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Role of Three and Four-Dimensional Ultrasound in Diagnosis of Neurologicalfetalcongenital Anomalies

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Abstract:
Objective: *The present work is designed to review the role of three dimensional and four dimensional (3D and 4D) ultrasound in diagnosis of neurological fetal congenital malformations.*
Patients and methods: *Over the study period (June 2017 to September 2018), about200 fetuses were evaluated by ultrasound. Out of the total number of women scanned with 2D & 3D/4D ultrasound; 11 neurological anomalies (5.5%) were detected and analyzed in 11 women with 11 fetuses. Inclusion criteria included US findings suggestive of neurological fetal anomalies.Initially, traditional 2DUS was routinely performed.The patients were then evaluated by 3DUS to determine whether data obtained by 3D imaging correlated to the 2D findings. Our protocol also included 4DUS while fetal movements were monitored in real time. The 3D images were compared with the 2D images and the ultrasound data given a score and analyzed to determine whether the same, additional or conflicting information was found. The results obtained with 2D and 3D US were compared; whereby the 3D technique was defined as advantageous when the malformation was identified or appreciated more rapidly or better regarding localization, size and depth or when a malformation undetected with 2D US was found.*
Outcome: the accuracy of diagnosis was ascertained by pathology of terminated pregnancies, post natal clinical examination, imaging & surgery performed in some cases
Results: *3D/4D ultrasound showed equal results such as 2DUS in 7 out of 11 anomalies (63.6%), while it was advantageous than 2DUS in 4 anomalies (36.4%). The advantage results were obtained for spina bifida myelomeningocele (MMC) and encephalocele; while it was equal as regard to hydranencephaly, anencephaly, agenesis of the corpus callosum, porencephalic cyst, intraventricular hemorrhage and holoprosencephaly.*
Conclusion: *According to our findings, 3D/4D US has shown advantage over 2DUS in demonstrating some anomalies of nervous system. Currently, the gold standard for evaluation of fetal anomalies remains by 2D US assessment, with 3D/4D US having an adjunctive role.*

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I. Introduction

Fetal congenital anomalies risk is reported to be about 2% to 3% regardless of their prior history, family history, maternal age or lifestyle**.**This risk increases in some patients (high risk pregnancy). Among these factors that increase the risk of fetal congenital anomalies are advanced maternal age, history of drug intake (teratogenic drugs) during first trimester, maternal smoking & alcoholism, exposure to radiation, prior history of recurrent abortion or delivery of malformed fetus(1).

The central nervous system malformation (CNS) is one of commonest congenital anomalies encountered in pregnancy (2). They account for approximately 0.3-1 % of live births. Prenatal detection of CNS malformation is important since these anomalies frequently have a severe prognosis and often associated with chromosomal anomalies and genetic syndromes (3).

One of the most consistently cause for the use of ultrasound in obstetrics is that precise diagnosis of fetal anomalies before labor can offer health care providers & parents a number of treatment decisions.In diagnosis of congenital anomalies, traditional two dimensional ultrasounds (2DUS) images may be confusing& difficult to construct to some clinicians because they must be interpreted to form a 3D impression of the anatomic structures available (4). Three dimensional ultrasound (3DUS) has become the new standard in prenatal diagnosis of fetal congenital anomalies. This technique enables detailed examination of the fetal anatomy and higher quality depiction of congenital anomalies. Furthermore, four dimensional ultrasound (4D US) enables visualization of more details regarding the dynamics of small anatomical structures. Using the advantages of this technology, a physiologic pattern of embryonic or fetal motor development was made (5).

II. Patients & Methods

Over the study period (June 2017 to September 2018), about200 fetuses were evaluated by ultrasound. Out of the total number of women scanned with 2D & 3D/4D ultrasound; 11 neurological anomalies (5.5%) were detected and analyzed in 11 women with 11 fetuses. The maternal age ranged from 18 to 42 years. Gestational age ranged from 13 weeks to 37 weeks. Women came for routine antenatal screening or for confirmatory advice from other centers. Inclusion criteria included US findings suggestive of neurological fetal anomalies. There were no specific exclusion criteria.

