medially deviated planter-flexed foot. Case of unilateral talipes equinovarus (clubfoot) confirmed postnatal

deformities, 3 cases (12%) of facial deformities, 2 cases (8%) thoracic malformation, and 2 cases (8%) hydrops fetalis (Table 1).

Analysis of risk factors for fetal malformation showed that consanguinity, past history or family history of congenital malformation, history of medication during pregnancy and diabetes were related to fetal malformations, and the differences were statically significant ($P<0.05$), while increased age of mother > 35 and hypertension during pregnancy were statically insignificant ($P>0.05$) (Table 2).

Out of 25 cases confirmed postnatal to have fetus with non-cardiac congenital malformation, 2D US established the diagnosis of 19 (76%) malformation, whereas 4D US diagnosed 20 (80%) malformation, whereas combined 2D and 4D US diagnosed 22 (88%) So the combined diagnosis of 2D-US + 4D-US achieved obviously higher diagnostic value (Table 3).

Regarding the comparison of 2D-US, 4D-US for the diagnosis of fetal malformations other than cardiac. The results of the comparison between various inspection techniques and the gold standard were exactly consistent

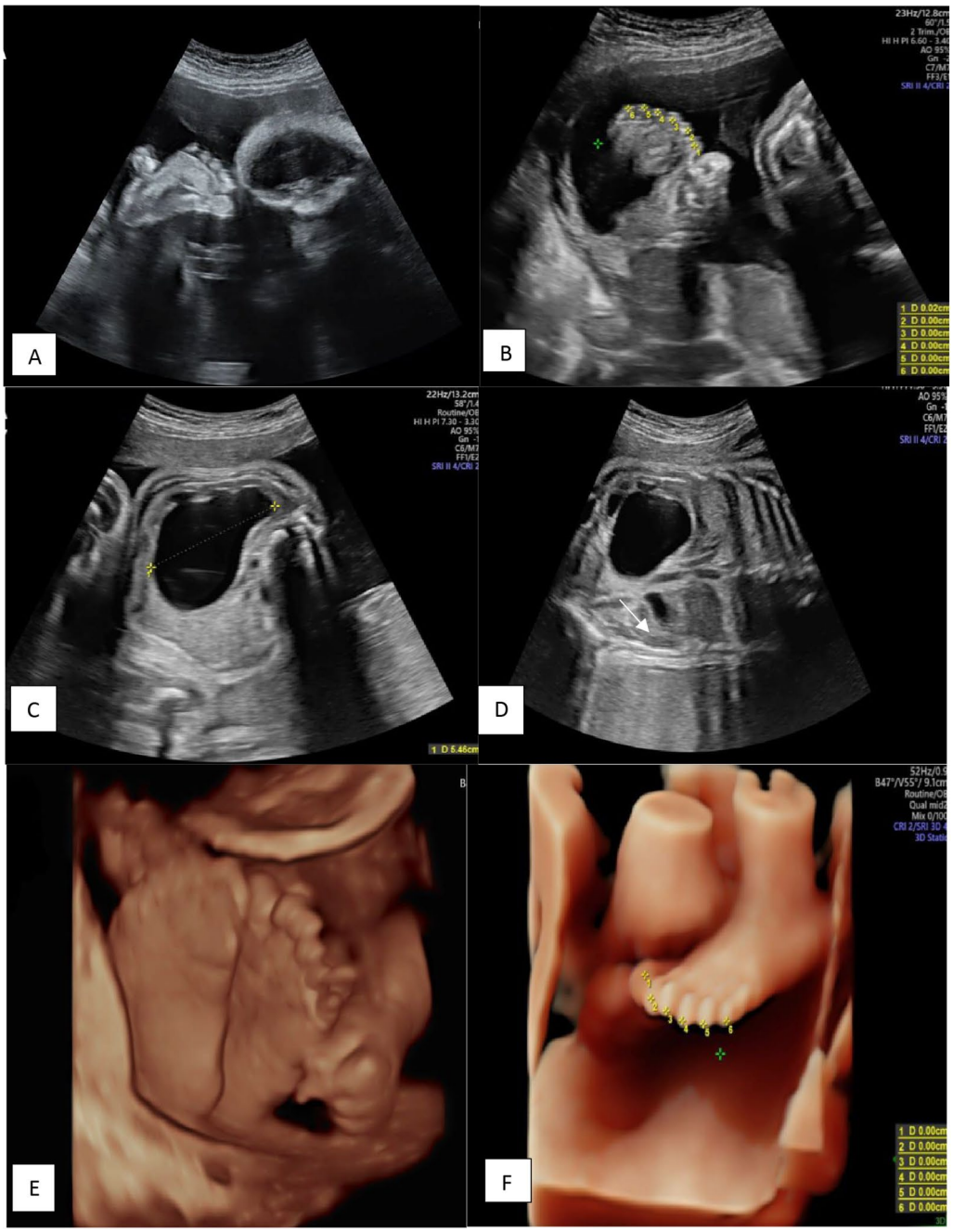

Fig. 6 A pregnant female aged 31 years presented at 28 weeks of gestation with a positive history of consanguinity and a past history of babies with skeletal congenital anomalies without any prior antenatal checkup. **A** A 2D US scan of a transverse section of the fetal foot (planter view) showed that the second and third toes were fused together, as well as the presence of an extra digit lateral to the little toe. **B** Six digits were also seen in sagittal view. **C**, **D** 2D US axial and coronal images of the fetal abdomen showed marked ballooning dilatation of the left renal pelvis with slight fullness of the renal pelvis on the right side. **E**, **F** Surface rendering 4D US image of the fetal foot confirming the fusion between the second and third toes and the presence of six digits A case of syndactyly and postaxial polydactyly associated with hydronephrosis (PUJO) was confirmed postnatally

