Learning objectives

To illustrate Magnetic Resonance Imaging (MRI) findings of placental adhesive disorders (PAD) with radio-pathologic correlation.

Background

PLACENTAL ADHESIVE DISORDER

Definition

Placental adhesive disorders (PAD) encompasses a spectrum of abnormal placental implantation variants in which a defect of the decidua basalis allows the invasion of chorionic villi into the myometrium. PAD forms (placenta accreta, increta and percreta) are classified on the basis of the depth of myometrial invasion (TABLE 1).

Prevalence of PAD is approximately 1/1000 deliveries, with a reported range from 0.04 to 0.9%. Major risk factors for PA are prior cesarean section and placenta previa (1). The risk of developing PAD is 3% in women with only placenta previa and increases to 24% in those with placenta previa and one prior cesarean delivery (2). The risk increases with the number of previous cesarean deliveries (3). Other risk factors are advanced maternal age, uterine anomalies, previous uterine surgery (curettage, myomectomy) and multiparity.

Advanced forms of PAD can be life-threatening for both the mother and fetus, since they can translate into massive hemorrhage at the time of placental separation. Hysterectomy is required in such cases, which is in turn associated with complications like adjacent organ injuries (ureteral injury) and serious co-morbidities (pulmonary embolus): up to 26% of patients are admitted to intensive care unit. Placenta percreta can also lead to disruption of adjacent organs, most often the urinary bladder.

Accurate prenatal detection of affected pregnancies allows optimal management in the means of timing and site of delivery, availability of blood products, and recruitment of a skilled anesthesia, interventional radiology and surgical team, that can be arranged in advance.

Pathology

PAD may occur because of: (i) primary defect of trophoblast function, (ii) secondary basalis defect due to failure of normal decidualization, and (iii) abnormal vascularization
and tissue oxygenation of scar tissue (e.g., at the site of cesarean section), resulting in defective decidualization and trophoblastic invasion.

Typical pathological findings in PAD are intraplacental lacunae (IPL) and placental or venous lakes (VL). IPL refer to intraplacental vascular spaces with ill-defined margins, irregular shape, and turbulent flow. Increase in the number and size of lacunae is associated with increased risk for PA.

**IMAGING IN PAD**

Ultrasonography (US) and Magnetic Resonance Imaging (MRI) are currently used in imaging of PAD.

**Ultrasonography**

US is the primary diagnostic tool for PAD and was shown to help detect this disorder in up to 50%-80% of cases. Placental lacunae with turbulent flow, loss of retroplacental clear space and reduced myometrial thickness are the most predictive US findings for PA. Significant number of IPLs at 15-20 weeks of gestation is the earliest reliable US sign of PAD in at-risk patients (sensitivity 79% and positive predictive value 92%). This is why routine US examination at 18-20 weeks gestation affords an ideal opportunity to screen for the disorder.

Doppler increases the accuracy of ultrasound in distinguishing normal decidua basalis vessels from those that pass through the myometrium, with demonstration of numerous coherent vessels involving the whole uterine serosa/bladder junction, detection of hypervascularity, evidence of inseparable cotyledonal and intervillous circulations, chaotic branching and detour vessels (4, 5).

However, normal screening US does not exclude PA in high-risk patients, who should be reevaluated in the third trimester (2).

**MRI**

Given its superior soft-tissue contrast, MRI has the potential to better define areas of abnormal placentation, degree and levels of invasion, and ultimately may impact on the planning of a safe delivery procedure. This is particularly true in the case of placenta percreta, which extends beyond the uterus, causing direct invasion of adjacent pelvic structures by highly-vascularized placental tissue.

Two recent comparative studies have shown US and MRI to be comparable in assessing PAD. According to Warshak et al, sensitivity and specificity of US and MRI in detecting placenta accreta were 93 % versus 80 % and 71 % versus 65 %, respectively (6). Other studies state that there was no significant difference in diagnostic performance between
MRI and US, although MRI was better at detecting the depth of infiltration in cases of placenta accreta (7).

US should remain the first-line modality to evaluate PAD in patients with clinical risk factors, then using MRI as a problem solving-tool to assess inconclusive or equivocal sonographic findings, especially in patients in whom sonographic visualization of the placenta is more challenging (e.g., posterior placenta). Whether MRI should be used routinely is still a matter of debate.

Images for this section:

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**Table 1:** Classification of placenta accreta.