Ultrasound examination was performed using GE (voluson) E6 medial system, Germany. A transabdominal 2-5 MHz, transducer with curved arraywas used for 2DUSand RAB6-D 4D convex probe to obtain 3D and 4D imagesand to obtain the 3D volume data set. Initially, traditional 2DUS was routinely performed. The study of fetus included assessment of the head & neck (brain & face), thorax & heart, abdominal wall & viscera, spine & limbs. After complete examination by the 2D sonography, initial diagnosis was made based on the detected findings. The patients were then evaluated by 3DUS to determine whether data obtained by 3D imaging correlated to the 2D findings, and if the 3D imaging offered any diagnostic superiority to 2D US. A 3DUS volume was taken to scan all regions, as well as the area of interest when 2DUS detected or suggested an abnormality. Our protocol also included 4DUS while fetal movements were monitored in real time. For both modalities, the patient underwent US for approximately 30-40 minutes. The 3DUS data were saved to permit further evaluation and manipulation once the patients had left the clinic. The volume sets were rotated and the images were obtained in standard anatomical orientation, and showed as concurrent topographic images in three planes (transverse, sagittal & coronal). Images with various filter settings were used to differentiate between the bony & soft tissue features. The 3D images were compared with the 2D images and the ultrasound datagiven ascore and analyzed to determine whether the same, additional or conflicting information was found. The results obtained with 2D and 3D US were compared whereby the 3D technique was defined as advantageous when the malformation was identified or appreciated more rapidly or better regarding localization, size and depth or when a malformation undetected with 2D US was found.

Outcome: the accuracy of diagnosis was ascertained by: pathology of terminated pregnancies, post natal clinical examination, imaging & surgery performed in some cases

III. Results

In the present work, 3/4D ultrasound showed equal results such as 2DUS in 7 out of 11 anomalies (63.6%), while it was advantageous than 2DUS in 4 anomalies (36.4%). The advantage results were obtained for spina bifida-myelomeningocele and encephalocele; while it was equal as regard to hydranencephaly, anencephaly, agenesis of the corpus callosum, porencephalic cyst, intraventricular hemorrhage and holoprosencephaly (table 1).

Table (1): Value of 3/4DUS compared to 2D US in all types of examined anomalies.

	Total scanned	Disadvantageous	Equal	Advantageous
Hydranencephaly.	1	0	1	0
Anencephaly.	1	0	1	0
Spina Bifida- MMC.	3	0	0	3
Agenesis of the corpus callosum.	2	0	2	0
Encephalocele.	1	0	0	1
Porencephalic cyst.	1	0	1	0
Intraventricular hemorrhage (IVH).	1	0	1	0
Holoprosencephaly	1	0	1	0
Total	**11**	0(0.0%)	7 (63.6%)	4(36.4%)

Disadvantageous=less information than 2DUS; Equal=similar information; Advantageous=More clear information than 2DUS.

Table (2): Risk Factors in females with fetal neurological anomalies

Risk Factor	Statistics
Drug intake	4 (36.4%)
Advanced maternal age (≥35 years).	1 (9.1%)
Past history of Rh incompatibility	1 (9.1%)
Diabetes mellitus	4 (36.4%)
Thyrotoxicosis	1 (9.1%)
Past history of malformed fetus	2(18.2%)
Past history of recurrent abortion	3(27.3%)

IV. Figures

First patient (figure 1)aged 24 years, (P 1 + 0), had type-1 diabetes mellitus (risk factor); the gestational age at examination was 24 weeks + 4 days; and there was no consanguinity between the female and her husband. The diagnosis was semi lobar holoprosencephaly associated with facial anomalies.

The second patient (figure 2), aged 26 years, (P1+0) with no identifiable risk factor, the gestational age was 35 weeks. The diagnosis was spina bifida (lumbar meningomyelocele) with severe hydrocephalus.

The third patient (figure 3)aged 26 years (P 2+0), gestational age was 27 weeks + 2 days and negative consanguinity. The diagnosis was anencephaly.

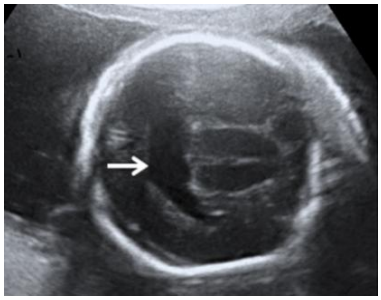

Figure (1a):2DUS (Axial view) showing fusion of lateral ventricles (arrow) with fused thalami

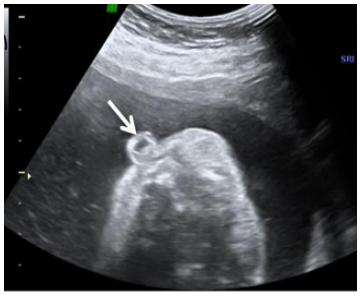

Figure (1b): 2D US of the same case Showing single nasal aperture (single nostril) (arrow).

Figure (1c): 3DUS Showing single nostril

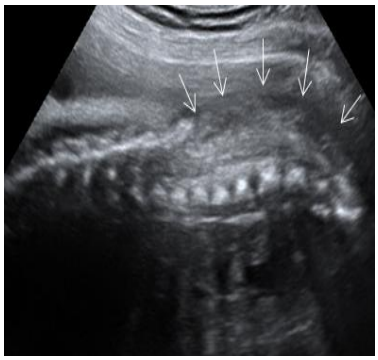

Figure (2a): 2DUS (sagittal view) of the fetal spine shows Large defect at lumbar region containing meninges and neural elements (arrows).