with the incidence of neonatal malformations following delivery (Table 4).

The accuracy, sensitivity, and specificity of the 2D-US diagnosis were 84%, 76%, and 86.67%, respectively, whereas the accuracy, sensitivity, and specificity of the 4D-US diagnosis were 87%, 80%, and 83.33%, respectively. The accuracy, sensitivity, and specificity of the

Table 1 The prevalence of fetal malformations ($N=100$)

Classification of fetal malformations	Number of cases	Ratio %
Neurological malformation	6	24.00
Facial deformity	3	12.00
Thoracic malformation	2	8.00
Abdominal malformation	4	16.00
Genitourinary system malformation	4	16.00
Skeletal system deformity	4	16.00
Hydrops fetalis	2	8.00
Total	25	100.00

combined 2D-US and 4D-US diagnosis were 94%, 88%, and 96%, respectively (Table 5).

Discussion

The results of this study showed that 25 non-cardiac fetal malformations proven postnatally were detected among the 100 pregnant women with high-risk pregnancies including diabetic, pre-eclampsia, other systemic diseases that affect pregnancy like epilepsy, thyroid disease, heart or blood disorders, poorly controlled asthma, infections, and women with bad obstetric history such as when a woman has previously had problems in previous pregnancies. This may include miscarriage, stillbirth, intrauterine fetal deaths, intrauterine growth retardation and congenital anomalies. The accuracy, sensitivity, and specificity of the combined 2D-US and 4D-US diagnosis were clearly greater than those of each method used alone.

Several studies have been conducted to compare the accuracy, sensitivity and specificity of different ultrasound methods. In a study by Yu et al. [8]. In terms of accuracy, sensitivity, and specificity, 2D-US diagnosis scored 81.40%, 43.68%, and 82.92%, whereas 4D-US scored 83.67%, 51.72%, and 84.95%, and 2D-US plus 4D-US scored 93.59%, 90.80%, and 93.70%. It shows that the 2D-US + 4D-US combination diagnosis had noticeably superior accuracy, sensitivity, and specificity to either 2D-US or 4D-US. Also Deng et al. found inferior diagnostic accuracy of 2D-US to 2D-US plus 4D-US for fetal anomaly at gestational week [9].

