

Observational Study

Assessment of fetus during second trimester ultrasonography using HDlive software: What is its real application in the obstetrics clinical practice?

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Abstract

AIM

To show imaging results from application of four-dimensional (4D) ultrasound lightening technique (HDLive™) in clinical obstetrics practice.

METHODS

Normal and abnormal fetuses at second and third trimester of pregnancy undergoing routine scan with 4D HDlive™ (5DUS) in the rendering mode are described. Realistic features of fetal structures were provided by 5DUS in the rendering mode. Normal anatomy as well as pathology like cleft lip, hypoplastic face, micrognathia, low-set ears, corpus callosum, arthrogryposis, aortic arch, left congenital diaphragmatic hernia are highlighted in this study. Anatomical details of the fetuses were provided by 5DUS with higher quality imaging modality compared to those obtained using conventional 2D/3D ultrasound.

RESULTS

Realistic views of fetal anatomy details were displayed by means of 5DUS in the rendering mode, with high image quality obtained either in low-risk or in high-risk obstetrics population. Corpus callosum, esophagus, and aortic arch were obtained in normal fetuses. Cleft lip, cleft lip and palate, micrognathia, hypoplastic face, low-set ears, arthrogryposis, left congenital diaphragmatic

hernia, exomphalos, and clitoris hypertrophy were clearly rendered by 5DUS application.

CONCLUSION

The use of 5DUS in the rendering mode, when clinical available, was diagnostic in a variety of congenital anomalies, aided understanding of the parents-to-be and improved prenatal counseling and perinatal management.

Key words: Three-dimensional ultrasound; Four-dimensional ultrasound; HDlive; Second trimester scan; Congenital anomalies

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Core tip: Four-dimensional ultrasound using HDlive™ allows realistic images of fetal anatomic structures in the second trimester of pregnancy. These images allow identifying fine details of fetal surface, with better understanding both multidisciplinary team and parents.

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INTRODUCTION

The second trimester scan, also called anomaly scan, is usually performed between 18-23 wk, and is based on a systematic anatomical survey of the fetus, placenta and umbilical cord, in order to detect possible fetal abnormalities^[1]. The ultrasound examination should be carried out according to international standard^[2] and possibly by accredited sonographers who have completed appropriate training program by scientific societies^[3].

The sensitivity and specificity for detection of congenital anomalies by means of conventional 2D ultrasound may be estimated around 83.5% and 99.8%, respectively^[4,5]. The technologic advancement gained by real-time, high definition three- and four-dimensional ultrasound (3D/4DUS), enable acquisition of volume that can be analysed online or offline by "navigating" within the volume in the three orthogonal planes. 3D/4DUS post-processing techniques allow anatomical details to be investigated in sagittal, axial and coronal planes, improving prenatal diagnosis of congenital malformations^[6-8].

Hereafter, we present a pictorial editorial from normal and pathologic cases obtained during second and third trimester of pregnancy in low- and in high-risk pregnancy using 4D HDlive™ (5DUS) software.

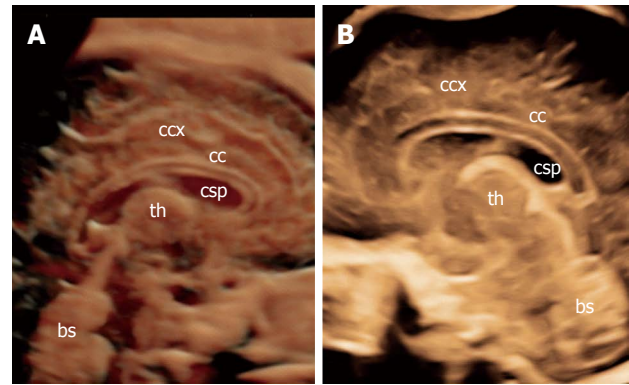


Figure 1 Normal fetal brain at 28 wk of gestation. A: 4DUS using HDlive™ shows, with impressive image quality resembling that of gross anatomy, the cerebral cortex (ccx), the corpus callosum (cc), the cavum septum pellucidum (csp), the thalamus (th) and brainstem (bs) in mid-sagittal plane; B: The same images using the conventional 3DUS in the rendering mode.

