HDlive for Assessment of Placenta and Umbilical Cord

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ABSTRACT

We present the latest HDlive images of normal and abnormal placentas and umbilical cords. By means of HDlive, more detailed information on placental and umbilical cord abnormalities can be obtained, because this technique is a new surface-rendering mode that uses an adjustable light source to create lighting and shadowing effects, thereby increasing depth perception. HDlive provides extraordinarily realistic imaging of the placenta and umbilical cord, making it almost impossible to differentiate between fetoscopic findings and ultrasound scans. This novel technique may assist in evaluation of the placental and umbilical cord anatomy, and offer potential advantages over conventional two- and three-dimensional ultrasound. HDlive may be an important modality in future placental and umbilical cord research and in the evaluation of their abnormalities.

Keywords: Two-dimensional ultrasound, Three-dimensional ultrasound, HDlive, Placenta, Umbilical cord.

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INTRODUCTION

There have been numerous studies on conventional three-dimensional (3D) sonographic diagnosis of normal and abnormal placentas and umbilical cords.¹⁻⁹ Three-dimensional ultrasound has the potential to provide improved visualization of the placental and umbilical cord anatomic morphology compared to two-dimensional (2D) sonographic imaging.¹⁰

HDlive, the latest ultrasound technology, facilitates the creation of clearer placental and umbilical cord images than those obtained using conventional 3D ultrasound owing to better depth perception and the depiction of

skin-like colors, which gives the placental and umbilical cord images a more realistic appearance.¹¹⁻¹⁵ The present paper describes the latest state-of-the-art HDlive imaging of normal and abnormal placentas and umbilical cords, and makes recommendations for future research in this field.

PLACENTA

Conventional 2D sonography has been widely used to evaluate the placental morphology, anatomy, location, implantation, size, and anomalies during pregnancy.^{10,16} In normal pregnancy, however, 2D sonographic changes of the placenta should not be considered as morphologic hallmarks of placental maturation or aging.¹⁷ Although, an accurate antenatal diagnosis of placental abnormality can usually be performed in most cases using 2D sonography, more detailed information on placental abnormality is obtained employing 3D ultrasound.¹⁰ In particular, visualization of the continuity and curvature of placental abnormality is more easily conducted with the 3D surface-rendered mode.² HDlive is a new surface-rendering mode, which uses an adjustable light source that facilitates the ability to create lighting and shadowing effects, thereby increasing depth perception.¹⁸ This technique provides such extraordinarily realistic imaging of the embryo and fetus that it is almost impossible to differentiate between actual photographs and sonographic images.¹⁹ The spatial relationship between the intrauterine abnormality and surrounding tissues during pregnancy visualized by HDlive is more readily discernible as compared with conventional 3D sonography.^{12,14,15}

Normal Placenta

Before 10 weeks of gestation, an overall view of the umbilical cord and its attachments to the decidua basalis (primary placenta) and fetal umbilicus could be clearly obtained (Figs 1 to 3). The entire placenta could be identified between 10 and 20 weeks of gestation (Figs 4 to 6). However, depiction of the entire placenta is impossible after 20 weeks of gestation, because the viewing area is limited to that of the 3D probe (Fig. 7).¹⁰

Chorionic Bump

A chorionic bump is an irregular, convex bulge passing from the choriodecidual surface into the first-trimester

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Fig. 1: Normal pregnancy at 6 weeks and 4 days of gestation (UC: Umbilical cord)

Fig. 2: HDlive image of the embryo and yolk sac at 7 weeks and 5 days of gestation (UC: Umbilical cord) (Courtesy: Reprinted with permission from Hata T et al)¹¹

Fig. 3: Normal pregnancy at 10 weeks and 3 days of gestation (MH: Midgut herniation; UC: Umbilical cord)

Fig. 4: Normal pregnancy at 11 weeks and 5 days of gestation (P: Placenta; UC: Umbilical cord)

Fig. 5: Normal pregnancy at 12 weeks and 2 days of gestation (P: Placenta)

Figs 6A and B: (A) Normal pregnancies at 15 weeks and (B) 16 weeks and 5 days of gestation (P: Placenta; UC: Umbilical cord)

gestational sac.²⁰ Its prevalence is 0.15%, and women with a chorionic bump in the first trimester have approximately double the risk of miscarriage compared with matched controls.²¹ The chorionic bump probably represents a small hematoma that bulges into the gestational sac.²⁰

HDlive clearly shows a realistic contour and shape of the chorionic bump, and the spatial relationship between the chorionic bump and embryo is more readily discernible as compared with conventional 2D sonography (Figs 8A to D).