According to one study by Goncalves et al. [10] examined 99 fetuses (54 were normal and 45 had 82 malformations) and observed conformity between 2 and 3D/4D ultrasonography for 90.4% of the findings. The

Table 2 The significance of maternal risk factors for fetal malformation

Risk factors	Normal fetal group ($N=75$)	Malformed fetus ($N=25$)	χ^2	P
Age of mother			0.851	$^{FE}P=0.460$
< 35	68 (90.7%)	21 (84.0%)		
≥ 35	7 (9.3%)	4 (16.0%)		
Consanguinity			7.125*	0.008*
Yes	47 (62.7%)	8 (32.0%)		
No	28 (37.3%)	17 (68.0%)		
Past history or family history of congenital anomalies			6.077*	0.017*
Yes	36 (48.0%)	5 (20.0%)		
No	39 (52.0%)	20 (80.0%)		
History of medication during pregnancy			3.922*	0.048*
Yes	55 (73.3%)	13 (52.0%)		
No	20 (26.7%)	12 (48.0%)		
History of diabetes			4.476*	0.037*
Yes	18 (24.0%)	9 (36.0%)		
No	57 (76.0%)	16 (64.0%)		
History of hypertension			0.014	0.906
Yes	46 (61.3%)	15 (60.0%)		
No	29 (38.7%)	10 (40.0%)		

P value is a statistical significance testing, if less than 0.05, is statistically significant*

χ^2: Chi square test, FE: Fisher Exact

P: *P* value for comparing between the studied groups

*Statistically significant at $p \leq 0.05$

Table 3 Classification of fetal malformation by 2D, 4D, and combined examinations, with correlation with postnatal outcomes (*N* = 25)

Classification of fetal malformations	Detected by 2D US (*N*)	Detected by 4D US (*N*)	Detected by combined examination (*N*)	Postnatal confirmed (*N*)
Neurological malformation (*N* = 6) (24%)	4	6	6	6
Anencephaly	1	1	1	1
Hydrancephaly	1	1	1	1
Aquiductal stenosis	1	1	1	1
Dandy walker variant	1	1	1	1
Chiari malformation	0	1	1	1
Holoprosencephaly	0	1	1	1
Facial deformity (*N* = 3) (12%)	1	3	3	3
Cleft lip	1	1	1	1
Hypoterolism	0	1	1	1
Micrognathia	0	1	1	1
Thorax malformation (*N* = 2) (8%)	2	1	1	2
Lung sequestration	1	0	0	1
Diaphragmatic hernia	1	1	1	1
Abdominal malformation (*N* = 4) (16%)	3	3	3	4
Omphalocele	1	1	1	1
Esophageal atresia	1	0	0	1
Gastrochiasis	1	1	1	1
Duodenal atresia	0	1	1	1
Genitourinary system malformation (*N* = 4) (16%)	3	1	3	4
PUJO	1	0	0	1
PUV	1	1	1	1
PCKD	1	0	1	1
Ambiguous genitalia	0	0	1	1
Skeletal system malformation (*N* = 4) (16%)	4	4	4	4
Skeletal dysplasia	2	2	2	1
Club foot	1	1	1	1
Polydactyly	1	1	1	1
Hydrops fetalis (*N* = 2) (12%)	2	2	2	2
Total	19 (76%)	20(80%)	22 (88%)	25

Table 4 Correlation of pregnancy's outcomes with 2D and 4D ultrasounds and combined examination

Examination method	Pregnancy outcomes		Total
	Positive	Negative	
2D-US			
Positive	19 (76.0)	10 (13.3)	29
Negative	6 (24.0)	65 (86.7)	71
4D-US			
Positive	20 (80.0)	8 (10.7)	28
Negative	5 (20.0)	67 (89.3)	72
Combined examination			
Positive	22 (88.0%)	3 (4.0)	25
Negative	3 (12.0%)	72 (96.0)	75

sensitivity [92.2% vs 96.1%] and specificity [76.4% vs 72.7%] of 3D/4D and 2D US, respectively, were insignificantly different ($P = 0.223$) in detection of congenital malformations confirmed postnatally.

