Placental implantation abnormalities: A Pictorial Review

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Learning objectives

• To understand normal uterine and placental anatomy and the different types of placental implantation abnormalities

• To present the various characteristic imaging findings of these abnormalities using magnetic resonance (MR) imaging

• To briefly discuss the role of interventional radiology in the management of patients with invasive placental disorders
Background

Introduction

Placental implantation abnormalities are an important cause of maternal morbidity and mortality making early and accurate detection on imaging vital.

The spectrum of implantation abnormalities includes placenta praevia, placenta accreta, placenta increta and placenta percreta.

Radiologists should be familiar with important risk factors and the imaging features of these abnormalities.

This poster will describe these abnormalities and their features on MR imaging.

Normal anatomy

Uterine zonal anatomy is well demonstrated on T2 weighted MR imaging (T2WIs). The low T2 signal junctional zone separates the high T2 signal of the endometrium and endometrial cavity from intermediate T2 signal outer myometrium.

The placenta normally lies along the anterior or posterior wall of the uterus and is comprised of both fetal and maternal components. Fetal chorionic villi, which contain fetal vessels, project into the intervillous space where they are in contact with maternal blood. The maternal decidua lines this intervillous space. Figures 1, 2 and 3 demonstrate examples of normal placental attachment in the axial, coronal and sagittal planes on MR imaging.

Imaging in Pregnancy

US is currently the first line modality to evaluate the placenta owing to its radiation safety, low cost and availability. US is the recommended first line modality in women with suspected placenta praevia or placenta accreta. Well documented risk factors include previous caesarean sections and other uterine interventions, although increasing maternal age, multiparity and multigestational pregnancies may also contribute.

However, US is entirely operator dependent and can present a diagnostic challenge when imaging obese women and in those with a posteriorly placed placenta.

The normal placenta on US appears homogenous and of intermediate echogenicity, with a hypoechoic layer dividing the myometrium and the decidua.

MR imaging to evaluate placental abnormalities is often performed in equivocal cases, in those with posterior placenta and for assessment of depth of invasion and pelvic...
organ involvement. MRI provides exquisite anatomical and pathological detail. Although there are no absolute contraindications, MR imaging is generally avoided in the first trimester but is safe in the third trimester when placental disorders present clinically and are investigated.

The normal placenta on MR imaging appears homogenous and of intermediate T2 signal intensity with a distinct low T2 signal myometrial-placental interface (4), figures 1, 2 and 3.

**Placenta Praevia (PP)**

The placenta is normally located in the anterior or posterior walls of the uterus and its inferior edge should lie more than 2 cm from the internal cervical os (5). When found to be overlying or less than or equal to 2cm from the internal os (IO), it is referred to as placenta praevia. No invasion of the underlying myometrium is present in PP. There are three types of PP:

1. *Complete* (placenta completely covers the internal os)
2. *Partial* (placenta partially covers the internal os)
3. *Marginal* (placental edge lies at the internal os)

The usual clinical picture is of painless vaginal bleeding in the third trimester, however presentation can be earlier and in some cases no symptoms are observed.

The diagnosis is usually made sonographically, with MR imaging reserved for equivocal cases or posteriorly placed placentas. The diagnosis should not be made prior to 15 weeks gestation as most low lying placentas migrate to a normal position (3).

On MRI images in the sagittal plane are the most useful to demonstrate the relationship of the placenta to the internal os of the cervix. Other features of Placenta Praevia include:

- Heterogeneous appearance of the placenta
- Dilated flow voids around the abnormally attached placenta

**Invasive Placental Disorders**

There are three types of placental invasive disorders, with an increasing depth of invasion and therefore complication rate:
1. **Placenta accreta** - placental villi adhere to or superficially invade the myometrium (most common type)

1. **Placenta increta** - placental villi invade the deep myometrium

1. **Placenta percreta** - placental villi invade through the full thickness of the myometrium and serosa and may invade into pelvic organs such as the bladder or bowel

The incidence of invasive placental disorders has increased more than 10 fold in the last 30 years (6), attributable to the rise in caesarean section rates. The two most significant risk factors for the development of invasive placental disorders are placenta praevia and previous uterine instrumentation.

