PICTORIAL ESSAY

SMI with Doppler Luminance in Obstetrics

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Abstract

Superb microvascular imaging (SMI) with Doppler luminance (Aplio i800, Canon Medical Systems, Tokyo, Japan) is a new color Doppler, which shows three-dimensional SMI information on a two-dimensional gray-scale image by shading based on the amplitude of the color Doppler signal. Moreover, we can obtain more precise vasculature of fetal organs and the placenta using an 18 MHz probe. In this picture-based article, cutting-edge SMI with Doppler luminance features of fetal peripheral vessels and normal and abnormal placentas are presented. Also, to aid investigations of fetal and placental circulations, the present and future applicability of SMI with Doppler luminance is considered.

Keywords: 3D, Color Doppler, Fetus, Obstetrics, Placenta, Superb microvascular imaging, SMI with Doppler luminance, Ultrasound.

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Introduction

Superb microvascular imaging (SMI) with Doppler luminance (Aplio i800, Canon Medical Systems, Tokyo, Japan) is the latest color Doppler, which shows three-dimensional (3D) SMI information on a two-dimensional (2D) gray-scale image by shading based on the amplitude of the color Doppler signal. In this pictorial essay, we present many unique images of the fetus and placenta using SMI with Doppler luminance.

Fetal Brain

Fetal intracranial vessels can be clearly recognized using SMI with Doppler luminance (transabdominal probe: PVI-475BX) (Figs 1 to 4). Moreover, the orbital vasculature can be clearly identified using this technique (Figs 5 and 6).

Fetal Lung

Vascular densities of the fetal lung increase with advancing gestation (Figs 7 to 10). Moreover, 3D reconstruction of pulmonary vessels can be obtained (Fig. 11). Using an 18 MHz probe (PLI-1205BX), more detailed 2D/3D lung vasculatures can be noted (Figs 12 and 13).

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Fetal Liver

Vascular densities of the fetal liver also increase with advancing gestation (Figs 14 to 19). 3D reconstruction of hepatic vessels can be easily performed (Fig. 20).

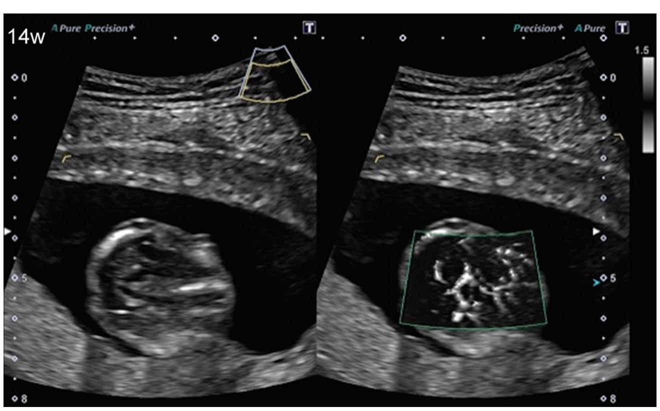


Fig. 1: Circle of Willis depicted by SMI with Doppler luminance at 14 weeks of gestation

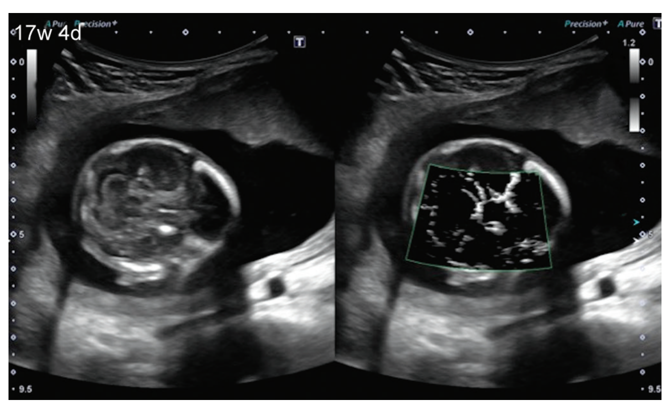


Fig. 2: Circle of Willis depicted by SMI with Doppler luminance at 17 weeks and 4 days of gestation

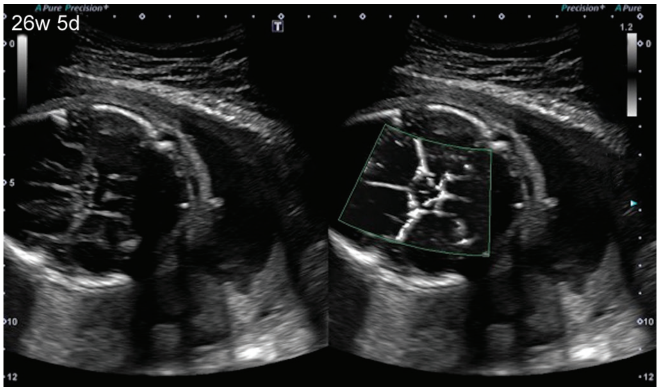


Fig. 3: Circle of Willis depicted by SMI with Doppler luminance at 26 weeks and 5 days of gestation

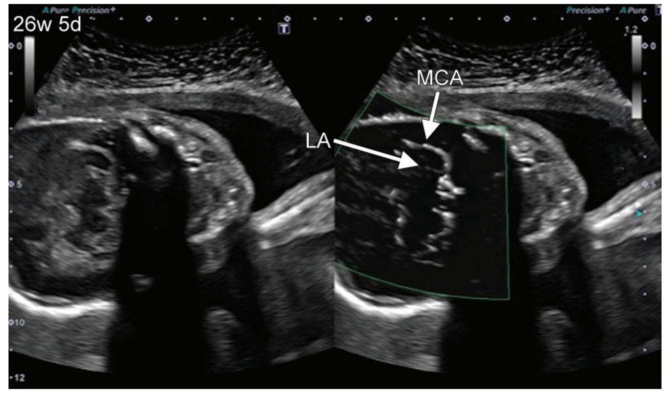


Fig. 4: Intracranial vessels depicted by SMI with Doppler luminance at 26 weeks and 5 days of gestation. LA, lenticulostriate artery; MCA, middle cerebral artery

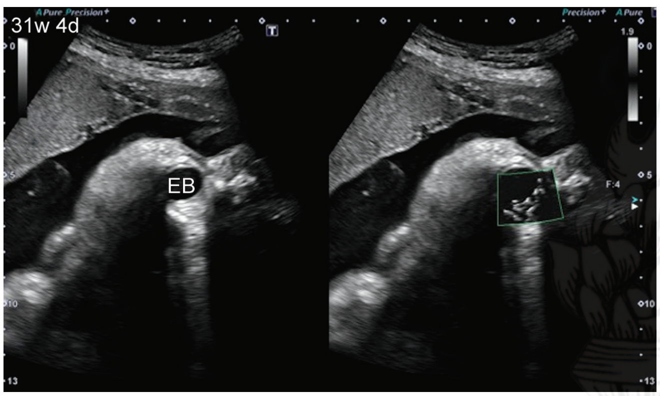


Fig. 5: Fetal orbital vasculature depicted by SMI with Doppler luminance at 31 weeks and 4 days of gestation. EB, eyeball

