

A novel microvascular flow imaging technique for the evaluation of fetal and placental circulation



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Introduction

Doppler imaging is commonly used for the assessment of fetal and placental circulation. Nevertheless, conventional Doppler techniques have a limitation in visualizing low-velocity blood flow in minute vessels due to motion artifacts caused by respiratory motion and fetal movement. A novel microvascular flow imaging technique, Superb Micro-vascular Imaging (SMI), provides extraordinary sensitivity in visualizing low-velocity blood flow, while suppressing artifacts and maintaining high resolution and high frame rates. With these features, SMI allows a more detailed evaluation of the fetus and placenta, compared to conventional Doppler technologies.

Suppression of motion artifacts

One of the major difficulties in obstetric ultrasonography is to overcome the motion artifacts generated by respiratory motion, maternal aortic pulsation, and normal fetal movements during the examination. Reduction of motion artifact is important in all ultrasound examinations, but has additional challenges in Obstetrics. SMI analyzes clutter motion and uses a new adaptive algorithm to identify and remove tissue motion in order to reveal low-velocity blood flow in minute vessels. With this significant reduction of motion artifacts, prenatal diagnosis can be done faster and more easily.

SMI operates in two modes: monochrome SMI (mSMI), which subtracts the background images for more focus on detailed vasculature, and color-coded SMI (cSMI), showing flow components in color on top of the grayscale B-mode image at a high frame rate.



Figure 1 Despite the motion artifacts generated from maternal respiratory motion, cSMI could clearly depict the low-velocity vessels in the placenta (Frame rate = 54 fps).

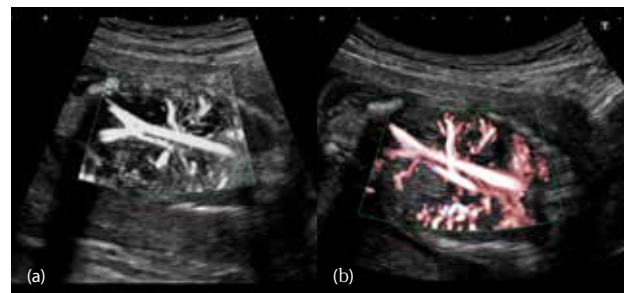


Figure 2 Abdominal vasculature at 19 weeks (a) mSMI (b) cSMI

Early prenatal diagnosis

Early detection of fetal abnormalities is critical in obstetrics. In early gestation, the organs of the fetus are small and contain low blood flow. Clinicians therefore require high-definition B-mode images for morphological evaluation, and Doppler technologies to depict low-velocity blood flow in minute vessels for functional analysis. Despite fetal movement, SMI can be used to obtain high resolution Doppler images at high frame rates and reveal minute vessels, such as abdominal vessels, the pulmonary vein and the intracranial vascularity.

Evaluation of placenta

SMI is useful for the evaluation of functional development and pathophysiology of the placenta.

In Fig. 4, SMI clearly depicted the villous capillaries at the chorionic plate as well as the maternal blood vessels at the basal plate, indicating the region of intervillous space.

In addition, during examination of placental growth with increasing gestational age, SMI is capable of delineating the reduction of villous capillaries within the terminal villi caused by placental insufficiency (Fig. 5).

