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Placental function assessed visually using half-Fourier acquisition single-shot turbo spin-echo (HASTE) magnetic resonance imaging

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ABSTRACT

Introduction: To investigate a simple visual assessment method of placental function using half-Fourier acquisition single-shot turbo spin-echo (HASTE) magnetic resonance imaging (MRI).
Methods: The institutional review board approved this retrospective study of fetal MRI in 48 singleton pregnant women for whom placentas had undergone clinical pathological examinations. Two readers independently assessed the placentas using the HASTE scoring system, particularly emphasizing the visualization of the regular two-tone pattern inside and signal intensity (SI) of placental parenchyma referring to SI of the fetal kidney and liver. After categorization using the HASTE scoring system, the associations between the scores and the presence of pathologically proven placental insufficiency or of low birth weight less than the tenth percentile were examined using chi-square tests. The associations between the HASTE scores and the MRI findings previously reported to suggest placental insufficiency, such as placental thickness and placenta to amniotic fluid SI ratio, were also examined using Student *t*-tests.
Results: The HASTE scores were associated significantly with the presence of pathologically proven placental insufficiency ($P = .003$ for reader 1; $P = .04$ reader 2) and birth weight less than the tenth percentile ($P = .005$ for reader 1; $P = .003$ for reader 2). The HASTE scores were associated significantly with the placenta thickness ($P < .0001$ for both readers) and the placenta to the amniotic fluid SI ratio ($P < .0001$ for both readers).
Discussion: The HASTE scoring system is feasible for use in clinical assessment of placental function and for diagnosing placental insufficiency.

1. Introduction

Placental insufficiency, a severe complication of pregnancy, can engender life-threatening conditions both for the fetus and mother. Early diagnosis is crucially important for management of the pregnancy. In clinical settings, placental insufficiency has been inferred indirectly from assessment of the umbilical, uterine, and fetal middle cerebral arteries using Doppler ultrasonography (US).

Magnetic resonance imaging (MRI) has attracted attention recently as a problem-solving modality that might enable the direct assessment of placental function. Several reports have suggested relations between placental insufficiency and MR parameters using T2 values measurement, intravoxel incoherent motion (IVIM), and arterial spin labeling (ASL) [1–4]. These quantitative analyses are expected to be promising for future objective evaluation of placental functions. However, they remain difficult to apply clinically because of the need for specialized MRI sequences and analyses. Damodaram et al. described a trend in the placenta of reduction of the amniotic fluid signal intensity (SI) ratio on T2-weighted images in patients with fetal growth restriction [5]. This ratio is anticipated as a good alternative to the T2 value and presents a simple means of measurement, but it requires some calculations and is not user-intuitive. Additionally, the inhomogeneous SI of amniotic fluid because of motion artifacts [6]

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remains problematic.

Half-Fourier acquisition single-shot turbo spin-echo (HASTE) imaging is now widely accepted for T2-weighted images for fetal MRI because of its rapidity. We previously reported that the placentas of fetal growth restriction (FGR) cases showed diffuse regular black-and-white two-tone patterns in HASTE images, which might reflect compensatory alternation caused by hypo-circulation of placenta [7]. Based on the case report, we hypothesized that the placental function can be visually and simply assessed using HASTE imaging, particularly addressing the regular two-tone signal pattern inside and the degree of low SI of placental parenchyma.

This study was designed to examine the feasibility of the visual assessment method using HASTE imaging comparing with factors predicting FGR reported [5], including placental thickness and amniotic fluid SI ratio measured by HASTE imaging, and with the presence of pathologically proven placental insufficiency and small for gestational age (SGA).

2. Materials and methods

2.1. Eligibility criteria and patients

Ethical approval for this retrospective study was granted by our institutional review board. The need for informed consent was waived.

The eligibility criteria were the following: (a) a pathological examination of placenta was conducted, (b) fetal MRI including HASTE imaging was performed after 24 completed gestational weeks at our institution for any clinical purpose, (c) singleton pregnancy without apparent fetal or placental abnormality pathologically, such as massive hemorrhage or infarction. Regarding criterion (b), we considered fetal viability as 24 completed weeks, and excluded cases in which MRI was performed before 24 weeks to reduce the influence of physiological placental maturation [8].

The patient search was conducted using a hospital information system for retrieving case data [9]. Between January 2006 and November 2013, 83 patients were found who had undergone both fetal MRI and pathological examination of the placenta at our institution. All pathological examinations were diagnosed by experienced board-certified pathologists.