Fig. 7: HDlive images of the placenta with different directions of the light source at 26 weeks and 3 days of gestation. Arrows indicate umbilical cord (UC) insertion into the placenta (P)

Figs 8A to D: Chorionic bump (arrows) at 7 weeks and 5 days of gestation: (A and B) two-dimensional images and (C and D) HDlive images with different directions of the light source (E: Embryo; YS: Yolk sac)

Fig. 9: HDlive image of hydrops fetalis at 16 weeks and 4 days of gestation (P: Placenta; UC: Umbilical cord)

Fig. 10: HDlive image of hydrops fetalis at 18 weeks and 5 days of gestation (P: Placenta)

Placenta in a Case of Hydrops Fetalis

In a case of hydrops fetalis early in the second trimester of pregnancy, a relatively large placenta can be noted using HDlive (Figs 9 and 10).

Large Subchorionic Maternal Lake

Subchorionic maternal lakes cover from approximately 10 to 50% of the placental surface, and are 2 to 6 cm in their longest dimension.²² They often contain slow

Figs 11A and B: Large subchorionic maternal lake (arrows) at 18 weeks and 5 days of gestation. (A) two-dimensional image and (B) three-dimensional power Doppler sonographic image (P: Placenta)

Fig. 12: HDlive images of the large subchorionic maternal lake (arrows) with different directions of the light source at 18 weeks and 5 days of gestation

venous-like flow on real-time sonography.²³ Subchorionic maternal lakes should be regarded as normal,²³ although occasionally large echo-free spaces are seen (Figs 11 and 12), and they may be associated with fetal growth restriction and premature delivery.²⁴

Placental Shelf

The 2D sonographic appearance of tissue contiguous with the edge of the placenta that protrudes into the amniotic cavity is called a placental shelf (Figs 13A and B),²⁵ and an early second-trimester placental shelf appears to be a common, benign, and transient sonographic finding, which never persists to the third trimester.²⁶ There have been only two reports of the antenatal detection of a placental shelf using conventional 3D ultrasound.^{26,27} HDlive provides new,

realistic sensations for the diagnosis of a placental shelf, and a near-fetoscopic image of it can be obtained by employing HDlive (Figs 14A and B).¹²

Uterine Synechia

There have been numerous reports on the antenatal 2D sonographic diagnosis of uterine synechia during pregnancy.^{28,29} However, the spatial relationships among uterine synechia, fetal parts, the umbilical cord, and placenta could not be easily understood with conventional 2D sonography.^{7,15,30} HDlive clearly depicts uterine synechia with umbilical cord prolapse and/or fetal foot prolapse, and provides entirely new visual experiences for the obstetrician and sonographer owing to the anatomically realistic depiction of uterine synechia during pregnancy (Figs 15 to 17).^{12,15}

Figs 13A and B: Two-dimensional sonographic transverse (A) and sagittal (B) views of the placental shelf (arrows) at 18 weeks and 2 days of gestation (P: Placenta) (Courtesy: Reprinted with permission from Hata T et al)²⁷

Figs 14A and B: HDlive images of the placental shelf (*) at 18 weeks and 2 days. A total image of the placental shelf is clearly shown (P: Placenta; UC: Umbilical cord) (A) superior view, (B) frontal view (Courtesy: Reprinted with permission from Hata T et al)¹²

Figs 15A and B: Umbilical cord (UC) prolapse through a transverse uterine synechia (arrows) at 26 weeks and 5 days of gestation. Loops of the umbilical cord are below and the fetus (F) is superior to the uterine synechia: (A) a two-dimensional ultrasound image, (B) HDlive image (Courtesy: Reprinted with permission from Hata T et al)^{7,12}

Fig. 16: Vertical, triangular uterine synechia (S) depicted by two-dimensional ultrasound at 29 weeks and 5 days of gestation (F: Foot; H: Hand; P: Placenta; Sp: Space; UC: Umbilical cord) (Courtesy: Reprinted with permission from Hata T et al)¹⁵