Life threatening hemorrhage may occur during delivery if the condition is not detected in the antenatal period and screening of women at high risk is vital.

Early detection also permits appropriate obstetric planning and management. In our institution, women diagnosed antenatally with invasive placenta undergo prophylactic interventional radiology procedures prior to delivery.

This management is in accordance with the RCOG (Royal College of Obstetricians and Gynaecologists) guidelines which state that interventional radiology can be used as emergency treatment for postpartum haemorrhage and as a prophylactic measure in anticipation of per or post partum haemorrhage. This is either where there is a previous history or current diagnosis of placenta praevia and/or invasive placenta.

Balloon catheters are placed in the internal iliac or uterine arteries prior to delivery. These can be inflated to occlude the vessels in the event of postpartum haemorrhage and selective embolisation can be performed if bleeding continues despite inflation. Despite intervention if hysterectomy is still required, blood loss, blood transfusion and intensive care unit admissions are still reduced by the pre-emptive use of interventional radiology. The RCOG advises that if these facilities are not available to the patient at the host hospital, patient transfer to centres with interventional facilities should be arranged (7).

Sonographic findings of invasive placenta include loss of the hypoechoic subplacental space, presence of placental lacunae and abnormal colour Doppler patterns (8).

US has a reported sensitivity and specificity of up to 0.77 and 0.95 respectively for the detection of placenta accreta, with slightly better values for MRI (0.88 and 1 respectively), this is depicted in Table 1 (6).
Table 1:

<table>
<thead>
<tr>
<th>Type of Invasive Placenta</th>
<th>Definition</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placenta Praevia</td>
<td>Placenta overlying or less than or equal to 2cm from the internal os</td>
<td>• Sagittal images are the best to demonstrate the relationship of the placenta to the internal os of the cervix</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Heterogeneous appearance of the placenta</td>
</tr>
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<td></td>
<td></td>
<td>• Dilated flow voids around the abnormally attached placenta</td>
</tr>
<tr>
<td>Placenta Accreta</td>
<td>Placental villi adhere to or superficially invade the myometrium</td>
<td>• Focal uterine bulge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Focal interruptions within the hypointense myometrial border</td>
</tr>
<tr>
<td>Placenta Increta</td>
<td>Placental villi invade the deep myometrium</td>
<td></td>
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</tbody>
</table>
Placental heterogeneity on T2 weighted sequences
• Intraplacental bands of low T2 signal intensity

Placenta Percreta
Placental villi invade through the full thickness of the myometrium and serosa and may invade into pelvic organs such as the bladder or bowel

• Full thickness invasion of the myometrium
• Direct visualization of the invasion of pelvic structures by placental tissue

Table 2: Characteristic MRI findings in placental implantation disorders.

Technique for MRI in Placental implantation Abnormalities:

Standard MRI safety screening should be performed in all patients. Ideally the patient should fast for 4 hours to reduce bowel peristalsis artefact and prevent postprandial foetal motion. The patient should empty their bladder prior to scanning.

The negligible nature of the risks posed by MRI in pregnancy should be explained to the patient and the discussion documented in the patient notes or scan report. This discussion should include the facts that there are no known deleterious effects from MRI at 1.5 Tesla (T) or lower magnetic field strengths. However, there is a lack of experience with the use of field strengths greater than 2.5T.

A pelvic surface coil can improve image quality. Positioning for pregnant patients is either supine or in the left lateral decubitus position to avoid inferior vena cava compression by the gravid uterus in later stages of pregnancy.

The field of view for the examination extends superiorly from the dome of the liver through to the symphysis pubis inferiorly.

A localiser is acquired and rapid T1 weighted imaging (T1WI) and T2 weighted imaging (T2WI) which will eliminate respiratory motion artefact and will reduce foetal motion artefact, is acquired in a maternal breath hold, if the patient is able to comply.
Axial, sagittal and coronal T2 weighted images are useful for assessment of pelvic anatomy.

The MRI protocol for imaging invasive placental conditions including placenta praevia, accreta and percreta at our institution is outlined in Table 3.