Combining SMI with Smart 3D allows visualization of

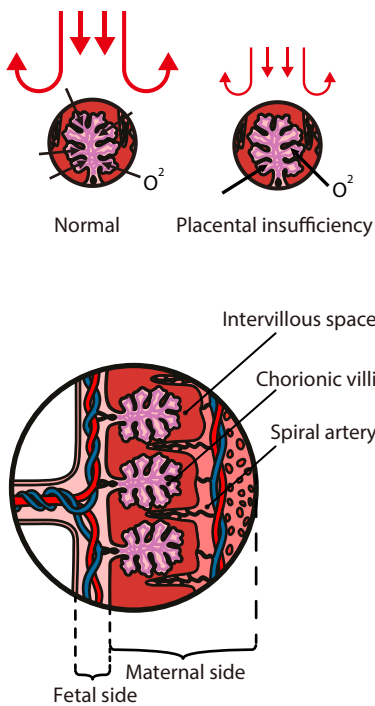


Figure 3 Anatomy of placenta

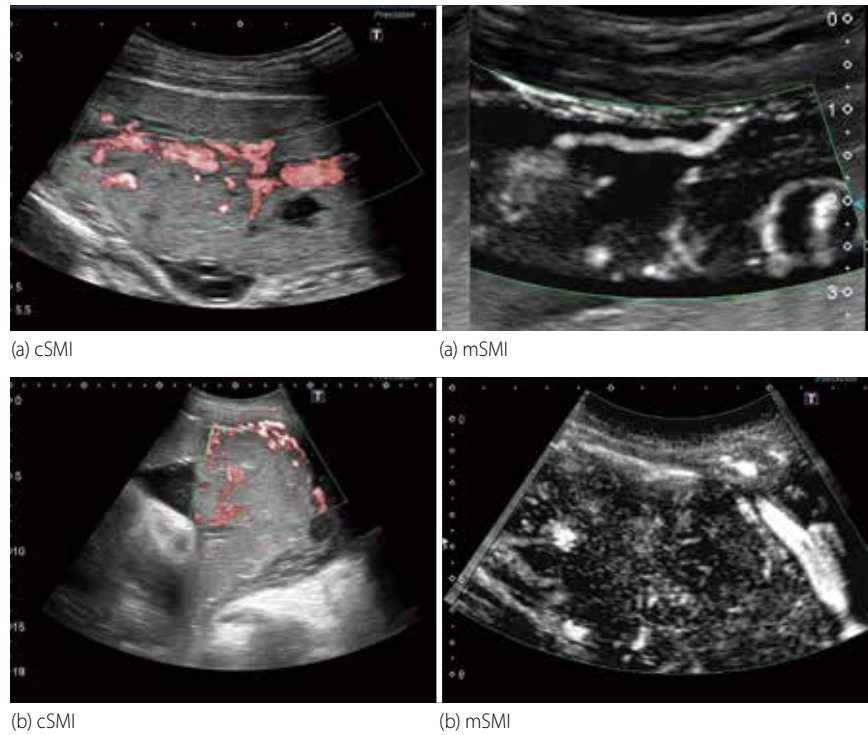


Figure 4 Delineation of placenta with SMI (a) Basal plate (maternal surface) (b) Chorionic plate (fetal surface)



Figure 5 Development of the placenta visualized by mSMI.

the entire vasculature in 3D. This volume is reconstructed from images acquired by free-hand scanning using conventional 2D transducers. Utilizing these two tools for placental assessment, the increased villous capillary growth and branching with placental maturation can be visualized (Fig. 6).

Early morphological evaluation of the placenta can be performed with ease for early detection of placental infarction (Fig. 7). As a result, SMI has a great potential for early detection of placental insufficiency .

Images with extraordinary resolution obtained with Aplio™ i-series also enable the examination of spiral arteries and branches of villous capillaries within the

terminal villi (Fig. 8). This is not possible when using conventional Doppler technologies.

Evaluating fetoplacental function with conventional Doppler technologies enables clear visualization of main stem vessels; however, SMI is capable of visualizing the low velocity flow vessels at the peripheral placental villi and provide a full profile for fetoplacental function.

Moreover, SMI has a high potential for evaluation of the methotrexate (MTX) treatment. In a case of cervical pregnancy (Fig. 9), MTX treatment was performed to induce termination. cSMI was able to visualize the decrease of vascular signal and confirm the treatment efficiency.