Our study also analyzed the risk factors leading to fetal malformations. The results showed that consanguinity, increased maternal age, past history or family history of

Table 5 The efficiency of various ultrasonic detection techniques in the diagnosis of fetal malformation

Examination method	Accuracy (%)	Sensitivity (%)	Specificity (%)
2D-US	84*	76*	86.67*
4D-US	87*	80*	89.33*
Combined examination	94	88	96

**P*: Statistically significant at $P \leq 0.05$ versus combination group

congenital anomalies, history of medication during pregnancy and maternal diabetes were all risk factors for fetal malformations. Consanguinity plays an important role in the occurrence of congenital malformations, This finding is in consistent with the study by Sarkar et al. [11] who found that (40%) of consanguineous couples had some congenital malformation in their babies which was highly significant, whereas in non-consanguineous couples, the prevalence was only 2.2%.

As regards to past history and family history of congenital anomalies, in this study 5 cases out of 25 cases (20%) had positive past history of birth defects or similar congenital malformation in some members of the family. This finding consistent with El Koumi et al. [12] who stated that a family history of birth defects has been associated with an increased recurrence risk of congenital anomalies, with a recurrence rate ranging between 2 and 5%.

As regards to increased maternal age and babies born with congenital anomalies. This study revealed that a majority of malformed babies were born of mothers aged 25–35 years; though, it was statistically insignificant. This finding consistent with those of Yu et al. [8] found that maternal age ≥35 was independent risk factors for fetal malformations. Also Sarkar et al. [11] who found that most of malformed babies were born of mothers aged 20–29 years; though, it was statistically insignificant, on the other hand, Chen et al. [13] found that teenage pregnancy was significantly associated with increased risk of congenital anomalies specially CNS anomalies.

As regard history of medication during pregnancy, in the current study 13 cases out of 25 cases (52%) have history of taking medication during pregnancy for different diseases. This finding is in consistent with the study by Martha et al. [14] who found that the anti-epileptic drugs exposure in early gestation increase the risk of birth defects associations with valproic acid exposure were appearing to increase the risk of neural tube defects, oral clefts and hypospadias. And Yu et al. [8] found that the history of medication during pregnancy is major risk for development of fetal malformations.. On the other hand BT Bateman et al. [15] found that maternal use of β-blockers in the first trimester is not associated with a large increase in the risk for overall malformations.

As regard to diabetes, the current study showed that incidence of fetal anomalies increases with pre-existing diabetes and gestational diabetes. This finding is in consistent with the study by Bell et al. [16] who found that the risk of major congenital anomaly increase among offspring of women with pre-existing diabetes, overall one in 13 singleton deliveries (7.7%) was affected. Also Wu et al. [17] found that pregestational diabetes and, to a lesser extent, GDM were associated with several subtypes of congenital anomalies of the newborn. These findings suggest potential benefits of preconception counseling in women with pre-existing diabetes or at risk for gestational diabetes for the prevention of congenital anomalies.

As regard to hypertension during pregnancy, the current study found that hypertensive is statically insignificant with non-cardiac fetal malformations. This finding is in contrast with the study by Bellizzi et al. [18] who studied 1152 women with chronic hypertension, 6163 women with preeclampsia, 765 women with eclampsia and 294 with preeclampsia superimposed on chronic hypertension & found that newborns of women with chronic maternal hypertension are at higher risk of fetal malformations The multivariable analysis strengthened the association between the chronic hypertension with superimposed preeclampsia and fetal malformations.

In our study, the major non-cardiac congenital anomalies observed were CNS (24%) followed by skeletal anomalies, abdominal and genitourinary (16%), facial deformity (12%), thorax malformation, and hydrops fetalis (8%). These findings are consistent with those of Yu et al. [8] who found that major malformations were CNS (24.14%)followed by facial anomalies (19%), genitourinary (16%), skeletal deformity (11%) and digestive system (6%) and Sadek et al. [11] who found that major anomalies are CNS followed by skeletal, abdominal, fascial and hydrops fetalis.

The current study revealed that 2D US made definite diagnoses of about 50% of genitourinary, abdominal, and thorax malformations, while 4D US made definite diagnoses of most facial and CNS anomalies.

Many previous studies discussed congenital anomalies in 2D-US with only suspected cases examined by 4D-US [8, 9, 11]; in contrast, in our study, we did both 2D-US and 4D-US for all cases. Also, previous studies had done the examination as part of a screening program [9], but in our study, we selected only high-risk pregnant females according to their clinical history. Lastly, most previous studies discussed isolated fetal system anomalies [19–21], but in our study, we collected many systems.