<table>
<thead>
<tr>
<th>Plane</th>
<th>Sequence</th>
<th>Slice/Gap</th>
<th>Field Of View</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 Localiser</td>
<td>8/20%</td>
<td>Whole pelvis</td>
</tr>
<tr>
<td>2</td>
<td>Axial T2 true FISP</td>
<td>5/10%</td>
<td>Whole uterus and baby</td>
</tr>
<tr>
<td>3</td>
<td>Coronal T2 true FISP</td>
<td>5/10%</td>
<td>Whole uterus and baby</td>
</tr>
<tr>
<td>4</td>
<td>Sagittal T2 true FISP</td>
<td>5/10%</td>
<td>Whole uterus and baby</td>
</tr>
<tr>
<td>5</td>
<td>Coronal T2 Single shot turbo spin echo/Fast spin echo</td>
<td>5/10%</td>
<td>Whole uterus and baby</td>
</tr>
<tr>
<td>6</td>
<td>Coronal T1 Volume interpolated gradient echo Fat saturation</td>
<td>5/20%</td>
<td>Whole uterus and baby</td>
</tr>
</tbody>
</table>

Table 3: MRI protocol for imaging invasive placenta. (10)
**Fig. 1:** Figure 1: Normal placental (P) implantation in the axial plane on T2 weighted image on MRI. A smooth, homogeneous placenta (P) situated away from the internal cervical os.

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Fig. 2: Figure 2: Normal placental (P) implantation in the coronal plane on T2 weighted image on MRI. A smooth, homogeneous placenta (P) situated away from the internal cervical os.

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Fig. 3: Figure 3: Normal placental (P) implantation in the sagittal plane on T2 weighted image on MRI. A smooth, homogeneous placenta (P) situated away from the internal cervical os.

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Findings and procedure details

Case 1

21 year old pregnant lady. 25 weeks gestational age. Two previous caesarean sections. Low lying placenta identified on routine antenatal sonography and referred for MRI to exclude invasive placenta.

Fig. 4: Case 1: 21 year old pregnant lady. 25 weeks gestational age. Two previous caesarean sections. Low lying placenta identified on routine antenatal sonography and referred for MRI to exclude invasive placenta. Sagittal T2 weighted image. Normal homogenous placenta (P) with the bulk lying anteriorly within the uterine cavity. There are large flow voids present (Yellow Arrows). There is a tongue of placental tissue (Red Arrow) which is overlying the internal os of the cervix (Asterix). The appearances are in keeping with a grade 2, incomplete placenta praevia. No features to suggest an invasive placenta.

References: Radiology, St Bartholomew Hospital - London/UK
Sagittal T2 weighted image.

Normal homogenous placenta (P) with the bulk lying anteriorly within the uterine cavity. There are large flow voids present (Yellow Arrows).

There is a tongue of placental tissue (Red Arrow) which is overlying the internal os of the cervix (Asterix). The appearances are in keeping with a grade 2, incomplete placenta praevia. No features to suggest an invasive placenta.

**Case 2**

37 year old pregnant patient. 37 weeks gestational age. Placenta praevia diagnosed on routine USS. Previous caesarean section with placenta accreta.

![Sagittal T2 weighted image](image)

**Fig. 5:** Case 2: 37 year old pregnant patient. 37 weeks gestational age. Placenta praevia diagnosed on routine USS. Previous caesarean section with placenta accreta. Sagittal T2 weighted image. The placenta (P) is low lying and covers the internal os completely (Red Arrows). The placenta is heterogeneous with flow voids, which are
low signal intensity on T2 (Yellow Arrows). There are multiple large vessels running through the centre of placenta. MRI findings are in keeping with a complete placenta praevia.

**References:** Radiology, St Bartholemew Hospital - London/UK

**Sagittal T2 weighted image.**

The placenta (P) is low lying and covers the internal os completely (Red Arrows). The placenta is heterogeneous with flow voids, which are low signal intensity on T2 (Yellow Arrows). There are multiple large vessels running through the centre of placenta. MRI findings are in keeping with a complete placenta praevia.