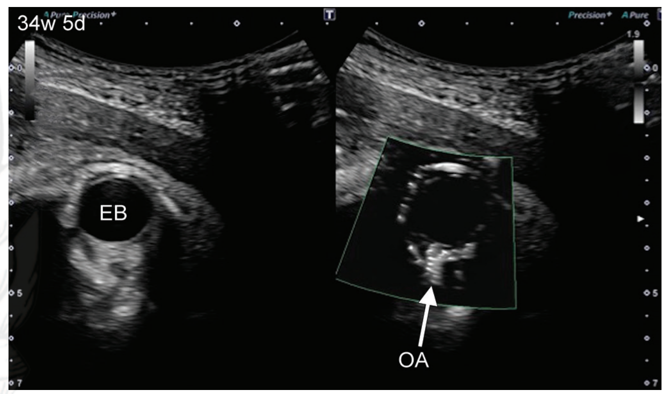


Fig. 6: Fetal ophthalmic artery (OA) depicted by SMI with Doppler luminance at 34 weeks and 5 days of gestation. EB, eyeball

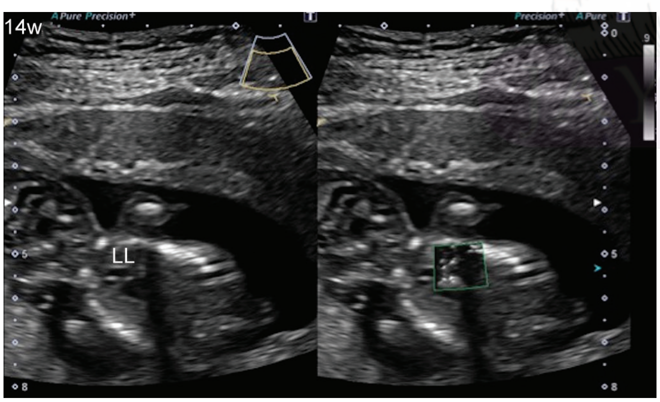


Fig. 7: Fetal pulmonary vessels depicted by SMI with Doppler luminance at 14 weeks of gestation. LL, left lung

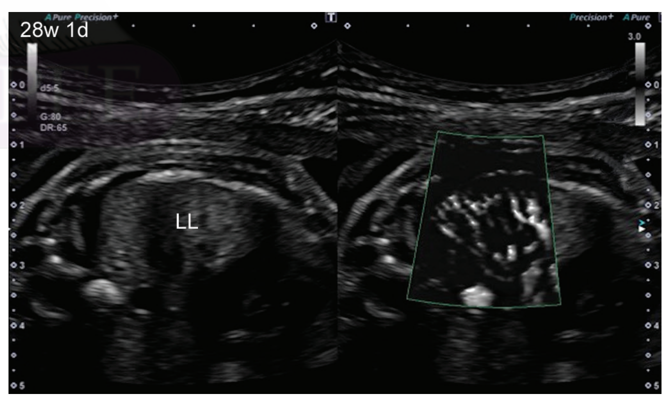


Fig. 8: Fetal pulmonary vessels depicted by SMI with Doppler luminance at 28 weeks and 1 day of gestation. LL, left lung

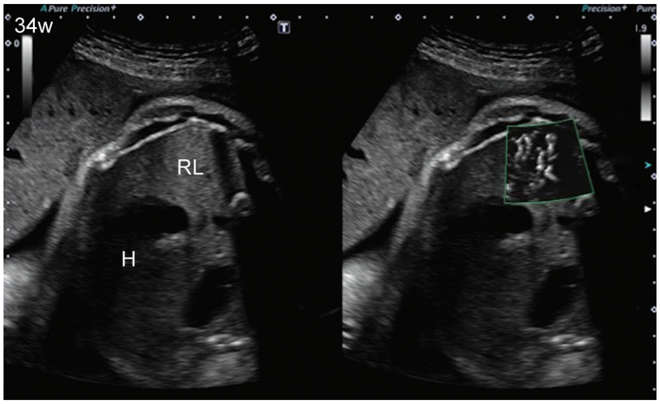


Fig. 9: Fetal pulmonary vessels depicted by SMI with Doppler luminance at 34 weeks of gestation. RL, right lung

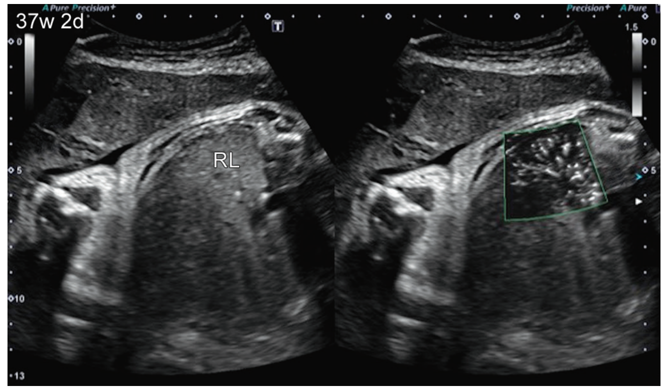


Fig. 10: Fetal pulmonary vessels depicted by SMI with Doppler luminance at 37 weeks and 2 days of gestation. RL, right lung