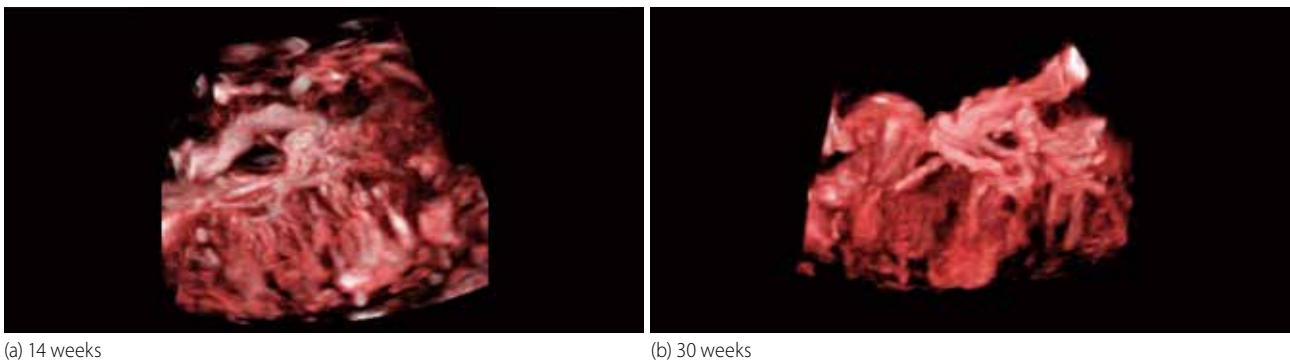


Figure 6 3D reconstruction of placenta using Smart Sensor 3D with SMI (a) 14 weeks (b) 30 weeks

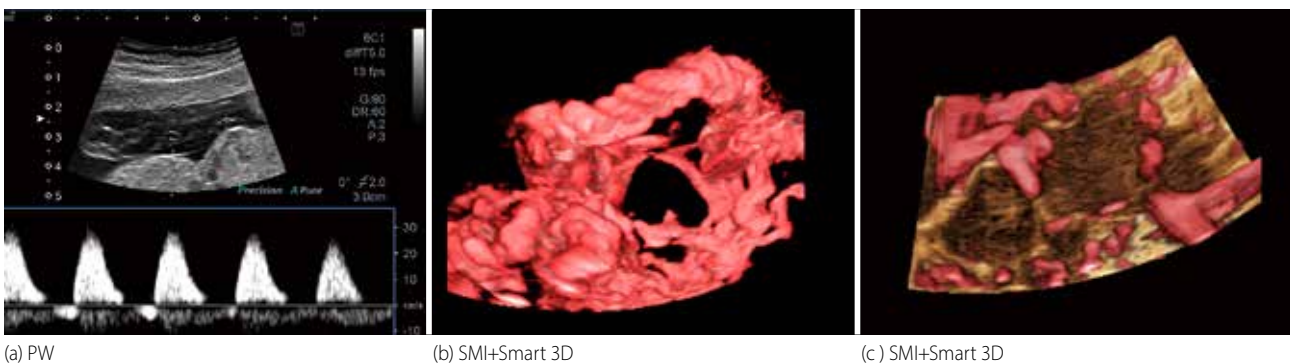


Figure 7 Placental insufficiency at 32 weeks (a) Pulse wave: arterial flow is low and resistance is high. (b, c) SMI +Smart 3D: Villous trees has decreased significantly in the placenta and branching vessels became congested.