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Findings and procedure details

MR IMAGING

PATIENT PREPARATION

- To better evaluate bladder involvement with placenta percreta, the urinary bladder should be at least partially filled.
- Patients should lie supine (as easily tolerated in the second trimester of pregnancy) or on left lateral decubitus (better tolerated in the third trimester because of reduced caval compression). In our experience, the large majority of patients tolerate the application of one or two surface coils on the abdomen. The examination can be performed with lower image quality with the body coil in the case of intolerance.
- The use of oxygen via a nasal cannula to reduce fetal motion is debatable. In our experience, the absence of oxygen does not translate in significant motion artefacts.

PROTOCOL

MRI protocol is designed to obtain maximum diagnostic information with the lowest specific absorption rate, and should include (Table 2):

- a 3-planar single-shot fast/turbo-spin-echo (SS-TTSE/SS-FSE) or half-Fourier acquisition single-shot fast-spin-echo (HASTE) sequences help demonstrate dark placental bands, loss of normal low-signal intensity myometrium, disorganized architecture of the adjacent placenta, a focal exophytic mass and, in case of invasion involving the bladder, thinning of the uterine serosal-bladder interface and extension of placental tissue beyond uterine margins with loss of fat planes between the uterus and pelvic organs (8). These sequences also demonstrate a good diagnostic accuracy in the detection of placental haematomas (9).
- a balanced-gradient echo sequence with hybrid T1 and T2* weighting (e.g., FIESTA, true-FISP, BSSFSP) to help eliminate artifacts caused by maternal and fetal motion.
- a T1-weighted 3D spoiled Gradient-recalled echo sequence, which is more accurate in the detection of placental abruption.
- MR diffusion-weighted imaging (DWI) being an excellent sequence for detecting intrauterine haemorrhagic lesions. Blood breakdown products cause susceptibility effects and can be accurately demonstrated with the diffusion-weighted sequence (10).
Planes can be oriented either perpendicularly or parallel to uterine body axis in order to provide better delineation of the placenta-myometrium interface. Ideally, the radiologist should supervise planes placement to obtain representation of “true” anatomic planes.

Some investigators advocated the use of gadolinium to improve the specificity in distinguishing placenta accreta from percreta. However, the use of i.v. contrast medium should be discouraged since gadolinium chelates is theoretically absorbed by fetal gastrointestinal tract and can undergo trasmetallation in the amniotic fluid. Potential effects on the fetus remain still unknown.

**MRI FINDINGS**

**Normal placenta on MRI**

Typically, the placenta is **discoid in shape** and lies along the anterior or posterior wall of the uterus, with the normal decidua basalis providing a plane of separation between the placenta and the uterine wall. Placenta may extend to lateral wall with increasing gestational age (11).

On T2 weighted MR imaging (T2W), the placenta appears as an intermediate signal-intensity soft-tissue structure along the margin of the uterus, which is usually clearly distinct from the underlying myometrium. The myometrial-decidual interface is visible as a low-signal-intensity line deep to the placenta. **Figures 1, 2 and 3** illustrate normal placental attachment. Histopathological correlation of normal placental attachment is shown in **Figure 4**.

Key imaging features of normal placentation are shown in **Table 3**.

**Main pitfalls in imaging interpretation**

- Dark intraplacental bands - also seen in placental infarction and intervillous thrombus. Placental infarcts are common in term placentas and in patients with risk factors for placental insufficiency. These confounding factors should be kept in mind while diagnosing PAD.
- Heterogeneity of the placenta - common finding, and the spectrum of normal appearance varies according to gestational age. Even though abnormal intraplacental vascularity denotes placental invasion, the increased pelvic vascularity is not a reliable indicator of abnormal placentation.
- The lower segment widening of gravid uterus - results in more of an hourglass shape to uterus. This appearance might be seen occasionally in healthy gravid uterus. Additional imaging perpendicular to the suspicious
interphase and localization of abnormality in at least two orthogonal planes are suggested.

**PAD**

The most reliable MR imaging findings of PAD are listed in **Table 4**.

**ASSOCIATED CONDITIONS: PLACENTA PREVIA**

Placenta previa refers to abnormal implantation of the placenta in the lower uterine segment, overlying or near the internal cervical os (Fig. 5). Normally, the lower placental edge should be at least 2 cm from the margin of the internal cervical os.

Classification of placenta previa is described in **Table 5**.