**Case 3**

38 year old pregnant lady, 37 weeks gestation. MRI obtained prior to delivery. Placenta praevia and placenta accreta diagnosed antenatally. Patient had prophylactic uterine artery embolisation, however had uterine rupture during delivery with post partum hemorrhage and required a total hysterectomy.
**Fig. 6:** Case 3: 38 year old pregnant lady, 37 weeks gestation. MRI obtained prior to delivery. Placenta praevia and placenta accreta diagnosed antenatally. Patient had prophylactic uterine artery embolisation, however had uterine rupture during delivery with post partum hemorrhage and required a total hysterectomy. Sagittal T2 weighted image. Large placenta completely covering (Red Arrow) the internal os of the cervix (Asterix). Generally thinned myometrium (Blue Arrows). Endocervical canal leading up to internal os of an engorged cervix (asterix), endocervical stroma present (between White Arrows). MRI findings are in keeping with a Type IV placenta praevia.

**References:** Radiology, St Bartholemew Hospital - London/UK

**Sagittal T2 weighted image.**

Large placenta completely covering (Red Arrow) the internal os of the cervix (Asterix). Generally thinned myometrium (Blue Arrows).

Endocervical canal leading up to internal os of an engorged cervix (asterix), endocervical stroma present (between White Arrows).

MRI findings are in keeping with a Type IV placenta praevia.
Fig. 7: Case 3: 38 year old pregnant lady, 37 weeks gestation. MRI obtained prior to delivery. Placenta praevia and placenta accreta diagnosed antenatally. Patient had prophylactic uterine artery embolisation, however had uterine rupture during delivery with post partum hemorrhage and required a total hysterectomy. Coronal T2 weighted image. Uterine bulge visible along the left lateral aspect (Yellow Arrows) raising the possibility of an invasive placenta.

References: Radiology, St Bartholemew Hospital - London/UK

Coronal T2 weighted image.

Uterine bulge visible along the left lateral aspect (Yellow Arrows) raising the possibility of an invasive placenta.

Case 4

31 year old pregnant patient. 28 weeks gestational age, continuous antepartum haemorrhage. Risk factors include previous placenta praevia and five previous
caesarean sections. MRI obtained whilst patient in labour, the internal os is open. Placenta accreta confirmed histologically.

**Fig. 8**: Case 4: 31 year old pregnant patient. 28 weeks gestational age, continuous antepartum haemorrhage. Risk factors include previous placenta praevia and five previous caesarean sections. MRI obtained whilst patient in labour, the internal os is open. Placenta accreta confirmed histologically. Sagittal T2 weighted image. There is a complete placenta praevia (Red Arrow) with the placenta overlying the os. The internal os (Asterix) and external os (Blue Arrow) of the cervix is open and there is soft tissue and haemorrhage within the dilated vaginal vault (White Arrows). This confirms that the patient is in labour. The lower anterior margin of the placenta is invading the myometrium (Yellow Arrows) but does not breach the full thickness of the myometrial muscle; MRI findings are consistent with a placenta praevia and placenta accreta.

**References**: Radiology, St Bartholemew Hospital - London/UK

**Sagittal T2 weighted image.**

There is a complete placenta praevia (Red Arrow) with the placenta overlying the os. The internal os (Asterix) and external os (Blue Arrow) of the cervix is open and there is soft
tissue and haemorrhage within the dilated vaginal vault (White Arrows). This confirms that the patient is in labour.

The lower anterior margin of the placenta is invading the myometrium (Yellow Arrows) but does not breach the full thickness of the myometrial muscle; MRI findings are consistent with a placenta praevia and placenta accreta.

**Case 5**

37 year old pregnant patient, 36 weeks gestational age. 3 previous caesarean sections. Sonographically diagnosed placenta praevia, high risk for placenta accreta therefore MRI obtained. Patient required bilateral iliac artery embolisation which obviated hysterectomy following a postpartum haemorrhage.