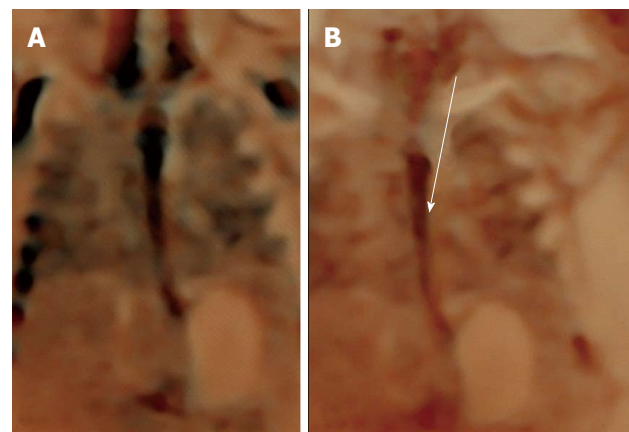


Figure 2 Normal fetal esophagus at 28 wk of gestation. A and B: 4DUS using HDlive™ application may be used to obtain a clear imaging of inner structure of esophagus (arrow) during fetal swallowing at the time of routine second trimester scan.

MATERIALS AND METHODS

Ultrasound examinations were performed using Voluson E8 apparatus equipped with a transabdominal volumetric RAB4D ultrasound probe (GE, Milwaukee, WI). Fetal anatomical survey was performed using conventional 2D ultrasound, and 3D/4D HDlive™ (5DUS) applied both in low- and in high-risk pregnancy. The study was approved by the local Ethics Committee of both Guastalla Civil (AUSL Reggio Emilia) and "Carlo Poma" hospitals (AUSL Mantua), Italy. Four-hundred low-risk and seventy-six high-risk pregnant women entering the clinical trial gave written informed consent. Two consecutive volumes were acquired during transient maternal apnea and fetal rest to reduce motion artefacts. The sweep took less than few seconds. Acquisition angle of 45-60 degree was used, depending on the gestational age. All 3DUS volumes were saved both onto the ultrasound equipment and onto a optical disk for post-processing analysis. 5DUS application was applied to the best 3DUS volume stored and different

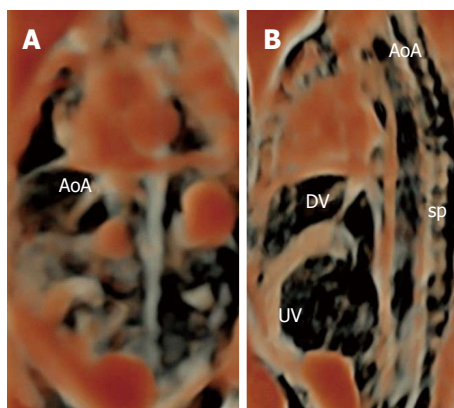


Figure 3 Normal fetal aortic arch at 28 wk of gestation. 4DUS echocardiography using HDlive™ application to the study of the great artery and veins: the AoA (A, image is rotated), the UV and the DV (B) are rendered with an enhanced quality resembling that of an angiographic study (sp, fetal spine). AoA: Aortic arch; UV: Umbilical vein; DV: Ductus venosus; sp: Fetal spine.

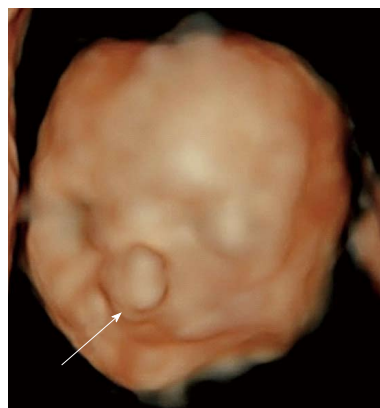


Figure 5 4DUS using Hlive™ showing the right-sided cleft lip and palate (arrow) in a fetus with 21 wk-3 d.