**MANAGEMENT STRATEGIES**

Despite improvement in antenatal diagnosis, by accuracy of US and MRI techniques, placenta accreta is still associated with a high maternal morbidity rate. The main challenges include controlling the hemorrhage and dissection of the invaded tissues. Hysterectomy has traditionally been advised in the management of placenta accrete, but there has been a recent trend towards conservative management and preservation of fertility (12).

All efforts should be made to control both intra- and post-operative hemorrhage; internal iliac artery and uterine artery ligation or balloon occlusion is performed in some cases to control hemorrhage. Over the past few decades, the role of pelvic arterial embolization has evolved from a novel treatment option to playing a key role in the management of obstetrics hemorrhage. Interventional radiology offers a minimally invasive, fertility-preserving alternative to conventional surgical treatment.

Placenta Percreta - management of placenta percreta invading the urinary bladder usually requires radical surgery, which may include partial or total resection of the bladder.

Multidisciplinary approach and the key role of interventional radiology may lead to a safe outcome for both the mother and the fetus (13).

**CASES WITH RADIO-PATHOLOGIC CORRELATION**
CASE 1

- 41-year-old woman at 29 weeks' gestation, with US findings suspicious for placenta praevia. The patient had previous caesarean section and was referred to MRI in order to exclude placental invasion (Fig. 6).

- **Focal accretismus** was found intraoperatively at the level of internal cervical os. Patient underwent bilateral iliac artery balloon occlusion prior to planned cesarean section. However, the patient finally required total hysterectomy due to severe post-partum hemorrhage.

CASE 2

- 23-year-old woman at 29 weeks' gestation and prior cesarean section.

- US examination diagnosed placenta previa and suspicious placenta accrete. Therefore, MRI was obtained.

- **Placenta accreta** was found both intraoperatively and at histological examination. The patient required uterine artery embolization (UAE) due to post-partum hemorrhage. Histopathological examination shows placenta accreta (Fig. 7b,c).

CASE 3

- 42-year-old woman at 30 weeks' gestation.

- Placenta previa was diagnosed on routine antenatal US, with high suspicion for PAD (Fig. 8, 9).

  The patient underwent hysterectomy after UAE failed to stop the bleeding.

- **Placenta increta** was confirmed at caesarean section and on histopathologic examination after total hysterectomy.

CASE 4

- 43-year-old woman with sonographically diagnosed placenta previa and hematuria, who had MR imaging at 30 weeks of pregnancy. The patient had prior caesarean section.

- MR findings were consistent with **placenta percreta** with cervical and urinary extensive bladder invasion, which were confirmed intraoperatively (fig. 10, 11, 12). The patient
required total hysterectomy with right UAE and partial cystectomy. Histopathological examination after total hysterectomy confirmed placenta percreta.

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**Table 1:** Classification of placenta accreta.

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Diffusion-weighted MR images are acquired with $b$ values of 50, 400 and $800 \text{ s/mm}^2$.

*FISP* fast imaging with steady state precession, *HASTE* half-Fourier single-shot turbo spin-echo, *FS* fat saturated

**Table 2:** Table 2. Our institutional 1.5T protocol for PAD (Magnetom Aera, Siemens Healthcare, Erlangen, Germany). Anatomic coverage extends from the diaphragm to pubic symphysis. Diffusion-weighted MR images are acquired with $b$ values of 50, 400 and $800 \text{ s/mm}^2$.

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Fig. 1: Axial T2-weighted HASTE MR image shows posterior discoid placenta (P) with intermediate signal intensity (higher than muscles). The three layers of the normal myometrium can be seen as the hypointense outer (green arrow) and inner (blue arrow) layers surrounding the more hyperintense middle layer (white arrow), which contains the vasculature.

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Fig. 2: T2-weighted HASTE MR image acquired on a paracoronal plane with respect to the uterine body shows a homogeneous placenta (P) with thin linear areas of decreased signal intensity arranged in a regular pattern (arrows) representing normal placental septa. Uterus is normally pear-shaped.

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Fig. 3: Sagittal T2-weighted HASTE MR image shows homogeneous bilobar placenta (P) extending anteriorly and posteriorly along inferior two-thirds of the uterus.

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**Fig. 4:** (a, b) Histopathological images showing normal placental villi (white arrow) and intact decidua basalis (black arrow) (H&E, x20, x100).

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Table 3: Key imaging features of normal placentation.