**Fig. 9**: Case 5: 37 year old pregnant patient, 36 weeks gestational age. 3 previous caesarean sections. Sonographically diagnosed placenta praevia, high risk for placenta accreta therefore MRI obtained. Patient required bilateral iliac artery embolisation which obviated hysterectomy following a postpartum haemorrhage. Sagittal T2
weighted image. Low lying placenta overlying the internal cervical os, in keeping with a placenta praevia. Multiple areas of heterogeneity and flowvoids within the placenta. The myometrium is thinned (White Arrows), the placenta invades through the full thickness of myometrial wall (Yellow Arrows) and anterior surface of the bladder wall (Blue Arrow). MRI findings consistent with a placenta praevia and placenta percreta with cervical and bladder wall invasion.

**References:** Radiology, St Bartholemew Hospital - London/UK

**Sagittal T2 weighted image.**

Low lying placenta overlying the internal cervical os, in keeping with a placenta praevia. Multiple areas of heterogeneity and flow voids within the placenta.

The myometrium is thinned (White Arrows), the placenta invades through the full thickness of myometrial wall (Yellow Arrows) and anterior surface of the bladder wall (Blue Arrow).

**Fig. 10:** Case 5: 37 year old pregnant patient, 36 weeks gestational age. 3 previous caesarean sections. Sonographically diagnosed placenta praevia, high risk for placenta...
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**References:** Radiology, St Bartholemew Hospital - London/UK

**Sagittal T2 weighted image.**

The placenta invades the posterior superior region of the cervical stroma (Yellow Arrow).

MRI findings consistent with a placenta praevia and placenta percreta with cervical and bladder wall invasion.

**Case 6**

41 year old patient, 28 days post partum MRI obtained for monitoring after placenta percreta left in situ. If there is deep invasion of the placenta or uncontrollable post partum haemorrhage the placenta can be left in situ and gradual resorption can occur.
**Fig. 11**: Case 6: 41 year old patient, 28 days post partum MRI obtained for monitoring after placenta percreta left in situ. If there is deep invasion of the placenta or uncontrollable post partum haemorrhage the placenta can be left in situ and gradual resorption can occur. Sagittal T2 weighted image. Post partum placenta praevia overlying the internal os of the cervix. Heterogeneous placenta (White Arrows). Myometrial thinning (Blue Arrow) with placenta invading through the full thickness of the myometrium (Yellow Arrow). MRI findings consistent with a placenta percreta post partum.

**References**: Radiology, St Barthelemew Hospital - London/UK

**Sagittal T2 weighted image.**

Post partum placenta praevia overlying the internal os of the cervix. Heterogeneous placenta (White Arrows). Myometrial thinning (Blue Arrow) with placenta invading through the full thickness of the myometrium (Yellow Arrow). MRI findings consistent with a placenta percreta post partum.
Fig. 12: Case 6: 41 year old patient, 28 days post partum MRI obtained for monitoring after placenta percreta left in situ. If there is deep invasion of the placenta or uncontrollable post partum haemorrhage the placenta can be left in situ and gradual resorption can occur. Sagittal T2 weighted image. High signal intensity on T2WIs; this is liquefaction of placental tissue which then fills with blood representing placental lakes (Red Arrows). MRI findings consistent with a placenta percreta post partum.

**References:** Radiology, St Bartholemew Hospital - London/UK

**Sagittal T2 weighted image.**

High signal intensity on T2WIs; this is liquefaction of placental tissue which then fills with blood representing placental lakes (Red Arrows).

**Case 7**

33 year old patient. 37 weeks gestational age. Low lying placenta diagnosed on routine antenatal sonography, high suspicion for accreta therefore MRI obtained. Placenta percreta diagnosed at caesarean section. The placenta was left in situ, over the series
of four images the placenta can be seen undergoing gradual involutional change and resorption.

Fig. 13: Case 7: 33 year old patient. 37 weeks gestational age. Low lying placenta diagnosed on routine antenatal sonography, high suspicion for accreta therefore MRI obtained. Placenta percreta diagnosed at caesarean section. The placenta was left in situ, over the series of four images the placenta can be seen undergoing gradual involutional change and resorption. Sagittal T2 weighted image (A). Gravid uterus. A low lying placenta (P) completely covers the internal cervical os and the anterior isthmic portion of the uterus, in keeping with placenta praevia. The placenta invades the cervical stroma (Yellow Arrows). Sagittal T2 weighted image (A). Undelivered placenta 1 month post partum. The low lying placenta covers the internal os. The endometrial cavity is distended with intermediate signal within it representing blood (Red Arrows). It contains a similar volume of pre delivery placental tissue.