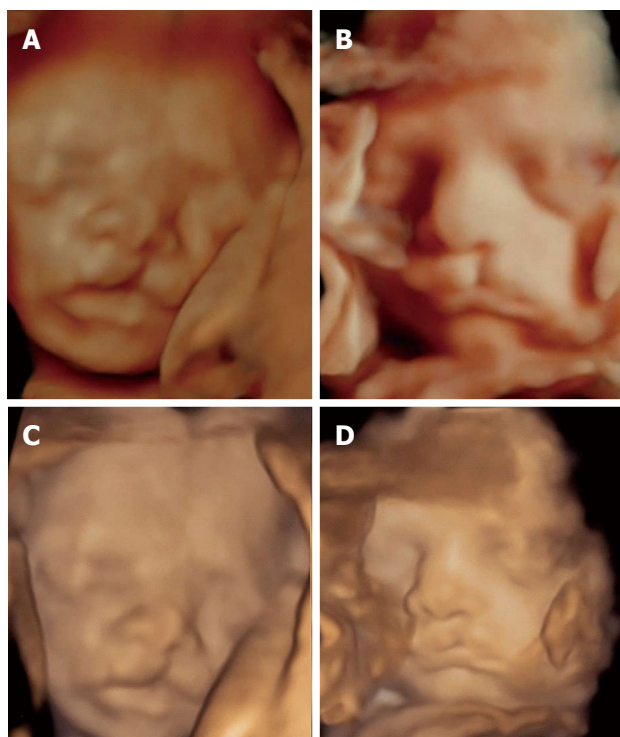


Figure 4 4DUS using Hlive™ (5DUS) lightening technique: Realistic rendering in a case (A) of left-sided cleft lip and palate and left-sided cleft lip (B). C and D: The same images using the conventional 3DUS in the rendering mode.

lightening and shadowing adjustments were made to obtain the highest image quality rendering. Offline analysis was performed using a computer developed platform (4DView™, Zipf, Austria); HDlive™ (5DUS) software was applied after uploading the software onto a personal computer using a freely released flash-drive pen.

RESULTS

Realistic views of fetal anatomy details were displayed



Figure 6 4DUS using HDlive™. Micrognathia (arrow) is clearly rendered.



Figure 7 4DUS using HDlive™ showing a hypoplastic face.

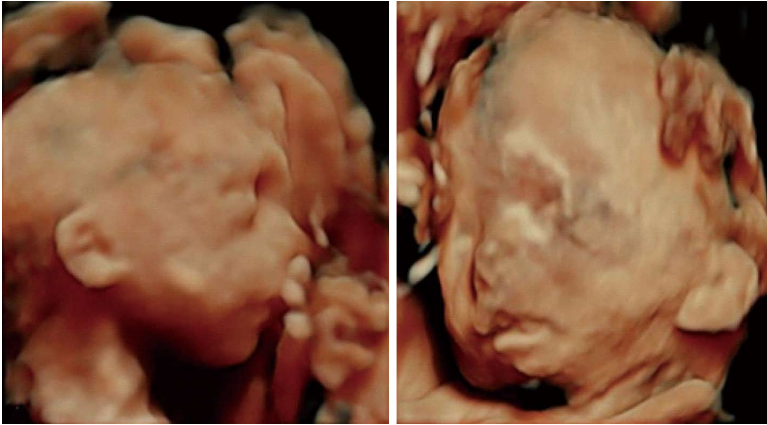


Figure 8 4DUS using HDlive™ enabled a clear snapshot of low-set ears in this case detected at 24 wk of gestation.

