MRI in detection of abnormal placentation: when and why.

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Authors: A. L. VALENTINI¹, B. Gui¹, V. ninivaggi², A. F. Cavaliere³, C. Mosseri², L. Bonomo²; ¹Roma (RM)/IT, ²Roma/IT, ³Roma, Italy/IT
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Learning objectives

- To help Radiologists in correctly perform and evaluate a magnetic resonance imaging (MRI) examination in suspect of abnormal placentation
- To define when and why MRI is needed for the correct diagnosis.
- To describe normal and abnormal MRI findings.

Background

Introduction

Placenta is the organ responsible for nutritive, respiratory and excretory functions of the fetus in pregnancy.

This is often overlooked in routine evaluation of a normal gestation and receives a more accurate analysis only when an abnormality is found.

Abnormal placentation could be a risk of morbidity and mortality for both mother and baby so it should be early identified and defined [1].

Anatomy and Embriology

Placenta is composed by fetal and maternal components.

Villi of chorion frondosum are the fetal contribute: they contain the arterial plexus equipped by the umbilical artery and protrude the intravillous space where they get through to the maternal blood.

Decidua placentalis is the maternal portion that outlines the intravillous space; groups of villi are separated by septa [1].

The deciduas basalis divides placental chorionic villi from the miometrium and this allows a complete separation of the placenta after delivery.

Abnormal placentation, or adhesive disorders of placenta, are divided in order of severity in placenta accreta, increta and percreta. Fig. 1 on page 4

In the case of placenta accreta vera there is a direct contact between chorionic villi and myometrium without deciduas basalis (76% of cases of abnormal placentation).
Placenta increta is the intermediate form of abnormal placentation: in this case chorionic villi invade the myometrium but do not reach the serosal layer (18% of cases of abnormal placentation).

Placenta percreta is the severe form, where chorionic villi invade through the miometrium to reach or extend beyond the serosa into surrounding tissues of organs (6% of cases of abnormal placentation).

Microscopically, the cardinal feature of adhesive disorders of placenta is partial or complete absence of decidual basalis, which may be replaced by loose connective tissue. The decidua parietalis may be normal but is commonly absent or deficient as well. Placental villi adhere directly to or invade the myometrium often partially separated from focally hyalinized myometrial smooth muscle cells by a layer of fibrin [2].

**Pathogenesis and Clinical Overview**

One third up to one half of emergency peripartum hysterectomy seems to be due to adhesive disorders [4].

The risk of placenta accreta increases in these cases:

- Uterine scar of gynecological procedures such as cesarean delivery, curettage, myomectomy, hysteroplasty especially when placenta implants on a scar area; in particular, previous cesarean delivery increases the risk up to 3% for the first, to the 40% for the third and 67% to the fifth delivery [4, 5].
- Maternal age greater than 35 years.
- Multiparity [5].
- Site of implantation; deciduas in low segments has been shown is poorly developed relative to the rest of uterus, which may contribute to the association between abnormal placentation. Placenta previa has 9.3% of incidence and is classified in [4]:
  
  1. Low lying: lower placental margin is within 2 cm of the internal cervical os;
  2. Marginal previa: placenta extends to the edge of internal os without covering;
  3. Complete previa: placenta covers the internal os;
  4. Central previa: the implant is on the internal os [1].

 Contributing factors of abnormal placentation are:

- Deficient decidualization
- Excessive trophoblast invasion
- Localized differences in oxygen tension,
- Abnormal vascular remodeling
- Combination of causes [4].
When the placenta fails to deliver, trying to force the delivery, it can result as a severe postpartum hemorrhage, with possible multiple organ failure, damage to the nearby organs such as bladder, emergency hysterectomy, increasing maternal mortality [5].

The management of placenta accreta suspected before delivery is operative or conservative because extirpative approach induces massive hemorrhage, and depends on the grade of adhesive disorder, the hospital and the woman. It's important to localize the site to guide the surgeon performing the cesarean section in the right way.

Cesarean hysterectomy is indicated for woman with strong suspect of placenta accreta who do not want more children. Maternal morbidity after hysterectomy is very low thanks to medical and technical resources such as an attending obstetrician and surgical team, blood bank and available interventional radiological procedures [5].

Images for this section:

**Fig. 1:** Placental adhesive disorders, modified from Alamo L et al, Eur J Radiol 2013 [3].
Findings and procedure details

Ist and IInd line evaluation: Ultrasound

Ultrasound (US) is always performed in pregnancy in most cases by gynecologist during fetal screening examinations that represents the I line method of diagnose placental abnormality with high specificity (77-100%) and sensitivity (71-100%). US is not expensive, available and doesn't use ionizing radiation. Color and power Doppler techniques allow the direct visualization of placental vascularity, both uteroplacental and fetoplacental [1]

The ultrasound exam should be performed with a bladder volume sufficient to visualize the serosa bladder interface to better explore the vescico-placental interface and the newly formed vessels [6].