This study still has several limitations, though. Initially, we only looked at pregnant women (between 24 and 34 weeks), which failed to differentiate between the diagnostic value of 2D and 4D ultrasound screening in the first and late third trimesters. Other risk factors, such as smoking, radiation and hereditary diseases were not taken into account. After 32 weeks, a 3D or 4D scan can be more difficult because the bay is beginning to drop into the pelvis and is taking up more space, and the amniotic fluid levels begin to reduce. In cases with oligohydramnios and renal anomalies, a 3D/4D scan can be more difficult because the amniotic

fluid decreases around the baby. The diagnostic value of 2D-US and 4D-US in the screening of non-cardiac fetal congenital abnormalities should thus be the subject of further study.

Conclusions

The diagnosis rate of fetal abnormalities can be significantly increased by combining two-dimensional ultrasound with four-dimensional ultrasound. Avoiding risk factors that raise the likelihood of fetal abnormalities should take priority for pregnant women with high risk factors. To lower the incidence of fetal abnormalities, prenatal screening and diagnosis should be standardized.

Abbreviations

US	Ultrasound
2D	Two-dimensional
4D	Four-dimensional
CNS	Central nervous system
ROI	Region of interest
CT	Computed tomography
MRI	Magnetic resonance imaging
BPD	Biparietal diameter
HC	Head circumference
FL	Femur length
AC	Abdominal circumference

Acknowledgements

To all the participants for their cooperation and patience.

Author contributions

NA suggested the research idea, follow-up cases, correlated the study concept and design and had the major role in analysis. AN supervised the study with significant contribution to design the methodology, manuscript revision and preparation. RS correlated the finding with clinical finding and managed the cases. KH collected data in all stage of manuscript, performed data for analysis, and all authors have and approved the manuscript.

Funding

No funding. Not applicable for this section.

Availability of data and materials

The author's confirm that all data supporting the finding of the study are available within the article and the raw data ad data supporting the findings were generated and available at the corresponding author on request.

Declarations

Ethics approval and consent to participate

Informed written consents taken from the patients and healthy volunteers, and the study was approved by ethical committee of Tanta university hospital, faculty of medicine. Approval code: 35112/12/21.

Consent for publication

All participants included in the research gave written consent to publish the data included in the study. Authors agreed to publish the paper.

Competing interests

The authors declare that they have no competing of interests.

Author details

[1]Department of Radiology Faculty of Medicine, Tanta University Assistance, Tanta University Hospital, Algish Street, Tanta, Gharbia Governorate 31511, Egypt. [2]Radiology Department Faculty of Medicine, Tanta University Assistance, Tanta University Hospital, 15 Ebn elphared Street, Tanta, Gharbia Governorate 31511, Egypt.

Received: 23 May 2023 Accepted: 24 November 2023
Published online: 30 November 2023