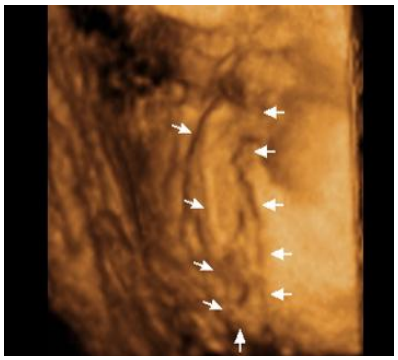

Figure (2b): 3DUS of the same fetus clearly delineates the defect (arrows).

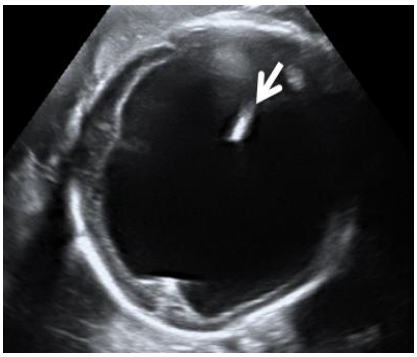

Figure (2c): 2DUS (axial view) of the brain shows markedly dilated lateral ventricle with preserved falxcerebri (arrow).

Figure (3a): 2DUS (axial view) of the head shows bulging eyes, absence of skull vault, overlying skin, meninges and brain

Figure (3b): 3DUS of the headconfirm the diagnosis of anencephaly

V. Discussion

Central nervous system (CNS)malformation is the second most frequent category of congenital anomaly, after congenital heart disease (6).Ultrasound detection of prenatal central nervous system (CNS) anatomic anomalies is very important in making decision about therapeutic management(7).

3D Ultrasound became a truthassociated with the greatdevelopment of computer speed, size and memory. The superiority of 3D and 4D ultrasound in certain areas are clear. Its use in the workup of fetal congenital malformationsincluded the face; limbs, thorax, spine and the central nervous system are already applied by most centers (8).

The main difference between 3D and 4D is that the later provide a dynamic examination compared to the static view of 3D so, it provides useful information about the fetal behavior and help for diagnosis of some musculoskeletal anomalies. Another advantage is the ease of getting more obvious 3D images through processing of the obtained 4D images. In addition, the live imaging is wonderful to the parents who may be fascinated with it and ask for the 4D clip for the memory of their offspring child. Also, 4D might have application in the field of interventional obstetrics such as guiding amniocentesis (9).

Several authors have compared the performance of 3D/4D versus 2D Ultrasound in detecting CNS anomalies. For example, in 1996, (10)compared 2D US and 3D US for diagnosis of CNS anomalies in 11 fetuses, in which 1 case of spina bifida out of 5 was missed by 2DUS, and correctly diagnosed by 3DUS. In addition, an inaccurate diagnosis of encephalocele by 2D US was modified as a cervical meningomyelocele by 3DUS.

There isimproved capability of 3D US to view the intracranial midline and corpus callosum when compared with 2D US(11).3D US visualized these structures in 78.1% of examinations; while 2D US visualized them in 3.1% of examinations(12).In addition, 3D UShad been found to be advantageous in all 5 cases of spinal anomalies (13). (14)Found 3D US better in demonstration of one case of neural tube defect.

Generally, some of previous studies found that 3DUS was advantageous for visualization of congenital anomalies (regardless the type or system of anomaly)(15, 16), whereas others (12)found that 3DUS did not offer marked extradata over what was offered by 2DUS**.**

Our study compared 2D and3/4D US and revealed that, 3/4D ultrasound showed equal results such as 2DUS in 7 out of 11 anomalies (63.6%), while it was advantageous than 2DUS in 4 anomalies (3 cases ofspina bifida and 1 case of encephalocele) (36.4%). Our results agreed with (17), who reported that, 3DUS offered advantages over 2D US imaging in terms of diagnosis of some anomaliesand data storage. However, it must be emphasized that, performing 2DUS before 3D US scanning is essential to determine the proper position for 3D scanning; consequently 3D US examination is impossible to be carried out without the prior use of 2D ultrasound (18).Thus, three-dimensional sonography is not a standalone screening technique but an adjunct to 2D sonography for those fetuses in which malformations are already determined or suspected on the basis of standard sonography.

VI. Conclusion

According to our findings, 3D/4D US has shown advantage over 2DUS in demonstrating some anomalies of nervous system. Currently, the gold standard for evaluation of fetal anomalies remains by 2D US assessment, with 3D/4D US having an adjunctive role.

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