

*Research Article***Output Indices in 2D versus 3D/4D Ultrasonography in Fetal Craniocerebral Anomalies**

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Abstract

Objective: to compare the acoustic output of conventional two-dimensional US and 3D/4D US in a group of pregnant women with fetal craniofacial malformations. **Method:** Fifty women with suspected craniocerebral anomalies during routine prenatal ultrasound examination are included in the study. For ultrasound assessment, we used a Doppler ultrasound system. Subsequently, 3D/4D images were obtained using a suitable probe. During both examinations, changes in thermal index (TI) and mechanical index (MI) were recorded. **Results:** Comparison between TI and MI of the different ultrasound techniques revealed no statistically significant differences. The reported TI for the studied modalities was 0.277 ± 0.01 , 0.271 ± 0.008 and 0.249 ± 0.01 ($p=0.43$) while MI was 1.12 ± 0.012 , 0.87 ± 0.014 and 1.19 ± 0.37 ($p=11$) for B mode, 3D and 4D techniques respectively. **Conclusion:** 3D/4D ultrasound imaging is comparable to 2D imaging regarding thermal and mechanical indexes in women with fetal craniocerebral anomalies.

Keywords: Craniocerebral anomalies, 3D/4D ultrasound, thermal index, mechanical index.

What's already known about this topic?

Ultrasound is an established technique for antenatal diagnosis. However, debate continues over the safety issues particularly for 3D/4D ultrasound imaging.

What does this study add?

The study confirms the safety of 3D/4D ultrasound imaging in a high-risk group with craniocerebral malformations.

Introduction

Craniocerebral malformations are critical conditions that are commonly encountered during prenatal counselling. Ventricular dilatation is the most common antenatal cerebral abnormality. Available imaging modalities include magnetic resonance imaging and ultrasound.^{1,2}

Over the past three decades, 3-dimensional/4-dimensional ultrasonography (3D/4D US) has witnessed tremendous evolution making it one of the most powerful tools in the field of fetal medicine. It has the advantages of multiplanar and precise imaging when compared with the conventional two-dimensional (2D) imaging.³

Unfortunately, fetal ultrasound technology isn't without drawbacks. The bioeffects of diagnostic

ultrasound on living tissues are likely produced by heating or inertial cavity production.

These effects are evaluated by measuring the acoustic output expressed by the thermal index (TI) and the mechanical index (MI). However, data on acoustic output of 3D/4D US are scarce.⁴

Reports from human and experimental studies linking prenatal ultrasound exposure to non-right-handedness and disturbance in neuronal migration raise attention about the possible hazards related to ultrasound exposure especially in fetuses with possible craniocerebral malformations.⁵ Moreover, in one experimental study, it was found that exposure of rats to diagnostic levels of ultrasound could adversely affect the permeability of blood brain barrier.⁶

The present study aimed to compare the acoustic output of conventional two-dimensional US and 3D/4D US in a group of pregnant women with fetal craniocerebral malformations.

Subjects and Methods

The present cross-sectional study was conducted at Al-Hussain Hospital, Al-Azhar University, Cairo, Egypt. The study was approved by the local ethical committee in accordance with Helsinki Declaration on clinical research involving human subjects. All women included in the study gave informed consent prior to participation in the study.

Fifty women with suspected craniocerebral anomalies during routine prenatal ultrasound examination are included in the study. All women were subjected to careful history taking and thorough clinical and obstetrical examination. For ultrasound assessment, we used a Doppler ultrasound system (Voluson, 730 PRO V, GE Medical Systems, Buckingham, UK). With the examined woman in the supine position, a 2D probe was used to scan the entire abdominal surface. The scanned details of the

fetal head, fetal skeleton, viscera, placenta and amniotic fluid were documented. Subsequently, 3D/4D images were obtained using a suitable probe. During both examinations, changes in TI and MI were recorded.

Data obtained from the present study are presented as mean \pm SD or number and percent. Numerical data were compared using student t test under SPSS 22 (IBM, USA). P value less than 0.05 was considered statistically significant.

Results

The present study included 50 women with craniocerebral fetal anomalies. Basic data of the studied women were shown in **Table 1**. Comparison between TI and MI of the different ultrasound techniques shown in **Table 2** revealed no statistically significant differences. The reported TI for the studied modalities was 0.277 ± 0.01 , 0.271 ± 0.008 and 0.249 ± 0.01 ($p=0.43$) while MI was 1.12 ± 0.012 , 0.87 ± 0.014 and 1.19 ± 0.37 ($p=11$) for B mode, 3D and 4D techniques respectively.