References: Radiology, St Bartholemew Hospital - London/UK

Sagittal T2 weighted image.

(A)
Gravid uterus. A low lying placenta (P) completely covers the internal cervical os and the anterior isthmic portion of the uterus, in keeping with placenta praevia. The placenta invades the cervical stroma (Yellow Arrows).

**Sagittal T2 weighted image.**

(B)

Undelivered placenta 1 month post partum. The low lying placenta covers the internal os. The endometrial cavity is distended with intermediate signal within it representing blood (Red Arrows). It contains a similar volume of pre delivery placental tissue.

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to intermediate signal previously consistent with persistent involution. Sagittal T2 weighted image (B). Undelivered placenta 3 months post partum. Placenta (P) reduced in volume but still in situ overlying internal os of cervix (Asterix).

References: Radiology, St Bartholemew Hospital - London/UK

Sagittal T2 weighted image.

(A)
Undelivered placenta 2 months post partum. Persistent retention of low lying placenta. The placenta is now heterogeneous (White Arrows) and low signal intensity (Red Arrows) compared to intermediate signal previously consistent with persistent involution.

Sagittal T2 weighted image.

(B)
Undelivered placenta 3 months post partum. Placenta (P) reduced in volume but still in situ overlying internal os of cervix (Asterix).
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**Fig. 5:** Case 2: 37 year old pregnant patient. 37 weeks gestational age. Placenta praevia diagnosed on routine USS. Previous caesarean section with placenta accreta. Sagittal T2 weighted image. The placenta (P) is low lying and covers the internal os completely (Red Arrows). The placenta is heterogeneous with flow voids, which are low signal intensity on T2 (Yellow Arrows). There are multiple large vessels running through the centre of placenta. MRI findings are in keeping with a complete placenta praevia.

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**Fig. 13:** Case 7: 33 year old patient. 37 weeks gestational age. Low lying placenta diagnosed on routine antenatal sonography, high suspicion for accreta therefore MRI obtained. Placenta percreta diagnosed at caesarean section. The placenta was left in situ, over the series of four images the placenta can be seen undergoing gradual involutional change and resorption. Sagittal T2 weighted image (A). Gravid uterus. A low lying placenta (P) completely covers the internal cervical os and the anterior isthmic portion of the uterus, in keeping with placenta praevia. The placenta invades the cervical stroma (Yellow Arrows). Sagittal T2 weighted image (A). Undelivered placenta 1 month post partum. The low lying placenta covers the internal os. The endometrial cavity is distended with intermediate signal within it representing blood (Red Arrows). It contains a similar volume of pre delivery placental tissue.

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Case 7: 33 year old patient, 37 weeks gestational age. Low lying placenta diagnosed on routine antenatal sonography, high suspicion for accreta therefore MRI obtained. Placenta percreta diagnosed at caesarean section. The placenta was left in situ, over the series of four images the placenta can be seen undergoing gradual involutional change and resorption. Sagittal T2 weighted image (A). Undelivered placenta 2 months post partum. Persistent retention of low lying placenta. The placenta is now heterogeneous (White Arrows) and low signal intensity (Red Arrows) compared to intermediate signal previously consistent with persistent involution. Sagittal T2 weighted image (B). Undelivered placenta 3 months post partum. Placenta (P) reduced in volume but still in situ overlying internal os of cervix (Asterix).
Conclusion

Radiologists play a pivotal role in the diagnosis and management of invasive placenta. Timely diagnosis of placental implantation abnormalities is essential to avoid catastrophic pre and postpartum hemorrhage with ultrasound serving as the first line modality for placenta praevia and MRI reserved for equivocal cases, those with posterior placentas and for assessment of depth of invasion and pelvic organ involvement.
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