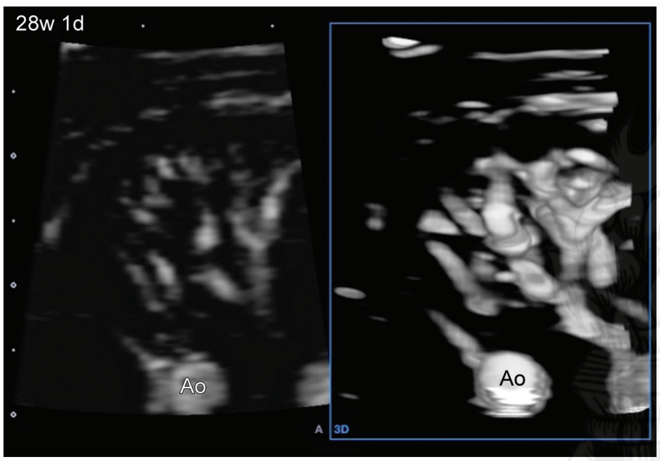
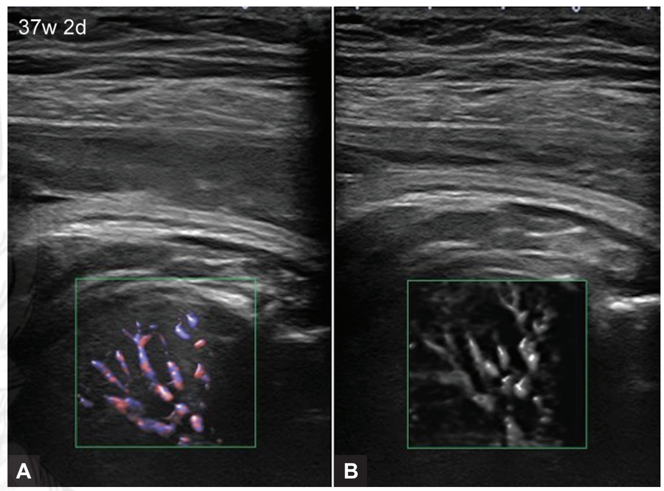


Fig. 11: 3D reconstruction of fetal lung vasculature using 3D SMI at 28 weeks and 1 day of gestation. Ao, aorta



Figs 12A and B: Fetal pulmonary vessels depicted by SMI with Doppler luminance and an 18 MHz probe at 37 weeks and 2 days of gestation. (A) Color-coded SMI with Doppler luminance; (B) Monochrome SMI with Doppler luminance

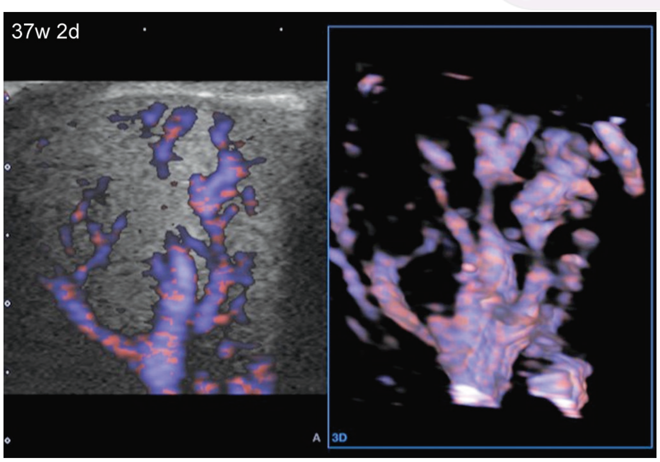


Fig. 13: 3D reconstruction of fetal lung vasculature using 3D SMI with an 18 MHz probe at 37 weeks and 2 days of gestation

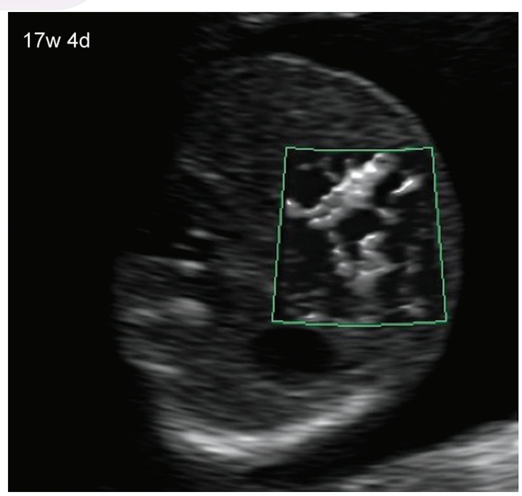


Fig. 14: Fetal hepatic vessels depicted by SMI with Doppler luminance at 17 weeks and 4 days of gestation

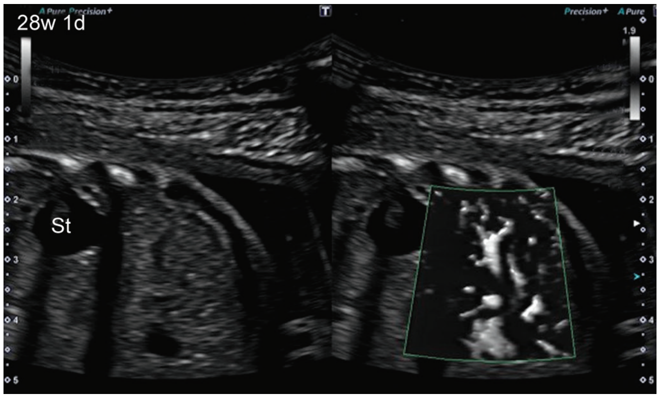


Fig. 15: Fetal hepatic vessels depicted by SMI with Doppler luminance at 28 weeks and 1 day of gestation. St, stomach

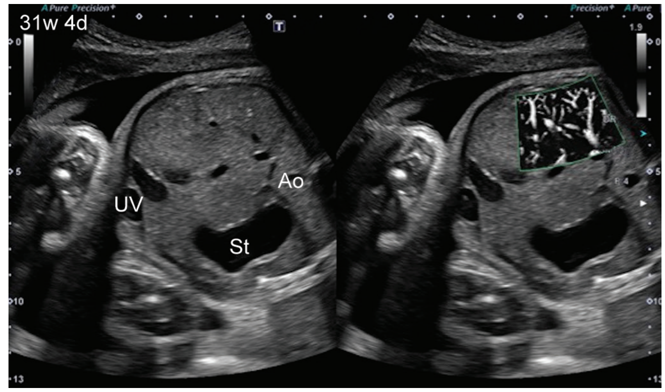


Fig. 16: Fetal hepatic vessels depicted by SMI with Doppler luminance at 31 weeks and 4 days of gestation. Ao, aorta; St, stomach; UV, umbilical vein

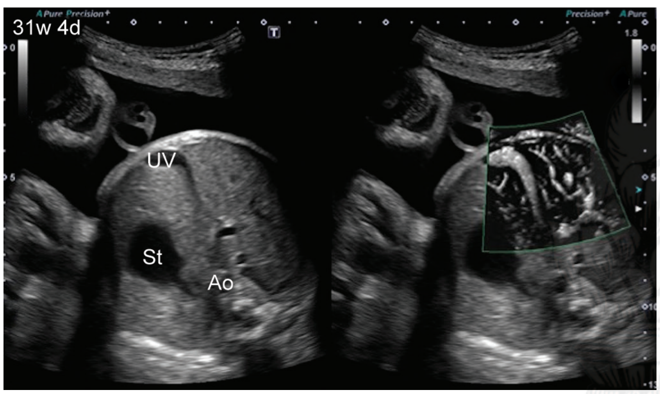


Fig. 17: Fetal hepatic vessels depicted by SMI with Doppler luminance at 31 weeks and 4 days of gestation. Ao, aorta; St, stomach; UV, umbilical vein

