Role of Fast MRI Pulse Sequences in Evaluation of Placental Adhesive Disease

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Abstract

Objective: The purpose of this study was to evaluate the diagnostic accuracy of fast, nearly motion free MRI pulse sequences (HASTE & true FISP) in the prenatal assessment of placental adhesive disease (PAD) compared to US and Doppler.

Patients and Methods: This prospective study included sixteen singleton pregnancies at risk of PAD, ten had actually PAD, all were investigated by transabdominal ultrasonography (gray scale & color Doppler methods) and prenatal fast MRI (including: HASTE; half-Fourier acquisition single-shot turbo spin-echo [T2], true FISP; true fast imaging with steady-state precession [GRE] & T1 weighted gradient-echo with fat suppression). Their gestational age ranged from 26 to 30 weeks. In each method placental location, appearance & invasion topography were assessed. Ultrasound and MRI findings were compared with surgical & pathological results.

Results: All patients had placenta previa: 2 marginalis, 2 incomplete centralis and 12 complete centralis, ten patients from the later proved to have PAD as follows: 7 were placenta accreta, one was placenta increta and 2 were placenta percreta. US & Doppler diagnosed 8 patients (diagnostic accuracy: 80%) with PAD; they showed lost retroplacental hypoechoic space, increased vascularity and vascular lacunes. Ultrasound misdiagnosed two patients with posterior placenta accreta. MRI successfully diagnosed all the patients with PAD. Fast, nearly motion free MRI techniques revealed 100% diagnostic accuracy compared to ultrasound findings. MRI allowed accurate evaluation of placental appearance & invasion, vascularity, uterine contour evaluation & extra uterine involvement. It also differentiated between venous lakes & septae in normal placentas and lacunae & dark bands in PAD.

Conclusion: Fast, nearly motion free placental MR pulse sequences provides excellent characterization of the degree and extension of placental invasion allowing optimal coordination with obstetricians in managing this complex life threatening conditions.

Key Words: Placental adhesive disease – Abnormal placental vascularity – Dark intraplacental bands – Placenta accreta.

Introduction

PLACENTAL adhesive disease (PAD) includes: Accreta, increta and percreta. It occurs where the placental villi reaches or penetrate into the myometrium, and the degree of villous invasion differentiates placenta accreta, increta, and percreta [1]. Placenta accreta (vera) occurs when chorionic villi (CV) implant on the myometrium without intervening deciduas (76% of abnormal placentations), in placenta increta CV partially invading the myometrium (18%) while in placenta percreta, CV penetrate through the entire myometrial thickness or beyond the serosa (6%) [1-4]. PAD prevents normal separation of the placenta at the time of delivery, potentially resulting in life-threatening uterine hemorrhage with subsequent hypovolaemic shock, coagulopathy and multiorgan failure or retained placental remnants. When recognized antenatally, steps can be taken to minimize blood loss during and after delivery [2,4].

Increasing rates of placental adhesive disease are strongly associated with a rising and high proportion of cesarean section almost worldwide, the risk of PAD increases to 11%, 40%, and 61% with one, two, and three previous cesarean sections.

Abbreviations:

- AIP : Abnormally invasive Placenta.
- CCDI : Color coded Doppler imaging.
- CS : Cesarean section.
- CV : Chorionic villi.
- IPL : Intraplacental lacunae.
- MRI : Magnetic resonance imaging.
- PAD : Placental adhesive disease.
- True FISP : True fast imaging with steady-state precession.
- T1WI : T1 weighted image.
- T2WI : T2 weighted image.
- VL : Venous lake.
Other risk factors include placenta previa (9.3% incidence), dilation & curettage, previous uterine surgery, uterine anomalies, advanced maternal age, smoking, and hypertension [1,3].

Ultrasound is an accurate method to diagnose PAD, widely available, relatively low-priced, and with high sensitivity and specificity. Doppler studies offer a complementary method to two-dimensional ultrasound imaging, although this has not conclusively been demonstrated to increase accuracy. However, Doppler can be used to diagnose early stages of PAD (power mode) and it is also of value in the assessment of placental involution when the placenta is left in situ after delivery [5].

Antenatal MRI was used in cases of ultrasonographic diagnostic doubt and also to classify the placental invasion degree. Placental MRI (pMRI) was used to evaluate the anatomy and limits of placental invasion [6,7].

It is recommended to use true fast imaging with steady state precession (true FISP) or Half-Fourier single-shot turbo spin echo (HASTE) sequences that reduce fetal and maternal artifact motions, thereby improving anatomical evaluation of the uteroplacental interface [8,9].

Markedly heterogeneous placenta, thick intraplacental dark bands on half-Fourier acquisition single-shot turbo spin-echo (HASTE), and disorganized abnormal intraplacental vascularity are the cardinal MRI features of placenta accreta [10-14].