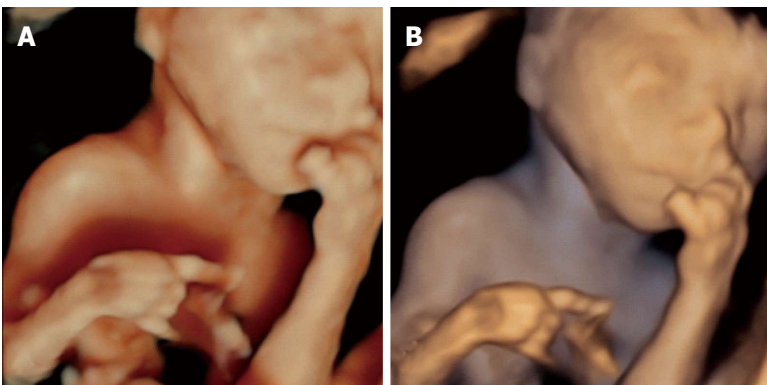


Figure 9 Arthrogryposis multiplex congenital. A: 4DUS using HDlive™, note the characteristic muscular contractions causing fingers deviation; B: The same using the conventional 3DUS in the rendering mode.

by means of 5DUS in the rendering mode, with high image quality obtained either in low-risk or in high-risk obstetrics population. Corpus callosum (Figure 1), esophagus (Figure 2), and aortic arch (Figure 3) were obtained in normal fetuses.

Cleft lip (Figure 4), cleft lip and palate (Figure 5), micrognathia (Figure 6), hypoplastic face (Figure 7), low-set ears (Figure 8), arthrogryposis (Figure 9), left congenital diaphragmatic hernia (Figure 10), exomphalos (Figure 11), and clitoris hypertrophy (Figure 12) were clearly rendered by 5DUS application.

DISCUSSION

This pictorial editorial displays a gallery of normal and pathologic cases obtained during second and third trimester of pregnancy by means of 5DUS in the rendering mode. 3D/4DUS with its technical applications has resulted in improved diagnostic accuracy compared with conventional 2DUS, especially when applied to the field of fetal medicine, where high definition 3D/4DUS produces real-time reconstruction of the fetal anatomy^[9-13]. HDlive™ imaging often looks like a picture taken inside the uterus^[14] and may enable detection of subtle malformations that may go undiagnosed using conventional 2DUS. This may be particularly seen when dealing with surface abnormalities such as those involving the fetal face where 4DUS, especially with HDlive™ rendering mode, may offers a potential imaging enhancement. Previous observation has documented

a role for 3DUS to provide additional information compared to 2DUS for the prenatal diagnosis of facial, skeletal and neural tube defect^[15]. An extended review from Tonni *et al.*^[16] has described the technical advancements obtained over the past 20 years by 3D/4DUS compared to conventional 2DUS in different fields of application, particularly in prenatal diagnosis. The study of the fetal face, palate and detection rate of cleft lip and cleft palates has resulted enhanced when 3D/4DUS has complemented 2DUS, either in the first as in the second trimester of pregnancy^[17-23]. Undoubtedly, one of the main advantages of 3D/4DUS is represented by the possibility of volume acquisition compared with “flat” images obtained by 2DUS. Once a volume is acquired, it can be further manipulate by “navigating” online or offline within the volume. In addition, anatomical details can be displayed in all the three orthogonal planes. Furthermore, 3D/4DUS can be used in training program as the volume can be freely section on demand and send to expert at remote site using DICOM (digital communication in medicine) technology^[16]. Moreover, observations have shown that 4DUS has been a valuable diagnostic investigation to assess fetal neurobehavioral state as it allows visualization of yawning, sucking, smiling, and blinking activity^[13,14]. 5DUS differs from conventional rendering methods because it uses a fixed virtual light source that calculates the propagation of light through skin and tissue. Operators can freely select the light source at any angle relative to the ultrasound volume to

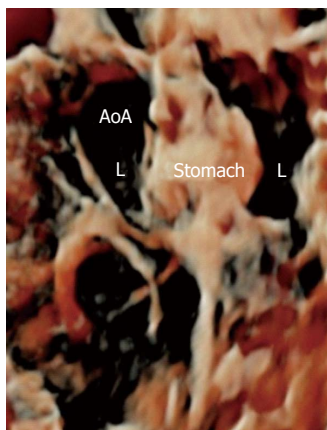


Figure 10 4DUS using HDlive™ application in a case of left congenital diaphragmatic hernia. AoA: Aortic arch; L: Lung.