Normal placenta appears as a mass characterized by homogeneous and granular structure that causes indentation of the gestational sac, hyperchoic than the underlying myometrium visible as a thin hypoechoic rim well remarked; some calcifications could be identified. Subplacental clear space should be visible.

Doppler Pattern reveals a large amount of retroplacental blood flow with regular and continuous pattern; occasional vessels get into the placental parenchyma.

Placentation disorder is suspected when placenta has a pseudotumoral appareance; intraplacental lacunae are visible in the accrete zone which make the placenta similar to "Swiss cheese", classified by Fingsberg Criteria. Hypoechoic zone between palcenta and myometrium is absent [6]. Thinning of myometrium overlying the placenta and loss of retroplacental sonolucent line could be seen. Vascularity of the uterine serosa bladder interface is increased [7]. Echoic area and interface of the serosa and the bladder could be interrupted.

US false positive are absence of retroplacental echolucent zone based on defective decidua, with marked thinning due to poor healing after previous cesarean section and the operator dependence. US false negative are posterior placenta and operator misdiagnosis [6]. Fig. 2 on page 8

IIIrd line evaluation: MRI

In case of inconclusive US examination, Magnetic resonance imaging (MRI) is usually requested to evaluate the placenta with a specific clinical question. Moreover, posterior uterine portions are sometimes difficult to examine, especially in patient with high risk factors (such as previous cesarean delivery, uterine surgery and advanced maternal age or in doubtful parametrial invasion in non conclusive ultrasound [1,7].
MRI examination is superior to US in soft tissue contrast and field of view, but limited by cost, patient claustrophobia, skilled imaging interpretation and presence of a MRI scanner [1].

MRI technique

In our institute we use this protocol suggested by literature informations; Fig. 3 on page 9 we use a a 1.5 T scan, the patient in supine decubitus with a multi channel surface coil when tolerate.

A multi-channel surface coil is used to maximize signal whenever possible because it provides a superior signal-to noise ratio; in larger patients and toward the end of pregnancy, a body coil may be necessary.

The bladder should have medium distention to better assess potential bladder.

Some authors indicate that in the third trimester patients better tolerated left lateral decubitus positioning than supine; it also decreases the risk of defective venous return from caval increasing pressure by uterus compression. In the second trimester of pregnancy patients well tolerate supine positioning in the MR system scanner.

The safety of MR at 1.5-T or 3 T has not yet been proven but presently none study documented any adverse effect on babies exposed at magnetic fields [8].

To minimize the deposition on radiofrequency energy in the pregnant patient, with high temporal resolution and good contrast, 256x160 or 256 x 224 matrix [1,8] is used with a partial phase field of view of 0,7 -0,75 in applicable rectangular geometries such as the axial plane.

Antepartum imaging of the placenta is possible using fast MRI sequences that can provide motion-free images of the abdomen in a limited time.

Protocols used in litterature includes MRI sequences such as:

- multi-planar T2-weighted single-shot echo train spin-echo (half Fourier rapid acquisition with relaxation enhancement (RARE), single-shot turbo spin-echo, or single-shot fast spin-echo) imaging,
- steady state of free procession gradient echo sequences such as fast-imaging employing steady-state acquisition (FIESTA) , true fast imaging with steady-state precession (FISP), balanced fast field echo (FFE).
- Sagittal T1-weighted gradient-echo imaging with and without fat suppression, to improve the detection of blood products.

Additional sequences are:
• T2-weighted fast spin-echo sequence in the desired plane, when higher-resolution imaging is required to maintain a satisfactory signal-to-noise ratio. This sequence can be performed over a limited area during a breath-hold using some type of flip back pulse to shorten the repetition and acquisition times.

To confirm all suspected abnormalities two imaging planes are useful because the normal curvature of the uterus can potentially lead to a false positive examination in a single imaging plane.

Some authors propose parallel imaging reconstruction algorithms. Some authors suggest GRAPPA with iPAT factor 2 are used to decrease the MR data acquisition time of the sequences and therefore reduce fetal and maternal motion artifacts [8].

Some studies have also investigated the value of pre and post contrast T1 spoiled gradient echo sequences, to improve the specificity of MRI and distinguishing placenta accreta from percreta by better definition of placental surface and myometrium.