Table (1): Basic data of the studied women (n=50)

Age (years)	24.7 ± 3.1
Gestational age (weeks)	32.7 ± 2.1
Gravidity	2.4 ± 1.5
Parity	1.8 ± 1.4
Duration of US examination (minutes)	
2D examination	26.6 ± 2.7
3D examination	27.1 ± 1.6
4D examination	28.9 ± 3.2

Table (2): Comparison between different imaging techniques regarding TI and MI

	B mode	3D	4D	P value
TI	0.277 ± 0.01	0.271 ± 0.008	0.249 ± 0.01	0.43
MI	1.12 ± 0.012	0.87 ± 0.014	1.19 ± 0.37	0.11

TI: Thermal index, MI: Mechanical index.

Discussion

Results of the present study shows comparable TI and MI in different US modalities used for assessment of craniofacial malformations. These findings confirm conclusions reported by previous studies. In their prospective study on 40 ultrasound examinations, Sheiner et al.,⁷

revealed no significant differences between acoustic exposures expressed by TI and during 3D/4D ultrasound examination and those of 2D B-mode ultrasound.

In fact, it should be kept in mind that the main determinant of acoustic exposure during ultra-

sound examination is the time need to obtain the appropriate plane of scanning. This role applies to all US scanning modalities. In their study assessing the acoustic output during routine obstetric US B-mode examinations, Sheiner et al.,⁸ noted a statistically significant correlation between MI and duration of examinations. This relation is remarkable during the learning process. In fact, and as expected the length of US examination is considerably prolonged during early learning stages and these is related to increased acoustic output.⁹

While results of our study may be assuring, real world practices of physician and sonographers are disturbing. In one survey conducted by US Food and Drug Administration (FDA) on diagnostic ultrasound devices whose indications for use include fetal applications, it was found that there is increased acoustic output for both Doppler and non-Doppler modes. These alarming findings showed low adherence to As Low As Reasonably Achievable (ALARA) principle contrasting previous beliefs.¹⁰

These data raise attentions about the necessity of adherence to practice guidelines. Moreover, it is recommended to unify various national guidelines and manufacturers to avoid discrepancies that may affect the consistency of conclusions derived from various studies.¹¹

References

- Zielinski R, Respondek-Liberska M. [Craniofacial malformations in prenatal ultrasound evaluation. Literature review]. *Ginekol Pol.* 2013; 84(9):801-6.
- Garel C, Moutard ML. Main congenital cerebral anomalies: how prenatal imaging aids counseling. *Fetal Diagn Ther.* 2014; 35(4):229-39.
- Salsi G, Cataneo I, Dodaro G, et al., Three-dimensional/four-dimensional transperineal ultrasound: clinical utility and future prospects. *Int J Womens Health.* 2017; 9:643-56.
- Sheiner E, Abramowicz JS. A symposium on obstetrical ultrasound: is all this safe for the fetus? *Clin Obstet Gynecol.* 2012; 55 (1): 188-98.
- Marsal K. Exposure to ultrasound in utero: epidemiology and relevance of neuronal migration studies. *Ultrasound Med Biol.* 2010; 36(8):1221-3.
- Yang FY, Lin GL, Horng SC, et al., Prenatal exposure to diagnostic ultrasound impacts blood-brain barrier permeability in rats. *Ultrasound Med Biol.* 2012;38(6):1051-7.
- Sheiner E, Hackmon R, Shoham-Vardi I, et al., A comparison between acoustic output indices in 2D and 3D/4D ultrasound in obstetrics. *Ultrasound Obstet Gynecol.* 2007; 29(3):326-8.
- Sheiner E, Freeman J, Abramowicz JS. Acoustic output as measured by mechanical and thermal indices during routine obstetric ultrasound examinations. *J Ultrasound Med.* 2005;24(12):1665-70.
- Nemescu D, Berescu A, Rotariu C. Variation of safety indices during in the learning curve for color Doppler assessment of the fetal heart at 11+0 to 13+6 weeks' gestation. *Med Ultrason.* 2015;17(4):464-74.
- Cibull SL, Harris GR, Nell DM. Trends in diagnostic ultrasound acoustic output from data reported to the US Food and Drug Administration for device indications that include fetal applications. *J Ultrasound Med.* 2013;32(11):1921-32.
- Harris GR, Church CC, Dalecki D, et al., Comparison of Thermal Safety Practice Guidelines for Diagnostic Ultrasound Exposures. *Ultrasound Med Biol.* 2016; 42(2): 345-57.