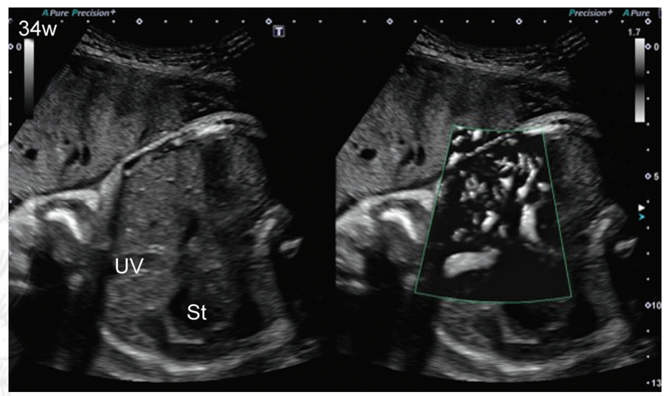


Fig. 18: Fetal hepatic vessels depicted by SMI with Doppler luminance at 34 weeks of gestation. St, stomach; UV, umbilical vein

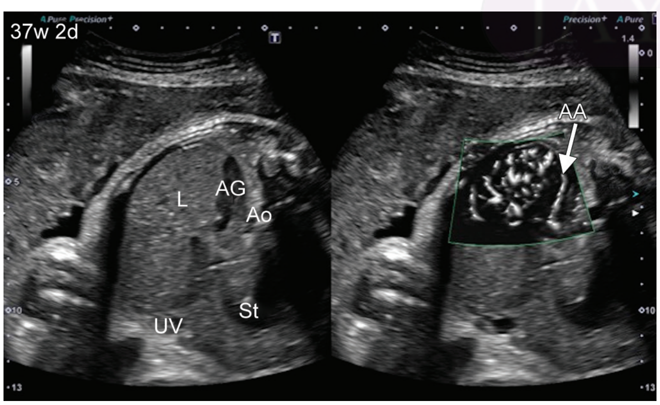


Fig. 19: Fetal hepatic vessels depicted by SMI with Doppler luminance at 37 weeks and 2 days of gestation. AA, adrenal artery; AG, adrenal gland; Ao, aorta; L, liver; St, stomach; UV, umbilical vein

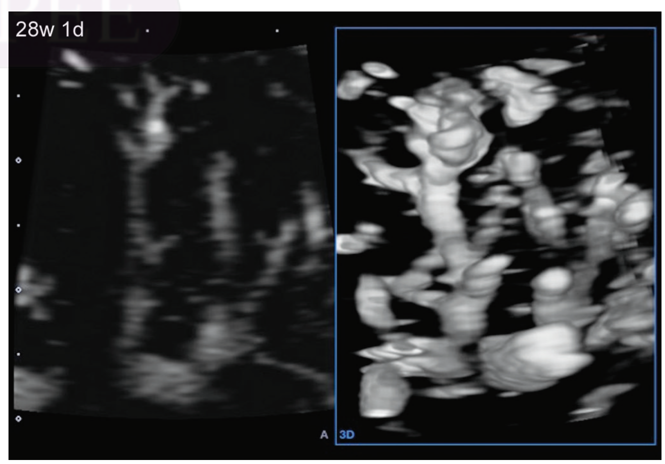


Fig. 20: 3D reconstruction of fetal liver vasculature using 3D SMI at 28 weeks and 1 day of gestation

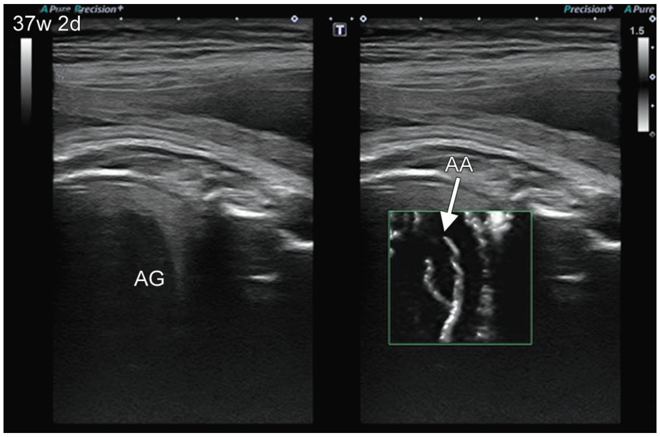


Fig. 21: Fetal adrenal artery (AA) depicted by SMI with Doppler luminance at 37 weeks and 2 days of gestation. AG, adrenal gland

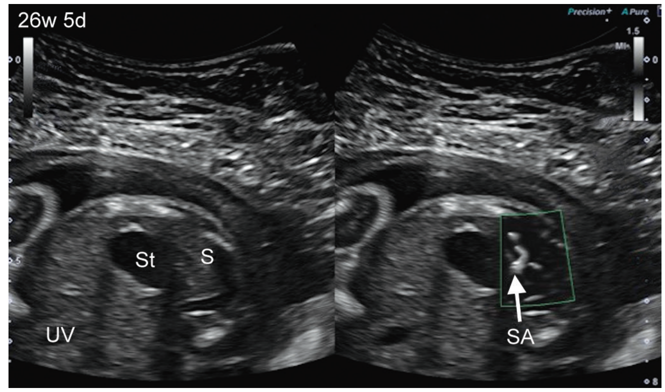


Fig. 22: Fetal splenic vessels depicted by SMI with Doppler luminance at 26 weeks and 5 days of gestation. S, spleen; SA, splenic artery; St, stomach; UV, umbilical vein

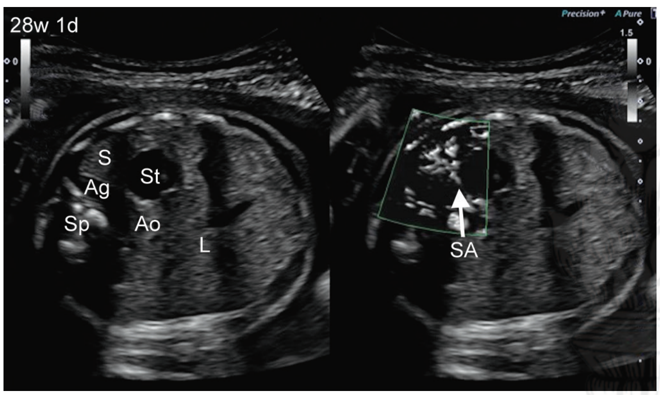


Fig. 23: Fetal splenic vessels depicted by SMI with Doppler luminance at 28 weeks and 1 day of gestation. Ag, adrenal gland; Ao, aorta; L, liver; S, spleen; SA, splenic artery; Sp, spine; St, stomach