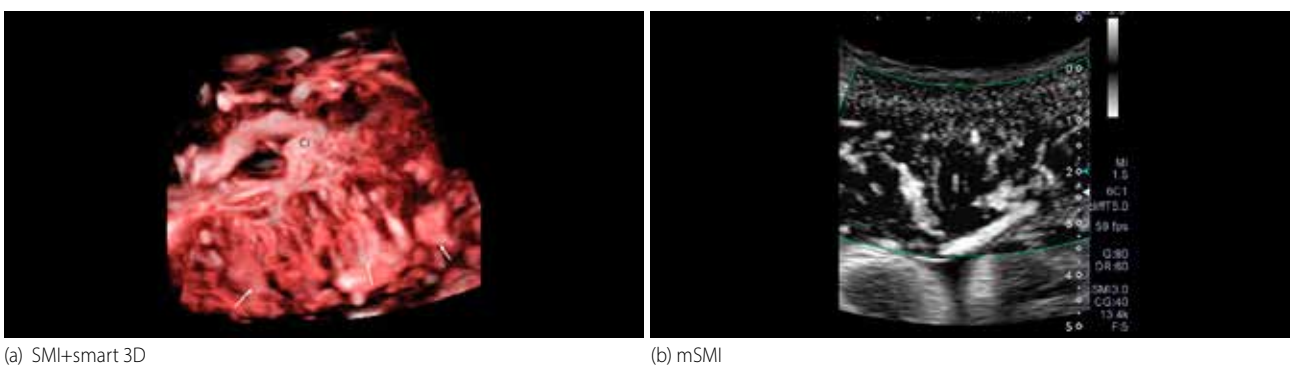


Figure 8 Spiral arteries using (a) SMI+smart 3D with (b) mSMI

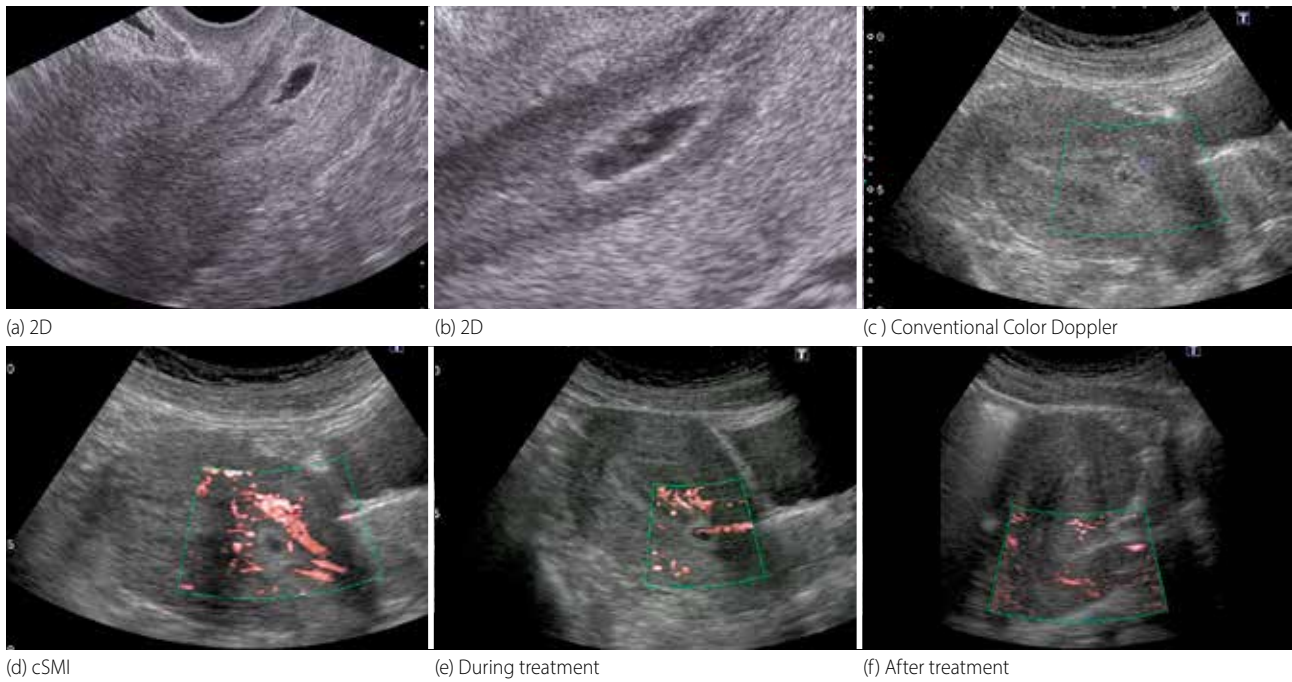


Figure 9

Conclusion

Superb Micro-vascular Imaging is a valuable tool for obstetricians. SMI can easily distinguish minute low-velocity flow in the placenta by suppressing motion artifacts caused by respiratory motion, aortic pulsation from the mother, and fetal movement. Therefore, SMI has high potential for the evaluation of placental function including accurate grading which allows early detection of placental insufficiency.

Reference

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