Is three-dimensional ultrasound adding new for detection of congenital anomalies?

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Abstract

Objective: to evaluate the three-dimensional ultrasound (3D US) as a recent method for detection of fetal congenital anomalies in comparison with the traditional 2 D US.
Materials and Methods: Thirty-eight fetuses had been examined with the same equipment containing the traditional 2D US and 3D US. Each fetus had been scanned with one volume probe that has the 2 options; 2D and 3D US. The gestational ages of the examined fetuses were 22-36 weeks.
Results: Seventy-two abnormalities were detected with 2D US, real-time 3D US, or both in 38 fetuses. Of the 72 fetal abnormalities, sixteen (22%) that had not been identified adequately at 2D US were disclosed with real-time 3D US. For eighteen abnormalities (25%) diagnosed at 2D US, real-time 3D US gave further information. Thirty-eight abnormalities (53%) were diagnosed only with 2D US.
Conclusion: Real-time 3D US is useful for evaluating fetal abnormalities as a supplement to 2D US, particularly for abnormalities of the face, head, fingers, and skeleton, but real-time 3D US is unlikely to be helpful for detecting intra-fetal abnormalities except for skeletal abnormalities and some pathologic changes with fluid accumulation.

Introduction

Following Food and Drug Administration (FDA) approval of 3-dimensional ultrasound (3D US) in November 1997, interest has increased to get more benefits from this new advance. The first 3D US equipment that developed in 1991 was consuming 25 seconds to store an image and minutes to hours to reconstruct the 3D image. In real-time 3D US with the volume-rendering technique, the ultrasound beam itself is regarded as a projection ray, and volume ray tracing is conducted in each case in real time; this technique generates a 3D image immediately after several seconds of scanning with simple settings (starting depth and opacity). 3D US have been shown to facilitate the diagnosis of fetal anomalies. The commonest fetal anomalies that have been investigated included face abnormalities, ear malformations, hydrocephaly, neural tube defects, abdominal wall defects, limb abnormalities, cardiac abnormalities and others (1-4). As a new advance and because of its relative high price, different studies was carried out to compare 3D US with the 2D US in detection of fetal congenital anomalies (5-15). In this study, 3D US will be evaluated as a recent advance comparing it with the 2D US.

Materials and methods

This study was conducted in King Khalid General Hospital, Hafr El-Batin, Saudi Arabia, in the period between January 2002 and June 2003. Thirty eight patients were included in the study. They have been scanned with a conventional convex 2D US (3.5 MHz) and 3D volume real time mode (Aloka SSD-1700, Japan). The 3D probe has a built-in electronic-scanning convex probe (3.5 MHz) that is swung by means of a motor to the direction of the section width. Gestational ages at examination were 22-36 weeks. Scanning included 4 cases of twin pregnancy with congenital abnormalities. Each fetus was scanned by 2D and 3D US. The 3D volume abdominal probe was used first without the use of mechanical scanning for 2D scanning. Any detected anomalies were recorded before shifting to 3D scanning.
The results were scored as follow: grade 1, detected with real-time 3D US but not with 2D US; grade 2, suspected at 2D US and confirmed with real-time 3D US; grade 3, detected with 2D US, with further information provided at real-time 3D US; grade 4, detected with 2D US but only suspected at real-time 3D US; or grade 5, detected with 2D US but not with real-time 3D US.

Results

Seventy-two abnormalities were detected with 2D US, real-time 3D US, or both in 38 fetuses (see table 1). Of the 72 fetal abnormalities, sixteen (22%) that had not been identified adequately at 2D US were disclosed with real-time 3D US (scored 1 or 2). For eighteen abnormalities (25%) diagnosed at 2D US, real-time 3D US gave further information (scored 3). Thirty-eight abnormalities (53%) were diagnosed only with 2D US (scored 4 or 5).
Two cases were shown with 3D US to have flat noses and slanted palpepral fissures, which suggested Down syndrome and had been overlooked at 2D US. Two other cases had been shown by 2D US to have polydactyl of the foot, but real-time 3D US could not depict it because of the limited viewing direction.
In 7 fetuses with oligohydramnios, surface-rendered images were difficult to visualize; while bones and skin surface were detected easily on real-time 3D US scanning with low opacity.
Intrauterine growth retardation was diagnosed with fetal biometry at 2D US in 8 fetuses, including 2 twins; the fetal weights were estimated to be below the mean -1.5 SD value pre-sited fetal growth standard curve in the US equipment. This diagnosis was not possible with real-time 3D US, which demonstrated only discordant growth between discordant twins.
Massive subcutaneous edema was evident in 2 fetuses, and a short, curved femur could be seen in another 2 fetuses.
By adjusting the starting depth, liver and bowel images in fetuses with ascitis were obtained by eliminating the unnecessary image of the fetal abdominal wall. Neural tube defects in the form of spina bifida in 2 fetuses at 33 and 35 weeks were detected by 3D US by setting the starting depth under the skin to eliminate any skin image.
Except for the small stomach cases, the US findings were confirmed with postnatal or post mortem follow up in 22 cases. The US findings of a small stomach might be a temporary finding in utero. Spondyloepiphyseal dysplasia was diagnosed in 2 fetuses after birth. In another 2 cases, an imperforate anus was found in the neonate that had been missed at conventional 2D US and real-time 3D US. Postnatal follow-up examinations were not possible in 2 neonates; consequently, the US findings were not confirmed after birth.

