The role of HDlive technology in improving the quality of obstetrical images

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Abstract

Imaging techniques have developed remarkably during the recent years. The technologic progress made in areas of obstetrics has been spectacular. High Definition live (HDlive) ultrasound is the latest novel ultrasound technology that improves both three-dimensional or four dimensional ultrasound images. This paper illustrates the potential of HDlive technology in the study of the embryo and fetus. This technology could be useful in studying the normal embryonic and fetal development, as well as in providing informations for fetuses at risk for specific congenital malformations by confirming normality. HDlive has a great potential in perinatal research and could help to provide a better understanding of the development of the early embryo and the fetus. Also, by providing the natural pictures of the fetus, HDlive could increase the fetal maternal bonding, which is an important element for correct management of the pregnancy. Although its advantages need to be further explored, HDlive represents, in our opinion, an innovative technique and a useful tool for a more realistic visualization of the embryo and the fetus surfaces.

Keywords: 3D, 4D, ultrasound, pregnancy, HDlive ultrasound

Introduction

Imaging techniques have developed remarkably during recent years. The development in obstetrics imagery during the last few decades has contributed to improve and refine the prenatal diagnosis. Previously, what could only be suspected by traditional methods (clinical examination and sometimes medical intuition) became certainty by using sonography. Today, ultrasound is a mandatory tool for managing pregnancy, and, in recent years, spectacular advances have taken place in obstetric sonography. Important advances in sonography have increased our knowledge of normal fetal development and improved the prenatal diagnosis of a great number of complex fetal anomalies. The possibility of performing serial sonography has expanded our understanding of the natural history of a number of these disorders.

Three-dimensional (3D) and four-dimensional (4D) ultrasound (US) are developments in imaging technology and were first demonstrated nearly 15 years ago, but are becoming a clinical reality only now [1]. The main advantage of using 3D ultrasound in obstetrics includes better assessment of complex anatomical structures, surface analysis of minor defects, volumetric measurement of fetal organs, and assessment of blood flow through Power Doppler [2]. The possibility of storing the volumes enables the provider to analyze them after the patient examination. Modern 3D US systems allow the reconstruction of images in rendering and multiplanar modes and also allow the possibility of image post-processing. The render mode with surface or transparent reconstruction allows the detailed assessment of fetal surface, particularly face and limbs, while X-ray reconstruction allows the assessment of fetal skeleton ossification. The multiplanar mode enable to obtain an unlimited number of two-dimensional planes, derived from the rotation of the image on the three orthogonal axes (x,y and z).

The introduction of high-resolution endovaginal probes and recent developments in the volumetric sonography has permitted detailed evaluation of the mor-

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phology of the embryo in utero [3]. The possibility of studying an embryo at this stage introduced the term “sonoembryology” [4]. 3D US improves spatial awareness and the volumetric and quantitative vascular information and could enhance our ability to discern normal from abnormal embryo and fetal development. The potential benefits of 3D US in the first trimester would be a reduction in the exposure time of the embryo to the ultrasound system, the possibility of storage of the volumes, and its later processing and analysis without the presence of the patient [5]. 3D US enables the practitioner to obtain volumes that can be reconstructed in any plane after the patient has left the examination room. 4D US can supplement the study of fetal behavior and is useful for observing specific movements, such as yawning, sucking, smiling, crying or blinking. This technology offers the basis for the study of fetal neurophysiologic development and simultaneous detection of anatomic pathology.

The introduction of 3D US impacted not only the medical community, but also raised attention from the patients and media because for the first time, technology created the opportunity to have noninvasive, realistic, easily understood images of the fetus. Moreover, the introduction of 4D US into clinical practice allows better viewing of facial expressions, such as mouth opening, tongue protrusion, yawning, smiling, and eye opening and blinking, to be studied in great detail. Visualization of the fetus by the mother may arouse emotions capable of triggering or improving maternal-fetal bonding, and that may lead to changes in behavior and lifestyle that promote maternal and fetal health [6].

Image quality is extremely important to delineate the origin and extension of a congenital anomaly. Clearer images and elimination of redundant structures and artifacts allows better understanding of the fetal structures. The latest achievement in the field of 3D /4D US is the High

Definition live (HDlive) technology. HDlive technology is a novel US technique that improves the 3D/4D images. HDlive uses an adjustable light source and software that calculates the propagation of light through surface structures in relation to the light direction [7]. The virtual light source produces selective illumination, and the respective shadows are created by the structures where the light is reflected [8].

This combination of light and shadows increases depth perception and produces remarkable images that are more natural than those obtained with classic 3D ultrasound.