We excluded patients with the following diseases based on the criterion (c): twin pregnancy ($n = 7$), fetal abnormality ($n = 5$), placental adhesion ($n = 3$), massive hemorrhage ($n = 2$), placental abruption ($n = 1$), chronic abruption-oligohydramnios sequence (CAOS, $n = 3$), pregnancy complicated with hydatidiform mole ($n = 3$), mesenchymal placental dysplasia ($n = 1$), and chorangioma ($n = 1$). Eight cases in which MRI was conducted before 24 completed gestational weeks and one case without HASTE images were also excluded. Finally, the remaining 48 pregnancies were included. All fetuses were alive when MRI studies were performed. The clinical purposes of MRI were: to assess the risk of placental adherent disorder with/without abnormal implantation (n = 22); to confirm the accurate location of uterine leiomyoma (n = 12); to exclude the placental or fetal abnormalities undetermined by US (n = 14). Clinical data related to patient age, gestational days at MRI and delivery, placental pathological findings, and birth weight (percentile) were collected. Patient characteristics are presented in Table 1.

Table 1
Clinical characteristics of the study population.

Characteristics	
Age, mean (range), y	35 (24–44)
Gestational week at MRI, mean (range), w	31 (24–38)
Gestational age at delivery, mean (range), w	35 (24–41)
Birth weight, mean (range), g	2296 (396–3344)
Delivery methods, no. (%) of patients	
Vaginal delivery	10 (21)
Planned cesarean section	23 (48)
Emergency cesarean section	15 (31)
Intrauterine fetal death, no. (%) of patients	*1 (2)
Placental insufficiency, no. (%) of patients	16 (33)
Small for gestational age, no. (%) of patients	9 (19)

* Cause of death was chorioamnionitis.

2.2. Magnetic resonance imaging

2.2.1. Protocols

MRI studies were conducted mainly using a 1.5 T scanner (Avanto; Siemens Healthcare, Erlangen, Germany). For clinical reasons, four patients were examined with a 3.0 T scanner (Skyra; Siemens Healthcare, Erlangen, Germany). For all examinations, patients were placed in the supine position. Each had a partially filled bladder. No premedication was administered.

In our institution, HASTE images have been included in the standard protocols of fetal MRI as recommended in previous reports [10,11]. Among the patients included, multi-plane pelvic HASTE images were acquired: axial, sagittal and coronal planes in 45 patients; axial and sagittal or coronal planes in 3 patients. The parameters for HASTE were the following: repetition time and echo time (TR/TE; ms/ms), 800–1000/80–90; 350 × 350 field-of-view in mm/mm; 260–360 band width in Hz/pixel; 4–6 mm section thickness.

2.2.2. Visual assessment using HASTE images

Two genitourinary radiologists who were blinded to the patients' clinical and pathologic data independently evaluated HASTE images. Readers were fellowship-trained radiologists with seven years (reader 1) and six years (reader 2) of experience in gynecologic imaging.

Visual assessments were performed particularly addressing two points: (1) the SI of placental parenchyma compared to the SI of the fetal renal cortex was classified following three groups: higher or slightly lower or markedly lower SI (similar to the SI of fetal liver); (2) the presence or absence of the regular black-and-white two-tone patterns inside the placental parenchyma, as described previously in a case report [7].

In reference to all available placenta HASTE images, two readers recorded the score of placenta using the HASTE scoring system, described as follows.

Score 1A and 1B: the SI of placental parenchyma was higher than SI of fetal renal cortex without/with sporadic high SI spots inside (1A/1B) (Fig. 1A, B).

Score 2A and 2B: the SI of placental parenchyma was slightly lower than that of the cortex of the fetal kidney without/with sporadic high SI spots inside (2A/2B) (Fig. 1C).

Score 3A and 3B: the SI of placental parenchyma was markedly low, and closer to the SI of fetal liver than fetal kidney without/with sporadic high SI spots inside (3A/3B) (Fig. 1D). A scheme of the HASTE scoring system is presented in Fig. 2.

Then, the scores were categorized, with scores of "1A and 1B" as the HASTE negative group, and scores of "2A, 2B, 3A, and 3B" as the HASTE positive group, in the view of the presence or absence of low signal intensity of placenta.

2.2.3. Placental thickness and placenta to amniotic fluid signal intensity ratio

To analyze associations with the HASTE scoring system, two readers independently measured the placental thickness and placenta to amniotic fluid SI ratio, which were reported as