Patients and Methods

This study included sixteen singleton pregnant women at risk of PAD; their ages ranged from 20 years to 38 years (mean age 29 Y.). The study conducted at radiology department and Obstetrics & Gynecology department of Mansoura University Hospital from the period of March 2013 till April 2014. High risk pregnant ladies were referred from Obstetric Outpatient Clinic of Mansoura University Hospital to the Radiology Department to perform routine antenatal US and they were suspected to have PAD (mainly: Placenta previa & previous C.S., others: Previous uterine operations, mother age). Their gestational age ranged from 26 to 30 weeks (no higher age was chosen to avoid placental maturation changes which could be wrongly interpreted as dark intraplacental bands and not earlier to avoid premature diagnosis of placenta previa). The pregnant ladies performed MRI with maximum 2 days interval from the US examination.

The patients were followed and delivered in Obstetric and Gynecology Department of Mansoura University Hospital by cesarean section, placental tissue specimens were sent to Pathology Department. Radiological, surgical & pathological information were compared.

Written consent was obtained from the patients. The ethical committee approved the study.  

Ultrasonography (US), color coded Doppler imaging (CCDI):

An ultrasound system (GE, Logic P5 2012) with curved 3.5 MHz transducer was used for the examinations. Trans-abdominal approach was done for all patients remove; transvaginal approach was avoided as patients refused it for fear of hemorrhage or ruptured membrane. Conventional gray-scale 2D imaging with color Doppler techniques was used to evaluate the placenta in all the cases.

Examination was done with the urinary bladder half filled, average time was 15 minutes.

Image interpretation:

Placenta: Location, shape, homogeneity, signs of PAD, invasion to adjacent structures & vascularity.

Normal placenta shows:

Homogeneous and granular structure, hyperchoic than the underlying myometrium, some calcifications could be identified. Sub placental clear space should be visible Doppler Pattern reveals a large amount of retro placental blood flow with regular and continuous pattern; occasional vessels get into the placental parenchyma.

Placenta in PAD shows:

Pseudotumoral appearance, intraplacental lacunae at the accreta zone, lost hypoechoic zone between palcenta and myometrium (or marked thinning: Less than 1mm), thinning of myometrium overlying the placenta, invasion of UB & increased vascularity of the uterine serosa bladder interface.

Points to be differentiated:

- Vascular lakes: Intraplacental sonolucent spaces appear usually rounded with distinct margins and show laminar flow, include decidual septal cysts, intervillous thrombosis, and placental infarction (depending on chronicity).
- Lacunae in PAD: Intraparenchymal vascular spaces with ill-defined margins, irregular shape, and turbulent flow [7,11].
MRI technique:

Patients examined by 1.5 T MR-unit (Magnetom Symphony Siemens Healthcare, Erlangen, Germany). The MRI protocol included:

1- Single-shot fast spin-echo T2-weighted MR sequences (HASTE) in axial, coronal & sagittal planes.

2- True fast gradient echo imaging with steady-state precession (True FISP) in coronal & sagittal planes.

3- T1 gradient-echo fat suppression in axial plane.

At least two breath-holding techniques were used to minimize respiratory motion artifacts. Total examination time was less than 5 minutes.

We avoided the use of intravenous Gadolinium in any cases as it can cross the placenta to the fetus circulation.

We used matrix of 256-380 x 224-270, FOV: 320-400mm, Flip angle 90 in HASTE and T1 & 50 in true FISP, slice thickness: 4mm, Gap: 1mm. TR/TE (ms): 1000/90 in HASTE, 4.3/2.2 in true FISP & 165/2.5 in T1 GRE.

T1-weighted image obtained with fat suppression to improve detection of any high-signal-intensity hemorrhage.

Examination was done with the urinary bladder half filled in the supine (2nd trimester patients, up to 28 weeks gestation) or left lateral decubitus (3rd trimester patients, 29-30 weeks) positions, the later was used as it was more comfortable & decreased the risk of defective venous return resulted from caval compression by the gravid uterus.

Image interpretation:

Placenta: Location, shape, homogeneity & signs of PAD.

Normal placenta & uterus show:

Homogeneous T2-intermediate signal intensity regularly spaced placental septae, minimal subplacental vascularity, placental venous lakes, triple-layered sandwich appearance of myometrium, pear-shape of normal gravid uterus with smooth contour. No focal bulge. No myometrial interruption.

Placenta with PAD shows:

Heterogeneous signal intensity due to increased vascularity, presence of lacunae, dark bands inside of hypointense signal on T2WI, invasion of adjacent structures.

Points to be differentiated:

- Placental septae in normal placentas: Hypointense lines on T2WI running through the myometrium with regular distribution.
- Dark bands in PAD: Hypointense signal on T2w images that usually extend from the uterine myometrial interface, have variable thickness and distribution (represent areas of fibrin deposition).

Uterus: Shape, focal bulge (normally fundus wider than lower part, in abnormal placenta the lower part will be wider than or equal to the fundus).

Myometrium: Homogeneity, continuity. Normal myometrium shows low signal than normal placenta. Focal interruption of continuity denotes sites of placental invasion.