UMBILICAL CORD

The umbilical cord is a lifeline to the fetus, and its impairment directly affects the fetal life.¹ Many pathologic

features of the umbilical cord adversely affect fetal well-being.³¹ Although, many umbilical cord abnormalities are detectable by conventional 2D sonography,³²⁻³⁵ the demonstration of their entire view is impossible, especially in the third trimester of pregnancy.^{1,4,6,9} Three-dimensional ultrasound allows visualization of umbilical cord abnormalities in all three dimensions at the same time, providing an improved overview and a more clearly defined demonstration of adjusted anatomical planes.^{1,6,36,37} HDlive pictures of umbilical cord abnormalities are more readily discernible than those obtained by conventional 3D ultrasound.^{12,14}

Normal Umbilical Cord

HDlive clearly shows developmental changes of the umbilical cord with advancing gestation (Figs 1 to 4, 6, 7, 18, 19). Cord entanglement during early pregnancy and a hypercoiled umbilical cord can also be clearly visualized employing HDlive (Figs 20 and 21).

Figs 17A to C: HDlive images of transverse, vertical, and triangular uterine synechia (S) with umbilical cord (UC) and fetal foot (F) prolapses through the right-sided space (Sp). A thin dividing membrane (DM) is noted in the low, liquor-filled amniotic cavity (Courtesy: Reprinted with permission from Hata T et al)¹⁵

Fig. 18: HDlive images of a normal pregnancy with different directions of the light source at 10 weeks and 3 days of gestation (MH: Midgut herniation; UC: Umbilical cord)

Fig. 19: HDlive image of a normal umbilical cord (UC) at 26 weeks of gestation

Fig. 20: HDlive image of cord entanglement at 12 weeks of gestation (UC: Umbilical cord)

Umbilical Cord Edema

Realistic visualization of umbilical cord edema in a case of hydrops fetalis is possible using HDlive (Fig. 22).

Umbilical Cord Cyst

HDlive provides a new realistic sensation for the diagnosis of umbilical cord cyst (Figs 23A and B).^{12,38}

Intra-amniotic Umbilical Vein Varix

Intra-amniotic umbilical vein varix is characterized by a high frequency of thrombosis in the varix.^{14,39-42} Conventional 2D sonography shows a large banana-like umbilical cord enlargement including umbilical vein varix with massive thrombosis (Fig. 24). Color Doppler shows bidirectional turbulent blood flow inside the varix (Fig. 25). HDlive clearly demonstrates fragile, massive thrombosis inside the varix (Figs 26A and B).¹⁴

Fig. 21: HDlive images of a hypercoiled umbilical cord with different directions of the light source at 32 weeks of gestation

Fig. 22: HDlive image of cord edema in a case (arrow) of hydrops fetalis at 27 weeks and 4 days of gestation

Figs 23A and B: Umbilical cord cyst (arrows) (UC: Umbilical cord). (A) HDlive image at 20 weeks and 1 day of gestation and (B) gross appearance after birth (Courtesy: Reprinted with permission from Hata T et al)^{12,38}

Fig. 24: Two-dimensional sonographic images of intra-amniotic umbilical vein varix (UVV). Massive thrombosis (arrows) is evident inside the varix (P: Placenta; UA: Umbilical artery; UV: Normal umbilical vein)

Fig. 25: Color Doppler image of intra-amniotic umbilical vein varix (UVV). Bidirectional turbulent flow inside the varix is clearly identified. Arrow shows thrombosis inside the varix (P: Placenta)

Figs 26A and B: Thrombosis inside the varix. Massive thrombosis inside the varix is evident: (A) HDlive image and (B) gross appearance of longitudinally cut view of the varix (UA: Umbilical artery; UV: Umbilical vein; UVV: Umbilical vein varix) (Courtesy: Reprinted with permission from Hata T et al)¹⁴

CONCLUSION

This review article focused on HDlive images of the placenta and umbilical cord. HDlive provides obstetricians with a new, realistic, and arguably much improved, view of the complexities and interrelationships of the placenta and umbilical cord *in utero*. The present and future application of this novel modality to the prenatal evaluation of normal and abnormal placentas and umbilical cords may be promising. However, this does not suggest that HDlive will replace conventional 2D and 3D sonography. This novel technique may assist in the prenatal diagnosis of abnormal placentas and umbilical cords, and offer potential advantages relative to conventional 2D and 3D sonography, and color/power Doppler ultrasound. Further studies are needed to clarify the present and future application of this modality to antenatal assessment of the placenta and umbilical cord.

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