The virtual light can be placed in the front, back, or lateral sides, where viewing is desired until the best image is achieved. When the light source is positioned behind the region of interest, a spectacular effect of translucency can be obtained (fig 1). The soft can be applied to all images stored in the memory of the machine [8]. HDlive was developed especially for obstetric usage because it provides a natural and realistic appearance of the fetus, but its use in gynecology should not be neglected [9]. HDlive could be used during all three trimesters of pregnancy. The images obtained with HDlive in the first trimester of pregnancy are very impressive for both parents and their relatives. The images closely resemble those from anatomy atlases or scientific documentaries (fig 2, fig 3). The introduction of 3D/4D US in the first trimester of pregnancy has resulted in remarkable progress in sonographic visualization of early embryos and fetuses and in the development of the 3D sonoembryology.

In a study by Hata et al, the authors proved the superiority of 3D US in relation to bidimensional (2D) US in the assessment of the surface of anatomical structures (face, hand and foot). They conclude that 3DUS is a promising technique in the assessment and detection of abnormalities in embryonic and early fetal development

Fig 1. HDlive at 8 weeks of amenorrhea. The light is positioned behind the embryo and translucency effect is obtained.

Fig 2. HDlive at 9 weeks of gestation demonstrating the fetus and the yolk sac; the amnion can be seen as a spherical hyperechoic membrane.

Fig 3. HDlive at 12 weeks of amenorrhea - complete morphologic development is observed; the limbs are completely developed and their segments are discernible.

during the first trimester of gestation [10]. HDlive will likely have its own contribution to the development of this field.

With the use of HDlive, both structural and functional developments in the first 12 weeks of gestation can be assessed more objectively and reliably. Figures 1-3 represent several examples of first trimester embryos and fetuses examined with HDlive software. Figure 1 presents an embryo of 8 weeks of amenorrhea. The light is positioned behind the embryo and translucency effect is obtained. Figure 2 presents HDlive image at 9 weeks of gestation with the fetus and the yolk sac. The amnion can be seen as a spherical hyperechoic membrane. Figure 3 represents several HDlive images at 12 weeks of amenorrhea and we can see the complete morphologic development of the fetus; the limbs are completely developed and their segments are discernible. We can observe the possibility of examining the same picture with different light and shadows (fig 4). The ability to visualize fetal hands, fingers, feet, and toes is better with volumetric ultrasound than 2D ultrasound. This technology is an important factor that can determine moving the study of embryology from *in vitro* studies to *in vivo* studies.

There are some limitations of the technique that have to be mentioned. These are represented by embryonic or maternal movement, which can reduce the quality of the image. Also, surface rendering of the embryo depends on the presence of enough amniotic fluid around the embryo [11]. Other limitations would be how close the embryo is from the uterine wall and the curvature of the gestational sac [10].

In the second and third trimesters, images of fetal faces are very natural and could also create a deep connection with the parents. Visualization of the fetal face has become one of the main applications of 3D ultrasound scanning (fig 5).

Fig 4. Pregnancy first trimester 8 weeks of amenorrhea. The possibility of changing light is clearly observed.

Fig 5. Fetal face – 3D and HDlive surface rendering of a fetal face at 32 weeks.

Fig 6. HDlive images demonstrating the anatomic structures of the fetal fingers; the anatomy of the fetal hand depicted by 3D ultrasound and HDlive technology.

Fig 7. External genital male genitalia can be clearly depicted by 3D HDlive.

More details of facial anatomy become available using volumetric ultrasound. US evaluation of the fetal face is very important because a detailed facial examination can provide a lot of information alerting the clinician to the possibility of associated anomalies in the fetal anatomy. For example, some facial and encephalic structures share the same embryologic origin, and the presence of a facial anomaly should raise the suspicion of the malformation in the encephalic region [12]. 3D ultrasound offers perspectives that cannot be

obtained with 2D techniques and depicts the anatomy in its most appropriate and comprehensive position [13,14]. Because of its particularities represented by the oval shape and small anatomic details, the fetal face can be visualized and analyzed only to a limited extend with conventional US and with 2D sonography it is not possible to see the entire face on a single image. While some facial anomalies are obvious, others are very subtle and their evaluation must be performed from the most suitable plane, depending on the aim of the assessment. Sometimes, the fetal position or the conditions of the exploration prevent appropriate slices being obtained in the 2D examination. In these cases, with appropriate rotations and translations, it is possible to move through the 3D volume until the target plane is obtained [15].

3D sonography provides a spatial reconstruction of the fetal face and simultaneous visualization of all facial structures such as nose, eyebrow, mouth and eyelids [15]. HDlive depicts the entire face and the relationship between facial structures. HDlive not only provides informations about the face anomalies, but also provides more convincing evidence about a normal face, very important information in cases with increased risk of recurrent surface malformations [15]. Beyond the spectacular beauty of the HDlive images, this technique will probably provide much more information to assess fetal face. It is important to emphasize that HDlive increases the ability to diagnose face and surface defects in a way that complements conventional 2D ultrasound. This technique does not replace, but rather supplements it.