Adjacent structures: Parametrium (invasion), UB (tenting & invasion).

Results

Sixteen singleton pregnancies at risk of PAD referred from obstetric outpatient clinic underwent US: Grey scale and Doppler and non contrast MRI. Gestational age ranged from 26-30 weeks, ten of them had actually PAD (62.5%): 7 had placenta accreta (43.8%), one had placenta increta (6.3%) and 2 had placenta percreta (12.5%). All the patients had placenta previa (PP): 2 had marginalis, 2 had incomplete centralis & 12 had complete centralis. Nine of PAD were associated with placenta praevia complete centralis & 1 was associated with placenta praevia marginalis).

All had previous cesarean section: (All had one previous C.S. except 2 had previous two C.S.) Table (1).

<table>
<thead>
<tr>
<th>Total PP (16)</th>
<th>Marginalis (n=2)</th>
<th>Incomplete centralis (n=2)</th>
<th>Complete centralis (n=12)</th>
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<tr>
<td>Previous CS</td>
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*2 patients with previous 2 S.C. showed placenta percreta.

In US & Doppler, seven of the patients with PAD showed loss of or interrupted retroplacental hypoechoic space, placental lacunae & increased vascularity. The patients with placenta percreta showed UB invasion. Patients with placenta previa with no PAD showed venous lakes instead of lacunae.
US missed 2 patients with placenta accreta having placenta previa (marginalis & complete centralis: More posterior in location). In these two cases, the retroplacental hypoechoic space was preserved Table (2).

In MRI all of our PAD patients showed low-signal intensity bands on maternal side of placenta near the cervix (on HASTE images), heterogeneous placentas, uterine bulging & focal interruptions of the myometrial wall (partial in increta and complete in percreta). Patients with placenta percreta showed in addition UB tenting & invasion. Patients with placenta previa with no PAD shows normal placental septae instead of dark bands Table (3).

US & Doppler diagnosed 8 patients from the 10 patients with PAD: Misdiagnosed two patients with placenta accreta located posteriorly (diagnostic accuracy: 80%) while MRI successfully diagnosed all patients with PAD (diagnostic accuracy: 100%).

**Cases:**

All cases showed placenta previa, previous one C.S. except placenta percreta (Case 4) showed previous 2 C.S., came for routine antenatal US, gestational age: 20-30 weeks.

Case (1): Patient with placenta previa marginalis, no PAD.

(A) : Doppler US: Showing homogenous placenta with few small rounded venous lakes (straight long arrow), preserved retro placental sonolucent line (curved arrow), shows scanty vascularity (straight short arrows).

(B,C): MR: Coronal HASTE & sagittal true FISP showing pear shaped uterus, with smooth contour, no focal bulge, no lacunae no dark bands near the cervix, no obvious vascularity at placental uterine interface (long arrow).

Case (2): Patient with placenta previa centralis, no PAD.

(A,B): Grey scale US & Doppler showing placenta previa centralis with smooth uterine contour, no focal bulge (straight long arrow), preserved retroplacental sonolucent line (straight short arrows), scanty parenchymal vascularity with no lacunae nor placental uterine interface vascularity (curved arrow). Note venous lake at the 2nd image: Regular nearly rounded vascular space (arrow head).

(C,D): MRI: Coronal and axial true FISP respectively showing pear shaped uterus with placenta previa centralis, smooth uterine contour, no focal bulge (straight long arrows), no dark bands and preserved thin myometrium(curved arrows).
Case (3): Patient with placenta previa centralis remove & placenta accrete which was missed by grey scale US, confirmed by MRI.

(A,B): Grey scale US & Doppler respectively showing placenta previa centralis (Remove: Black thick arrow) with focal bulge. Apparently preserved retroplacental sonolucent line (white curved arrows). Also showing parenchymal lacunae (vascular spaces with color saturation at Doppler image (white straight short arrow) and obvious placental uterine interface vascularity (white straight long arrow).

(C,D,E): MRI: Coronal HASTE & sagittal true FISP respectively showing: Placenta previa centralis with heterogeneous appearance, focal bulge (straight long arrow), dark bands (curved arrow), tortuous numerous vessels at placental uterine interface (straight small arrows) and placental lacunae: Irregular vascular spaces hypointense at true FISP (arrow heads).

Case (4): Patient with placenta previa centralis & placenta percreta.

(A,B): Grey scale US & Doppler showing placenta previa centralis with focal bulge & obliterated retroplacental sonolucent line (straight long arrow). Also showing lacunae: Irregular parenchymal vascular spaces (straight short arrows) and marked placental uterine interface vascularity (curved arrow).

(C,D,E): MRI: Axial HASTE, coronal HASTE, sagittal true FISP respectively showing: Placenta previa centralis with heterogeneous appearance, broad lower segment (straight large arrows), focal bulge, dark bands (curved arrows), tortuous numerous vessels at placental uterine vesical interface (signal void at HASTE & hyperintense at true FISP differentiating them from dark bands) invading UB wall (arrow heads).