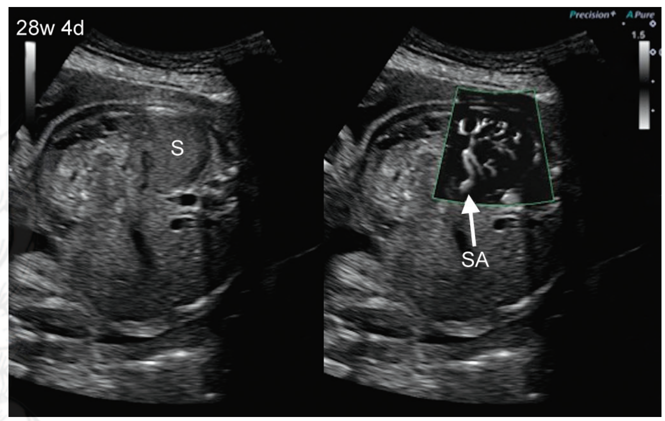


Fig. 24: Fetal splenic vessels depicted by SMI with Doppler luminance at 28 weeks and 4 days of gestation. S, spleen; SA, splenic artery

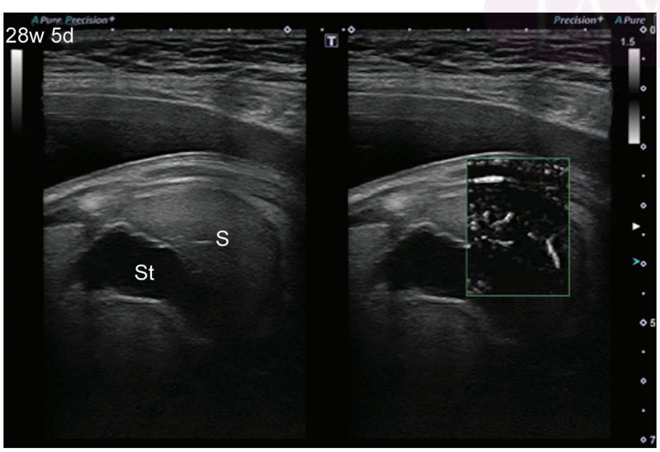


Fig. 25: Fetal splenic vessels depicted by SMI with Doppler luminance and an 18 MHz probe at 28 weeks and 5 days of gestation. S, spleen; St, stomach

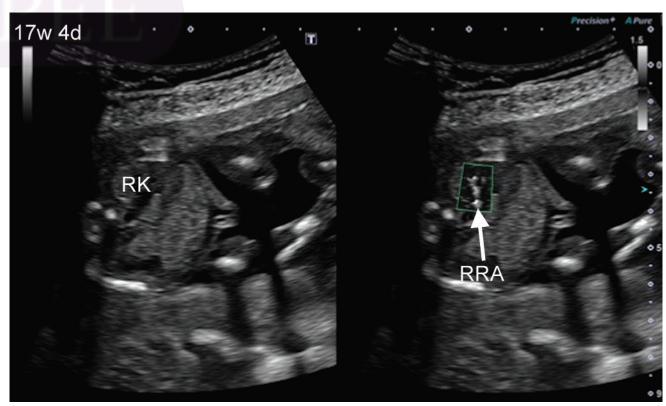


Fig. 26: Fetal renal vessels depicted by SMI with Doppler luminance at 17 weeks and 4 days of gestation. RK, right kidney; RRA, right renal artery

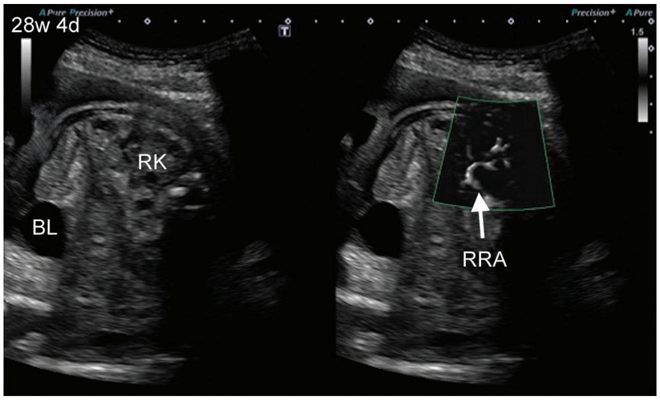


Fig. 27: Fetal renal vessels depicted by SMI with Doppler luminance at 28 weeks and 4 days of gestation. BL, bladder; RK, right kidney; RRA, right renal artery

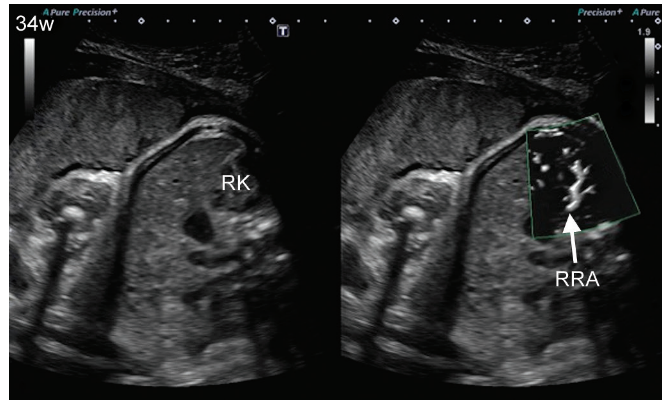


Fig. 28: Fetal renal vessels depicted by SMI with Doppler luminance at 34 weeks of gestation. RK, right kidney; RRA, right renal artery

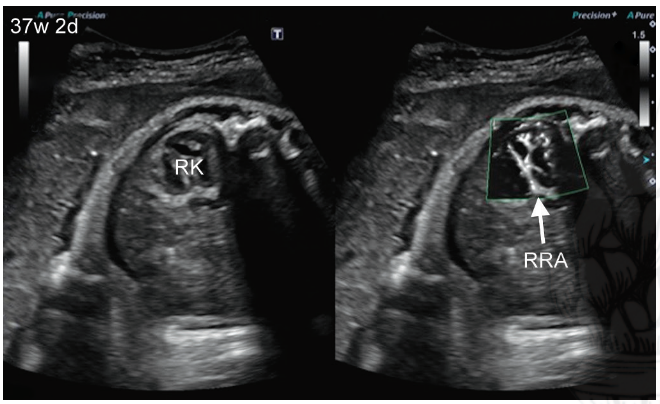


Fig. 29: Fetal renal vessels depicted by SMI with Doppler luminance at 37 weeks and 2 days of gestation. RK, right kidney; RRA, right renal artery