A very important advantage of 3D and HDlive are their ability to display a true midsagittal plane of the face. Merz et al analyzed the effect of 3D facial profile reconstruction on 125 fetuses and they found that in 30.4% of the cases the profiles were turns 3° - 20° from the correct one. These mean that the true plane was obtained with 2D ultrasound in only 69.6% cases. When the true plane is not identified, anomalies can be either not seen either over diagnosed [16]. 3D sonography and HDlive can be very helpful in the identification of anomalies, since images can be obtained in orientations and planes that are very difficult or even impossible to obtain with 2D US.

HDlive is useful not only in face examination, but also in examining the surface details: hands, feet, abdomen, or spine (fig 6). Also, the clear images of fetal genital organs are impressive (fig 7).

The recent development of the advanced technique of 4D US and HDlive open a new perspective for research into fetal behavior and, particularly, facial movements.

2D, 4D and 4D HDlive are complementary methods used for the evaluation of fetal movements. 4D HDlive make us visualize some morphologic dynamics such as yawning, sucking, smiling, crying and blinking. This offers practical means for assessment the neurophysiologic development as well as for detecting anatomic pathology [15]. Fetal motility is considered to reflect the function of the central nervous system (CNS) and the introduction of the 4D sonography was an important landmark for its study. The new imaging techniques open advanced ways of analyzing the fetal behavior and in the light of the tight links between fetal behavioral patterns and the CNS development we can assess a lot more accurately the integrity of the CNS. In this way, by the methodic analysis of fetal movements at different stages it is now possible to diagnose in an early manner the potential cerebral dysfunctions, increasing a better outcome for the newborn and later for the child. Observation of facial expressions may be of scientific and diagnostic value, and this approach opens an entirely new field. There are still numerous unanswered questions. An important diagnostic aim of the facial expression is to identify facial paresis. The criteria for this diagnosis are asymmetric facial movement and detection of movements limited to only one side of the face [15].

Normal fetal movements are defined as synchronized movements showing fluency and elegance and creating an impression of complexity and variability. Because of the natural appearance of the image with HDlive, the movements of the fetus could produce a great impact on the parents. Because of this impact on the parents, an important issue that should be emphasized is represented by the possibility of increasing fetal-maternal bonding using HDlive.

Pregnancy is characterized as a physiologically and biologically interdependent experience, wherein mother and child develop a bond that is qualitatively distinct, unlike any other. The maternal-fetal bond is the strongest bond in humans, and this bond begins often shortly after conception [17]. The terms bonding and attachment are used interchangeably in the literature to indicate the feelings that parents have toward their fetus [18]. Bonding is the parents' tie to the neonate during the first hours after birth [19]; attachment is the relationship between the infant and caregiver that develops during the first year of life [20]. Cranley defined maternal-fetal attachment (MFA) as: "*the extent to which women engage in behaviors that represent affiliation and interaction with the unborn child*" [21,22]. Research on the impact of 2D ultrasound (US) on fetal-parental attachment suggests that these images have a positive influence

on the attitude of expectant parents toward the pregnancy by reducing anxiety in parents, and increasing awareness of the importance of maintaining maternal health [23,24].

Several authors have studied the effects of volumetric sonography on fetal-maternal bonding. According to Steiner, patients recognize easier 3D images of the fetus than 2D images, and they feel more attached to the fetus after 3D ultrasound [25]. Ji et al compared maternal-fetal bonding between mothers exposed to 2D US only and to both 2D US and 3D US and show that 3D US may have a greater impact on the maternal-fetal bonding process than 2D US [26]. Rustico et al published a study in which the addition of 4D US did not significantly change the perception women have of their fetuses in comparison with 2D US [27]. Preliminary analyses of a current study that we are performing in our center show that the role of HDlive should not be neglected. We intend to publish the results of this study in the near future. HDlive images can contribute not only to fetal-maternal bonding, but also to physician-patient bonding with the aid of life-like images. We believe that the impressive images obtained with HDlive offer us the occasion to feel closer to our patients and we can establish a friendlier professional environment useful during the monitoring of the pregnancy.

Conclusions

Recent improvements in 3D US enable detailed examination of the morphology of the embryo and fetus. HDlive is the latest ultrasound technology, which gives us more clear and natural images of the fetus. This technology could be useful in studying normal embryonic and fetal development, as well as in providing information for fetuses at risk for specific congenital malformations by confirming normality. Also, by providing the natural pictures of the fetus, HDlive could increase the fetal maternal attachment, which is an important element for correct management of the pregnancy. Although its advantages need to be further explored, HDlive represents, in our opinion, an innovative technique and a useful tool for a more realistic visualization of the embryo and the fetus surfaces. Motherhood is an extraordinary opportunity for both the mother and child to participate in a relationship that is irreplaceable in value and meaning. HDlive may play a role in further strengthening this relationship between parents and their future child, but the exact role remains to be established in the future.

Conflict of interest: none

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