The use of intravenous gadolinium contrast material remains controversial in the antepartum period and is recommended only when the potential risks to the patient are outweighed by the potential benefits of contrast-enhanced imaging [1,8, 9].

Clinical experience of diffusion-weighted imaging (DWI) in placental studies is limited, but recently it has been demonstrated to be useful in the detection of placental hematoma [7].

Sensitivity and specificity are variable in litterature (from 80 to 100% of sensitivity and form 65 to 100% of specificity) and seems to depend on observer experience too [3,7].

**MRI Normal appearance**

At MRI examination uterus is "Pear shaped" uterus with the fundus and the body wider than the caudal segments.

Placenta has homogeneous intermediate signal without focal bulging, clearly distinct from normal myometrium.

Normal placenta septa are visible as hypointense lines on T2w images running through the myometrium with regular distribution

Myometrium has three distinct layers, with the inner and the outer layers hypointense on T2w images and the inner one with intermediate intensity, that often contains flow voids. Myometrium has variable thickness the that thins as the pregnancy progresses.
Numerous flow voids under, within the placenta and in the region of insertion of the umbilical cord represent vascularization [10]. Fig. 4 on page 10

**MRI appearance of Placenta disorders (placenta previa and accreta)**

When an adhesive disorder of placenta occurs the normal shape of uterus could be modified, with lower part wider than the fundus. Uterine bulge are visible, seen as a focal outward contour protrusion or as disruption of normal pear shape of uterus. Placenta has a heterogeneous signal intensity associated to increased vascularity and presence of lacunae, especially when the heterogeneity is marked and may represent either areas of hemorrhage in the placenta or the lacunae that can be visualized at US. Dark intraplacental bands are linear or nodular areas of hypointense signal on T2 w images that usually extend from the uterine myometrial interface, that have variable thickness and distribution and represent areas of fibrin deposition; this differentiate them from normal septa. Myometrium could become very thin in pregnancy and difficult to evaluate, but focal interruption of continuity are considered as sites of placental invasion. Focal thinning is not a reliable sign of invasion.

In case of placenta percreta placental tissue could invade adjacent structures. The most involved organ is the bladder, so directly invasion or tenting is highly specific but not sensitive, because patients could have low levels of invasion in these sites [10]. Fig. 5 on page 11 Fig. 6 on page 12 Fig. 7 on page 13 Fig. 8 on page 14

In absence of all these criteria the examination is considered negative and but the possibility of PA is not excluded completely until the time of delivery[6].

**Images for this section:**
<table>
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<th>US evaluation</th>
<th>Normal placental US findings</th>
<th>Abnormal placentation US Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of placenta</td>
<td>• A mass that indentate the gestational sac</td>
<td>• Pseudo-tumoral appearance</td>
</tr>
<tr>
<td>Ultrasound pattern</td>
<td>• Hypoechoic than the myometrium</td>
<td>• Intra-placental lacunae in the accrete zone as a “Swiss cheese”</td>
</tr>
<tr>
<td></td>
<td>• Homogeneous and granular structure</td>
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<td>• calcifications</td>
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<td>Myometrium</td>
<td>• Myometrium: a thin hypoechoic rim well remarked</td>
<td>• Thinning of myometrium overlying the placenta</td>
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<td>Limit with surrounding</td>
<td>• Sub-placental clear space</td>
<td>• Loss of retro placental sonolucent line</td>
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<td>structures</td>
<td>• Vescico-placental interface</td>
<td>• Absence of hypoechoic zone between palcента and myometrium</td>
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<td></td>
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<td>• Interruption of echoic area and interface of the serosa and the bladder</td>
</tr>
<tr>
<td>Vascular pattern</td>
<td>• Regular and continuous blood flow</td>
<td>• Increased vascularity of the uterine serosa bladder interface</td>
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**Fig. 2:** US findings in normal placenta and adhesive disorders
**Fig. 3:** MRI imaging protocol for placenta evaluation