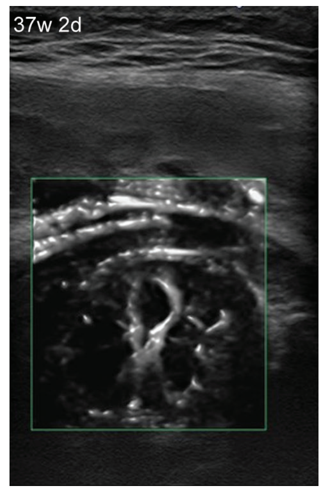


Fig. 30: Fetal renal vessels depicted by SMI with Doppler luminance and an 18 MHz probe at 37 weeks and 2 days of gestation

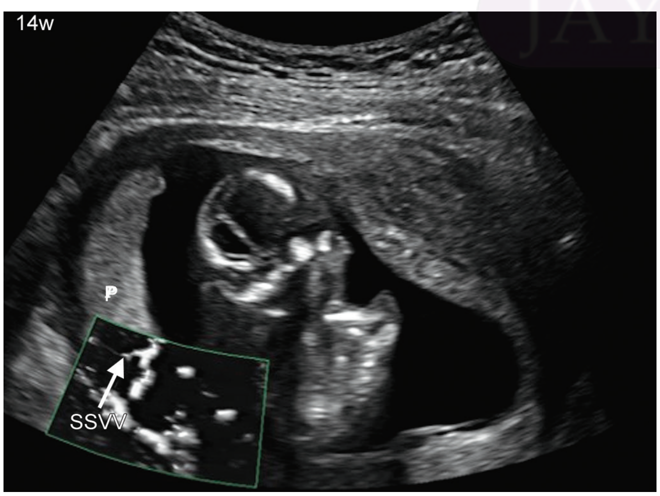


Fig. 31: Normal placenta depicted by SMI with Doppler luminance at 14 weeks of gestation. P, placenta; SSV, secondary stem villous vessels

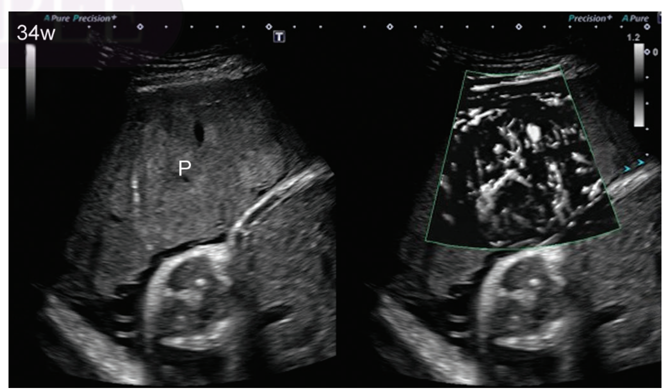


Fig. 32: Normal placenta depicted by SMI with Doppler luminance at 34 weeks of gestation. P, placenta

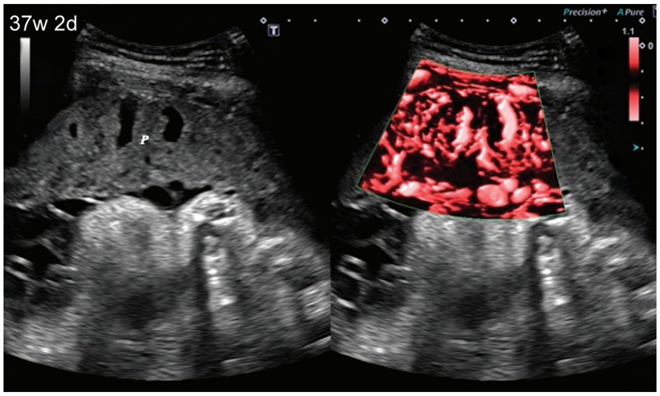


Fig. 33: Normal placenta depicted by SMI with Doppler luminance at 37 weeks and 2 days of gestation. P, placenta

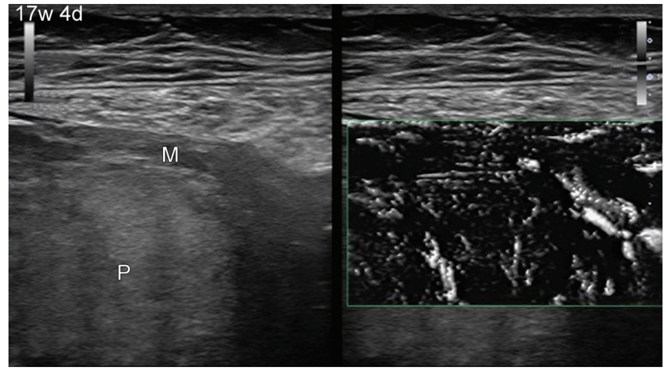


Fig. 34: Normal placenta depicted by SMI with Doppler luminance with an 18 MHz probe at 17 weeks and 4 days of gestation. M, myometrium; P, placenta

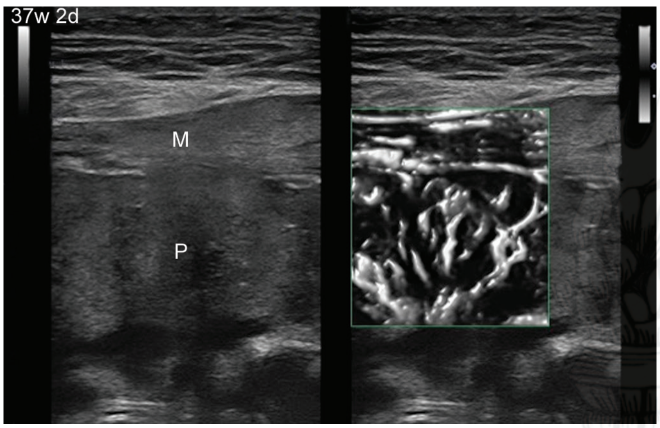


Fig. 35: Normal placenta depicted by SMI with Doppler luminance and an 18 MHz probe at 37 weeks and 2 days of gestation. M, myometrium; P, placenta