Discussion

Three-D US plays an important role in obstetrics, predominantly for assessing fetal anatomy. Presenting volume data in a standard anatomic orientation valuably assists both ultrasonographers and pregnant patients to recognize the anatomy more readily.16 In spite of taking more time in scanning than 2D US, 3D US generates realistic fetal images for fetuses surrounded by adequate amniotic fluid. Although the viewing direction is limited to that of the probe, the desired viewing direction for fetuses with hydramnios is possible in most cases by selecting the proper position and direction of the probe on the abdominal wall.
Surface-rendered images of the fetus with oligohydramnios and the fetus with thin skin or thin subcutaneous tissue were difficult to obtain with real-time 3D US. In such fetuses real-time 3D US essentially failed to depict intrafetal abnormalities except those of the skeleton and some pathologic changes with fluid accumulation. Fetal growth could not be evaluated, except in cases such as discordant twins and fetuses with severe short-limb dysplasia, because fetal biometry is not possible with real-time 3D US. For biometry, the same probe can be used as 2D US.
Face, ears, and fingers, which are difficult to discern on 2D US images, can be seen realistically with real-time 3D US. Abnormal fetal flexion, clubfoot, and abnormal limb curvature may be diagnosed more easily and accurately with real-time 3D US than with 2D US. It is necessary to distinguish real abnormal findings, such as overlapping fingers and severe flexion of the limb, from temporary findings by observing the fetus repeatedly. The 3D fetal images can be obtained in succession at 3-second intervals with real-time 3D US, thus ensuring correct diagnosis.
In their study, Dyson et al., (2000) reported that 3D US images provided additional information in 53 anomalies (51%), were equivalent to 2D US images in 46 anomalies (45%), and were disadvantageous in four anomalies (4%). The 3D US was most helpful in evaluating fetuses with facial anomalies, hand and foot abnormalities and axial spine and neural tube defects. Planar images derived from 3D US volume data sets generally were more helpful for diagnostic purposes, whereas rendered 3D US images were more useful as a point of reference and were better appreciated by patients in understanding fetal abnormalities. Additional information provided by 3D US images impacted clinical management in 5% of patients. The 3D US images were disadvantageous in two fetuses with multiple anomalies and two with cardiac anomalies. The authors concluded that this modality can be a powerful adjunctive tool to 2D US in providing a more comprehensible 3D US impression of congenital anomalies (7).
In our study, real-time 3D US was useful for detecting, confirming, and clearly depicting 34 (47%) of 72 fetal abnormalities (scored 1, 2, or 3) when the technique was applied to fetuses suspected of having abnormalities on the basis of 2D US findings. The 3D US diagnosis could have been influenced by the 2D US results in our study because both the 2D US examination and the real-time 3D US examination were performed by the same individual. However, performing 2D US before real-time 3D US scanning is essential to determine the proper position for 3D scanning and the proper starting depth (17). Consequently, real-time 3D US examination is impossible to perform without the 2D images.

The results of our study demonstrate that real-time 3D US is useful for evaluating fetal abnormalities as a supplement to 2D US, particularly for abnormalities of the face, ears, fingers, and fetal axis. It is easy to switch back and forth between 2D US and 3D images with real-time 3D US. By using real-time 3D US in conjunction with 2D US, a perinatal diagnosis may be determined speedily and accurately. Real-time 3D US surface-rendered images easily provide good visual perception not only to physicians but also to parents and thus may provide assurance that the parents see the abnormality.