Figure 11 4DUS using HDlive™ application in a fetus with exomphalos (curved arrow) was diagnosed at early second trimester scan (15 wk-3 d).

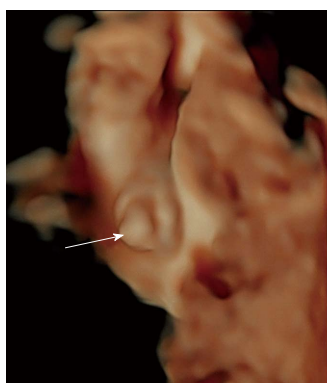


Figure 12 4DUS using HDlive™ application in a case of clitoris hypertrophy (arrow) detected at 27 wk of gestation in an intersexual state (post-natal chromosomal assessment resulted in 46,XY karyotype).

enhance anatomical details^[11]. 5DUS is a relatively easy technique to be applied and does not require specific clinical training for operators already confident with post-processing 3D/4DUS techniques. The time needed to obtain online the desired reconstructed image and

display it on the ultrasound screen can be estimated usually in about 1 minute, depending upon experience gained and anatomical details that need to be rendered. For comparison analysis of image quality between 3DUS vs 4D HDlive™, it is advisable to save and stored the 3DUS volumes on the ultrasound apparatus and to export them onto a flash-drive pen or onto an optical disk for further offline post-processing analysis. This is required because once HDlive™ is applied to a 3DUS volume, the rendered image will be saved automatically in this modality and previous 3DUS volume is lost. 5DUS may represents a complementary diagnostic tool to confirm fetal abnormalities and to characterize anatomical details such as those seen in rare syndromes thus improving accurate prenatal diagnosis, genetic counseling and antenatal management in targeted cases. Importantly, these "life-like" images provided by HDlive™ may represent a technological improvement in 3D imaging that may strengthen the maternal-fetal bonding process^[24,25]. HDlive™ software has shown limitations in conditions of poor imaging quality, such as in cases of increased maternal body mass index, presence of abdominal scar or uterine myomata as well as fetal positioning *in utero*. In the current clinical trial, unsuccessful volume acquisition for adequate 4D HDlive™ rendering has occurred in 6.75% of cases in low-risk and 3.9% in high-risk pregnancies. However, some of these clinical limitations may be overwhelm by transvaginal approach. Nonetheless, further studies will be needed to assess the role of 5DUS and its clinical validation before the use of this advanced lightening software may be included in obstetrics practice and be used at the time of routine scan in low-risk women or applied to the study of structural fetal malformations in high-risk pregnancies.

COMMENTS

Background

The second trimester scan, also called anomaly scan, is usually performed between 18-23 wk, and is based on a systematic anatomical survey of the fetus, placenta and umbilical cord, in order to detect possible fetal abnormalities. The ultrasound examination should be carried out according to international standard and possibly by accredited sonographers who have completed appropriate training program by scientific societies. The sensitivity and specificity for detection of congenital anomalies by means of conventional 2D ultrasound may be estimated around 83.5% and 99.8%, respectively.

Research frontiers

The technologic advancement gained by real-time, high definition three- and four-dimensional ultrasound (3D/4DUS), enable acquisition of volume that can be analysed online or offline by "navigating" within the volume in the three orthogonal planes. Previous observation has documented a role for 3DUS to provide additional information compared to 2DUS for the prenatal diagnosis of facial, skeletal and neural tube defect.

Innovations and breakthroughs

The authors present a pictorial editorial from normal and pathologic cases obtained during second and third trimester of pregnancy in low- and in high-risk pregnancy using 4D HDlive™ (5DUS) software.

Applications

3D/4DUS post-processing techniques allow anatomical details to be investigated in sagittal, axial and coronal planes, improving prenatal diagnosis of congenital malformations.

Peer-review

Well written manuscript, nice pictures.

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