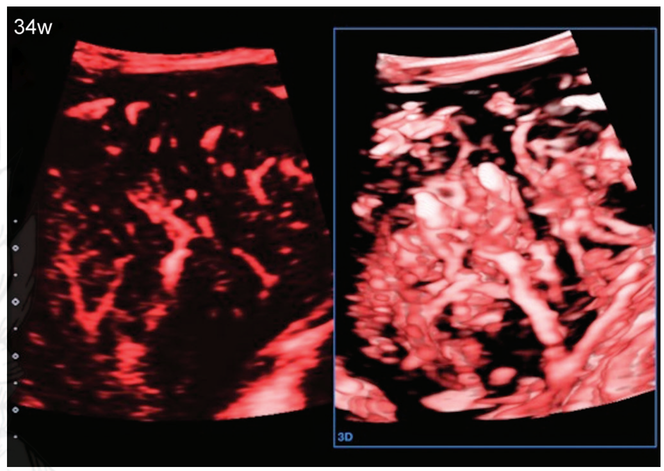


Fig. 36: 3D reconstruction of placental vasculature using 3D SMI at 34 weeks of gestation

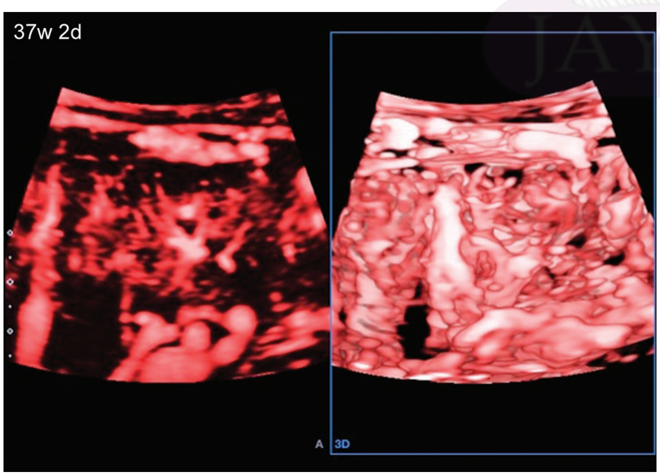


Fig. 37: 3D reconstruction of placental vasculature using 3D SMI at 37 weeks and 2 days of gestation

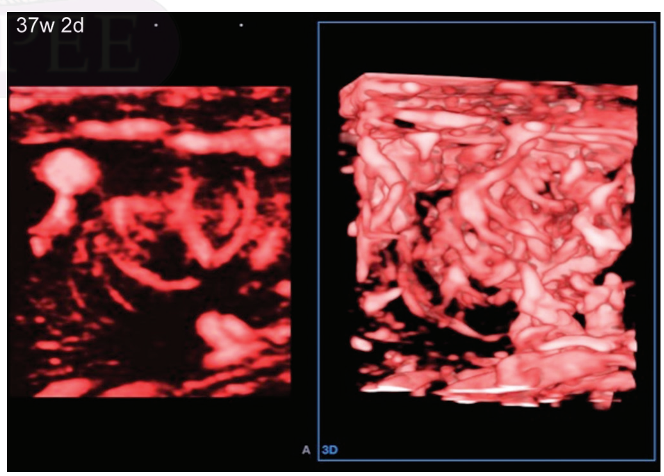


Fig. 38: 3D reconstruction of placental vasculature using 3D SMI with an 18 MHz probe at 37 weeks and 2 days of gestation

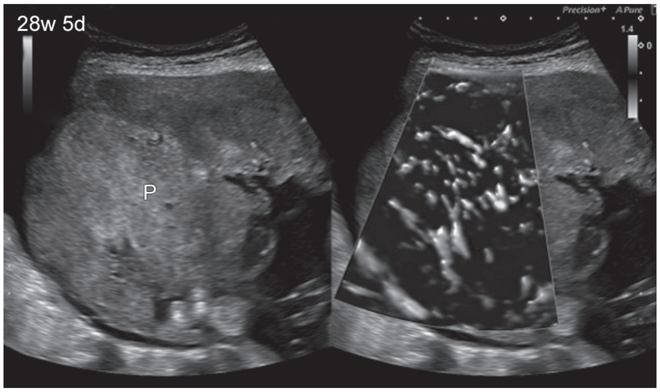


Fig. 39: Circumvallate placenta depicted by SMI with Doppler luminance at 28 weeks and 5 days of gestation. P, placenta

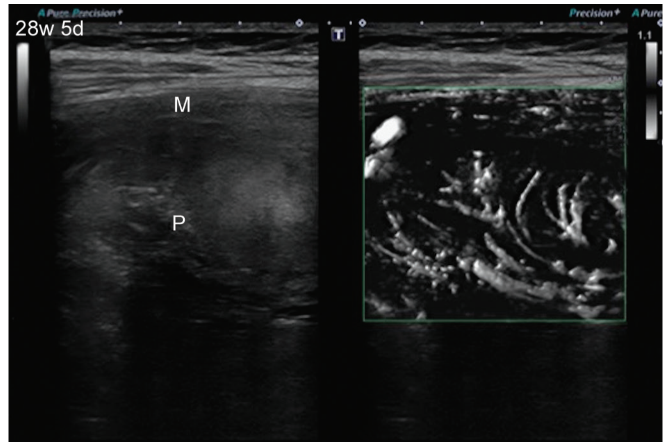


Fig. 40: Circumvallate placenta depicted by SMI with Doppler luminance and an 18 MHz probe at 28 weeks and 5 days of gestation. M, myometrium; P, placenta

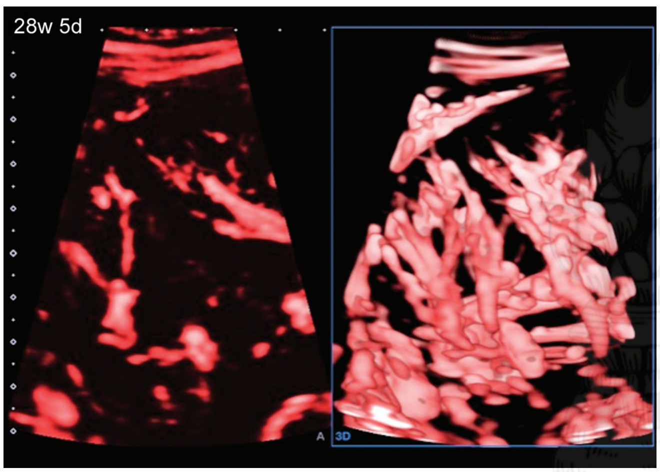


Fig. 41: 3D reconstruction of placental vasculature in the case of circumvallate placenta using 3D SMI at 28 weeks and 5 days of gestation