References

1. Budorick NE, Pretorius DH, Nelson TR. Sonography of the fetal spine: technique, imaging, findings and clinical implications. AJR 1995; 164:421-8.
2. Nelson TR, Pretorius DH. Visualization of the fetal thoracic skeleton with three-dimensional sonography. AJR 1995; 164:1485-8.
3. Bonilla-Musoles F. Three-dimensional visualization of the human embryo: a potential revolution in prenatal diagnosis. Ultrasound Obstet Gynecol 1996; 7:393-7.
4. Baba K, Okai T, Kozuma S, Taketani Y, Mochizuki T, Akahane M. Real-time processable three-dimensional US in obstetrics. Radiology 1997; 203:571-4.
5. Xu HX, Zhang QP, Lu MD, Xiao XT: Comparison of two-dimensional and three-dimensional sonography in evaluating fetal malformations. : J Clin Ultrasound 2002;30(9):515-25
6. Scharf A, Ghazwiny MF, Steinborn A, Baier P, Sohn C.: Evaluation of two-dimensional versus three-dimensional ultrasound in obstetric diagnostics: a prospective study. Fetal Diagn Ther 2001;16(6):333-41
7. Dyson RL, Pretorius DH, Budorick NE, Johnson DD, Sklansky MS, Cantrell CJ, Lai S, Nelson TR.: Three-dimensional ultrasound in the evaluation of fetal anomalies. Ultrasound Obstet Gynecol 2000;16(4):321-8
8. Johnson DD, Pretorius DH, Budorick NE, Jones MC, Lou KV, James GM, Nelson TR. : Fetal lip and primary palate: three-dimensional versus two-dimensional US. Radiology 2000;217(1):236-9
9. Blaas HG, Eik-Nes SH, Berg S.: Three-dimensional fetal ultrasound. Baillieres Best Pract Res Clin Obstet Gynaecol 2000;14(4):611-27
10. Yanagihara T, Hata T.: Three-dimensional sonographic visualization of fetal skeleton in the second trimester of pregnancy. Gynecol Obstet Invest 2000;49(1):12-6
11. Baba K, Okai T, Kozuma S, Taketani Y.: Fetal abnormalities: evaluation with real-time-processible three-dimensional US, preliminary report. Radiology 1999;211(2):441-6
12. Meinel K, Guntermann E.: Transparent 3-D ultrasound in fetal abnormalities. Ultraschall Med 1998;19(3):120-5
13. Pretorius DH, House M, Nelson TR, Hollenbach KA.: Evaluation of normal and abnormal lips in fetuses: comparison between three- and two-dimensional sonography. : AJR Am J Roentgenol 1995;165(5):1233-7
14. Bonilla-Musoles F, Raga F, Osborne NG, Blanes J.: Use of three-dimensional ultrasonography for the study of normal and pathologic morphology of the human embryo and fetus: preliminary report. J Ultrasound Med 1995;14(10):757-65
15. Merz E, Bahlmann F, Weber G, Macchiella D.: Three-dimensional ultrasonography in prenatal diagnosis. J Perinat Med 1995;23(3):213-22
16. Benoit B; Hafner T; Kurjak A; Kupesic S; Bekavac I; Bozek T: Three-dimensional sonoembryology. J Perinat Med 2002;30(1):63-73
17. Baba K, Okai T, Kozuma S, Taketani Y, Mochizuki T, Akahane M. Real-time processable three-dimensional US in obstetrics. Radiology 1997; 203:571-574.

Table 1. Fetuses Examined with Real-time 3D US

Number of cases	Fetal Anomaly	Gestational Age at Detection (wk)
2	Trisomy 21; hydramnios	26-28
2	Microcephaly	26-36
1	Dolicocephaly	34

3	Anencephaly; hydramnios	29-32
2	Occipital encephalocele (twin)	24-26
1	Hygroma colli; oligohydramnios	22
2	Omphalocele	26-28
1	Hydrops fetalis	32
2	Short-limb dysplasia; hydramnios	28-29
2	Short-limb dysplasia; oligohydramnios	25
2	Spina bifida	33-35
2	Polydactyl	28-34
1	Fetal ascites	30
2	Unilateral cleft palate	31-33
1	Bilateral cleft palate	32
2	Small-bowel obstruction	34-36
4	Ureteropelvic junction stenosis	24-34
2	hydrocephalus; oligohydramnios	30-34
2	Urethral obstruction; oligohydramnios	20-32
2	Discordant twins	24-28