References

1. Patel ZM, Adhia RA (2005) Birth defects surveillance study. Indian J Pediatr 72:489–491. https://doi.org/10.1007/BF02724426
2. Elfeshawy MS, Aly WE, Abouzeid MA (2019) The role of 3D & 4D ultrasonography in diagnosis of fetal head and neck congenital anomalies. Int J Med Imaging 7(4):81–90. https://doi.org/10.11648/j.ijmi.20190704.11
3. Wilson RD, Audibert F, Brock JA et al (2014) Genetics committee; special contributor. Prenatal screening, diagnosis, and pregnancy management of fetal neural tube defects. J Obstet Gynaecol Can 36(10):927–939. https://doi.org/10.1016/S1701-2163(15)30444-8
4. Cloutier M, Gallagher L, Goldsmith C et al (2017) Group genetic counseling: an alternate service delivery model in a high risk prenatal screening population. Prenat Diagn 37(11):1112–1119. https://doi.org/10.1002/pd.5149
5. Vinals F, Ruiz P, Quiroz G et al (2017) Two-dimensional ultrasound evaluation of the fetal cerebral aqueduct: improving the antenatal diagnosis and counseling of aqueductal stenosis. Fetal Diagn Ther 42(4):278–284. https://doi.org/10.1159/000458439
6. Sklar C, Yaskina M, Ross S et al (2017) Accuracy of prenatal ultrasound in detecting growth abnormalities in triplets: a retrospective cohort study. Twin Res Hum Genet 20(1):84–89. https://doi.org/10.1017/thg.2016.92
7. Merz E, Abramowicz (2012) 3D/4D ultrasound in prenatal diagnosis: Is it time for routine use? Clin Obstet Gynecol 55(1):336–351. https://doi.org/10.1097/GRF.0b013e3182446ef
8. Yu X, Liu F, Gao W et al (2022) Diagnostic value and high-risk factors of two-dimensional ultrasonography combined with four-dimensional ultrasonography in prenatal ultrasound screening of fetal congenital malformations. J Comput Math Methods Med. https://doi.org/10.1155/2022/7082832
9. Deng B, Hu D, Liu J et al (2015) Application of two-dimensional ultrasonography combined with four-dimensional ultrasonography in prenatal screening for fetal anomaly at different gestational weeks. J Eval Anal Drug-Use Hosp China 15(7):904–906
10. Gonçalves LF, Nien JK, Espinoza J et al (2006) What does 2-dimensional imaging add to 3- and 4-dimensional obstetric ultrasonography? J Ultrasound Med 25(6):691–699. https://doi.org/10.7863/jum.2006.25.6.691
11. Sadek SM (2019) Diagnosis of non-cardiac fetal malformations during mid-trimester anomaly scan: Does three-dimensional ultrasonography have any added value? Evid Based Women's Health J 9(4):549–560. https://doi.org/10.21608/EBWHJ.2019.64358
12. El Koumi MA, Al Banna EA, Lebda IB (2013) Pattern of congenital anomalies in newborn: a hospital-based study. J Pediatr Rep 5(1):e5. https://doi.org/10.4081/pr.2013.e5
13. Chen XK, Wen SW, Fleming N et al (2017) Teenage pregnancy and congenital anomalies: which system is vulnerable? Hum Reprod 22(6):1730–1735. https://doi.org/10.1093/humrep/dem043
14. Werler MM, Ahrens KA, Bosco JLF et al (2011) Use of antiepileptic medications in pregnancy in relation to risks of birth defects. J Ann Epidemiol 21(11):842–850. https://doi.org/10.1016/j.annepidem.2011.08.002
15. Bateman BT, Heide-Jørgensen U, Einarsdóttir K et al (2018) β-blocker use in pregnancy and the risk for congenital malformations: an international cohort study. J Ann Intern Med 169(10):665–673. https://doi.org/10.7326/M18-0338
16. Bell R, Glinianaia SV, Tennant PWG et al (2012) Peri-conception hyperglycaemia and nephropathy are associated with risk of congenital anomaly in women with pre-existing diabetes: a population-based cohort study. J Diabetol 55(4):936–947. https://doi.org/10.1007/s00125-012-2455-y
17. Wu Y, Liu B, Sun Y et al (2020) Association of maternal pre-pregnancy diabetes and gestational diabetes mellitus with congenital anomalies of

the newborn. J Diabetes Care 43(12):2983–2990. https://doi.org/10.2337/dc20-0261
18. Bellizzi S, Ali M, Abalos E et al (2016) Are hypertensive disorders in pregnancy associated with congenital malformations in offspring? Evidence from the WHO multicountry cross sectional survey on maternal and newborn health. J BMC Pregnancy Childbirth 16(1):1–10. https://doi.org/10.1186/s12884-016-0987-8
19. AL-Najjar SAA (2016) Three-dimensional ultrasound in evaluation of fetal brain anomalies. Zanco J Med Sci 20(3):1490–1496. https://doi.org/10.15218/zjms.2016.0049
20. Liu IF, Chang CH, Yu CH et al (2015) Prenatal diagnosis of fetal acrania using three-dimensional ultrasound. Ultrasound Med Biol 31(2):175–178. https://doi.org/10.1016/j.ultrasmedbio.2004.10.005
21. Mak ASL, Leung KY (2019) Prenatal ultrasonography of craniofacial abnormalities. Ultrasonography 38(1):13. https://doi.org/10.14366/usg.18031

Publisher's Note