<table>
<thead>
<tr>
<th></th>
<th>FIESTA</th>
<th>T2w SS-FSE</th>
<th>T2w SS-FSE fat sat</th>
<th>T1w gradient echo</th>
<th>T1w gradient echo fat sat</th>
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<tr>
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<td>axial oblique</td>
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<td>to long axis of</td>
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<tr>
<td>Section thickness</td>
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Fig. 4: The trans-vaginal sonogram shows normal placental findings (A). The T2w MR sagittal (B) and axial (C) images show normal “pear” shaped uterus, with the placenta that extends to the edge of internal os without covering it. Placenta is homogeneous with thin hypointense regular lines that represent septa. The three distinct layer of myometrium are visible, with the inner and the outer layers hypointense and the inner one with intermediate intensity, that contains flow voids. Umbelical cord is visible on this T2w coronal oblique MR image (D). The structures previously described are visible in these FIESTA coronal (E) and axial (F) MR images too. A photomicrograph of histological specimen (G) of normal term placenta shows hypotrophic terminal villi (V) with few syncitial and fibrotic nodes, perivillar fibrin deposits, blood lacunas and placental septum (arrows).
<table>
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| **Shape of uterus** | &bull; “Pear shaped” uterus  
&bull; The fundus and the body are wider than the caudal segments.  
&bull; Absence of focal bulging. | &bull; Caudal segments. Wider than the fundus and the body  
&bull; Focal bulging |
| **MRI pattern** | &bull; Homogeneous intermediate signal  
&bull; Clearly distinct from normal myometrium  
&bull; Normal placenta septa, visible as hypointense lines on T2w images running through the myometrium with regular distribution | &bull; Heterogeneous signal intensity  
&bull; Increased vascularity  
&bull; Presence of lacunae  
&bull; areas of hemorrhage in the placenta  
&bull; Areas of fibrin deposition seen as dark intra-placental bands, linear or nodular areas of hypointense signal on T2w images extended from the uterine myometrial interface, with variable thickness and distribution. |
| **Myometrium** | &bull; Variable thickness of the myometrium relative to the pregnancy progress  
&bull; Three distinct layers of the myometrium, with the inner and the outer layers hypointense on T2w images and the inner one with intermediate intensity,  
&bull; Inner layer often contains flow voids representing the normal myometrial vascularity | &bull; Focal interruption of continuity  
&bull; Focal thinning is not a reliable sign of invasion. |
| **Limits with surrounding structures** | &bull; Preserved | &bull; Invasion of structures  
&bull; Bladder tenting |
| **Vascularity** | &bull; Numerous flow voids under, within the placenta and in the region of insertion of the umbilical | &bull; Increased placental vascularity |

**Fig. 5:** MRI findings in normal placenta and ashesive disorders
Fig. 6: The trans-vaginal sonogram (A) shows increased vascularity of vescico-uterine space. The sagittal (B and C) and coronal oblique (D) T2w MR images show modified shape of uterus and central placenta previa that covers uterine os (white arrow); placenta has heterogeneous signal intensity with dark intra-placental bands (harrowhead) In this coronal oblique (E) T2w MR images shows on the left side (void arrow) thinned myometrium associated to increased vascularity and presence of lacunae; these findings are suspicious for plecента accreta in the site of previous cesarean sections, confirmed in the histologic specimen (F) where chorionic villi (V) are adherent to myometrium (M), without microscopic invasion of the villi into muscle wall (black arrow).
Fig. 7: The sagittal (A) T2w MR image shows central placenta previa that covers uterine os (white arrow). Placental signal is heterogeneous in this coronal oblique (B) and axial oblique (C) T2 images; myometrium is thin (black arrow) in correspondence of a focal area of heterogeneity (void arrow). The T1w oblique axial MR image (D) reveals the hyperintense signal of degradation hemoglobin product of a recent hematoma. The histological specimen of the same patient (E) shows a placenta increta where hypotrophic terminal villi extend up to affect the outer third myometrial (black arrow).
Fig. 8: In the trans-abdominal sonogram image (A) the placenta seems to invade the full thickness of the myometrium in suspect for infiltration of sierosa. The sagittal (B), axial (C) T2w MR image ad axial T2w with fat saturation (D) shows central placenta previa with heterogeneous structure and dark intraplacental bands within the parenchima (white arrow). Areas of hemorrhage (arrow head) are visible on the T1w axial image with fat saturation (E) too. On the right anterior portion myometrium is very thin and seems to be discontinuous with focal interruption and minimal increased vascularization (void arrow). On the hystological specimen(F) the villi infiltrate the full thickness of the myometrium without the interposition of the decidua (black arrow as in placenta percreta findings.
Conclusion

The prevalence of placenta accreta is increasing; after US evaluation, in equivocal cases, in presence of posterior placenta and previous uterine surgery MRI should be performed.

MRI now is an excellent modality of evaluation of placenta; the Radiologist should know its imaging features to better confirm the suspect of adhesive disorder and ensure the correct preoperative assessment for appropriate treatment planning.

Personal information

Prof. A.L. Valentini alvalentini@rm.unicatt.it
Dott. V. Ninivaggi ninivaggi.valeria@hotmail.it
Policlinico A. Gemelli-UCSC- Roma/IT

References