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### MOST SENSITIVE SIGNS
- Dark intraplacental bands on T2-weighted images
- Heterogeneity within the placenta
- Disorganized abnormal intra-placental vascularity

### LESS SENSITIVE SIGNS
- Uterine focal/multifocal bulging
- Myometrial thinning, with focal interruption of the myometrial wall (high specificity for increta and percreta)
- Invasion of adjacent organ by placental tissue, especially the bladder, with tenting of the bladder dome (highly specific for percreta)

Table 4: Main MRI criteria to diagnose PAD.

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**Fig. 5:** Sagittal T2-weighted HASTE MR image shows posterior placenta implanted directly over the internal os (asterix) - complete previa. Thin strip of tissue (arrow) that is slightly hyperintense relative to the placenta is consistent with thinned myometrium in the lower uterine segment, which can be seen in normal pregnancies. The homogeneity of the placenta made PAD unlikely.

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Table 5: Classification of placenta previa.

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Fig. 6: CASE 1 (a) Sagittal T2-weighted HASTE MR image shows anterior placenta (P) extending to the edge of the internal os (asterix) but does not cover it - findings consisting of marginal placenta previa. (b) There is a focal disruption of the hypointense inner myometrial layer in the lower uterine segment (green arrow) at the site of placental invasion. Placenta accreta was found intraoperatively.

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**Fig. 7:** CASE 2 (a) Sagittal T2-weighted HASTE MR image demonstrate that there is a complete placenta previa (red arrow) with the placenta overlying the os (asterix). The lower anterior margin of the placenta is invading the myometrium (yellow arrow) but does not breach the full thickness of the myometrial muscle. MRI findings are consistent with a Grade IV placenta previa and placenta accreta. These findings were confirmed intraoperatively. (b,c) Placenta accreta. Microscopic examination of the uterine specimen shows placenta accreta with myometrial fibers (M) immediately apposed to placental villi (V) in the absence of intervening deciduas (H&E, ×20, x100).

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**Fig. 8:** CASE 3 (a) Sagittal T2-weighted HASTE MR image shows central placenta previa entirely covering the cervical os with slightly heterogeneous signal intensity and posterior disruption (green arrow) of low signal inner layer of utero-placental interface. Bulging of the uterus can be seen anteriorly (red arrow). (b) Paracoronal T2-weighted HASTE MR image shows a discontinuity of the hypointense inner myometrial layer on the left lateral uterine segment (blue arrow). (c) Axial T2-weighted HASTE MR image shows low signal intensity placental bands extending from the myometrial-placental interface (yellow arrow).

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Fig. 9: Placenta increta. Microscopically, the placental villi (V) interdigitate directly with the uterine myometrium (M), without an intervening decidua plate (H&E, ×100).

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Fig. 10: CASE 4 Sagittal T2-weighted HASTE MR images show placenta previa, abnormal anterior placental bulging (green arrow) and "tenting" of the bladder along its superior margin (red arrow) with placental protrusion through serosa because of the focal defect of the utero-placental interface. Thick intraplacental dark bands of a heterogeneous signal intensity are seen within the placenta (blue arrow).

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**Fig. 11:** CASE 4 (a) Paracoronal T2-weighted HASTE MR image shows right lateral uterine margin with parametrial invasion (green arrow). (b) Axial T2-weighted HASTE MR image shows higher-signal-intensity placenta extending through the serosal surface along the right anterior and lateral uterine margin with parametrial invasion (white arrowhead).

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**Fig. 12:** Placenta percreta. Chorionic villi (V) penetrating through the myometrium into the uterine serosa and infiltrating the adipose/loose connective tissue of parametrium (A). (H&E, ×100).

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Conclusion

PAD is a greatly feared obstetric complication, even when presenting at full-term delivery as it may lead to emergency hysterectomy, consumptive coagulopathy, extensive hemorrhage, and urinary complications. The prevalence of PAD is increasing, and radiologists should be aware of this entity.

Ultrasonography remains the dominant imaging modality for evaluation of the placenta. A placental MRI provides a morphological description, as well as topographical information that optimizes diagnosis and surgical management. Furthermore MR examination has allowed the correct clinical and radiological evaluation in the series between the placenta accreta and percreta. The changes of attitude given by the anatomic and vascular knowledge by this technique, have allowed correct changes of attitude in the surgical opportunity and management.

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References