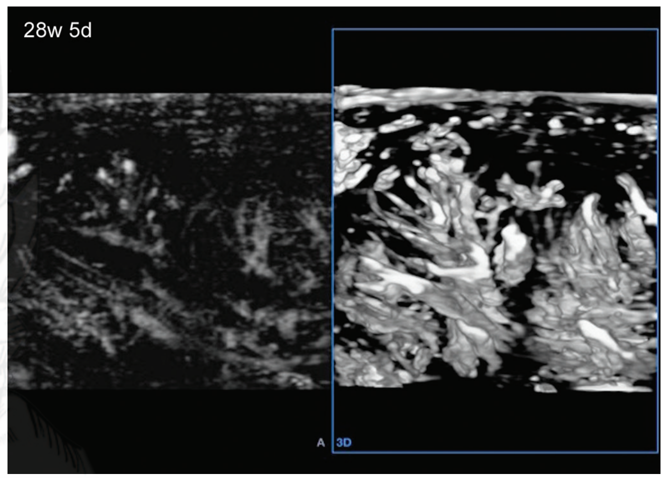


Fig. 42: 3D reconstruction of placental vasculature in the case of circumvallate placenta using 3D SMI with an 18 MHz probe at 28 weeks and 5 days of gestation

Fig. 43: Gross specimen of the circumvallate placenta

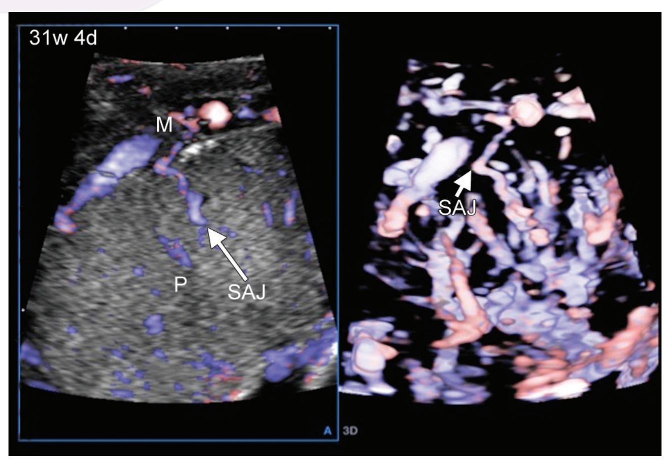
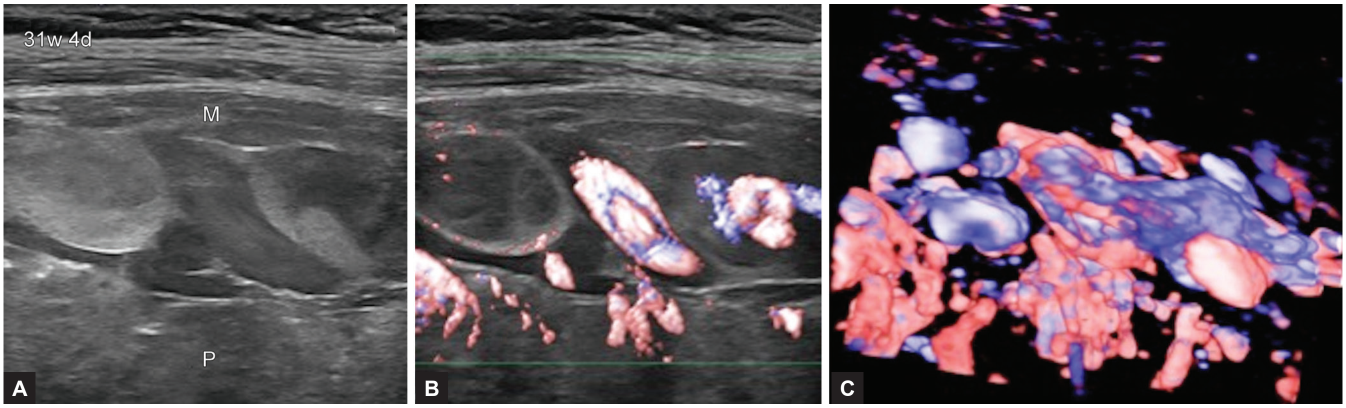


Fig. 44: Placenta previa depicted by SMI with Doppler luminance at 31 weeks and 4 days of gestation. M, myometrium; P, placenta; SAJ spiral artery jet flow



Figs 45A to C: Lower uterine segment of placenta previa depicted by SMI with Doppler luminance and an 18 MHz probe at 31 weeks and 4 days of gestation. M, myometrium; P, placenta. (A) 2D imager; (B) Color-coded SMI with Doppler luminance; (C) 3D SMI

Fetal Adrenal Gland

The fetal adrenal artery (AA) can be identified in the third trimester of pregnancy (Fig. 19). Moreover, a detailed vasculature of the AA can be noted using an 18 MHz probe (Fig. 21).

Fetal Spleen

Splenic blood vessels increase with advancing gestation (Figs 22 to 24). Using an 18 MHz probe, we can recognize smaller vessels in the spleen (Fig. 25).

Fetal Kidney

The renal vasculature becomes dense with advancing gestation (Figs 26 to 29). Using an 18 MHz probe, more detailed information on the fetal kidney can be obtained (Fig. 30).

Placenta

Normal Placenta

Intraplacental blood vessels become dense with advancing gestation (Figs 31 to 33). An 18 MHz probe can clearly show small intraplacental vessels compared with those depicted with a standard probe (Figs 34 and 35). 3D SMI more clearly demonstrates spatial relationships of intraplacental blood vessels (Figs 36 to 38).

Circumvallate Placenta

An increased placental thickness with rolled up edges protruding into the uterine cavity[1] is evident on 2D sonographic images, and moderate intraplacental vessels are noted using SMI with Doppler luminance (Fig. 39). An 18 MHz probe shows more detailed blood vessels in the placenta (Fig. 40). 3D SMI clearly demonstrates intraplacental blood vessels spatially (Figs 41 and 42). Figure 43 shows a gross specimen of the placenta after birth.

Placenta Previa

In the middle part of the uterus, the texture of placenta previa is the same as that of a normal placenta (Fig. 44). However, significant dilatation of decidual vessels is evident in the lower uterine segment (Fig. 45).

Discussion

In conventional SMI, an algorithm is used to filter out clutter at low velocities with no loss of significant information. It is able to remove motion artifacts while preserving data on low vascularity; however, both are removed by the conventional color Doppler. As a result, SMI is able to detect peripheral small vessels in the presence of low-velocity flow. There have been several studies on conventional SMI features of the fetus and placenta.[2–8] SMI with Doppler luminance demonstrates 3D SMI information on a 2D gray-scale image. Therefore, we can clearly understand spatial blood flow information on small vessels with low-velocity flow. In this article, various unique ultrasound images are shown with SMI with Doppler luminance. We can obtain new information on blood flow in the fetus and placenta using this technique. Future research is indispensable for the definite validation of this technique in obstetrical fields.

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