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Nonfetal Imaging During Pregnancy: Placental Disease

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KEYWORDS

• Hemorrhage • MR imaging • Placenta • Ultrasound • Placenta accreta spectrum disorder • Placental masses • Placenta previa • Abruption

KEY POINTS

- Placenta is a vital organ connecting the maternal and fetal circulations.
- Placenta accreta spectrum disorders and placental masses are the most common indications for dedicated placental imaging with ultrasound or MR imaging.
- Placental accreta spectrum disorders present with characteristic imaging findings of irregular lakes, myometrial thinning, abnormal intraplacental vascularity, and placental bulge on ultrasound and MR imaging. Imaging is helpful in assessing the extent of involvement and presurgical planning.
- Antepartum hemorrhage is an important cause of maternal and fetal morbidity and mortality, and most of the cases are due to placenta abnormalities including placenta previa and placental abruption. MR imaging can help distinguish hematomas from other causes of antepartum bleeding, such as vasa previa, degenerated uterine fibroid, cervical pathology, and placental tumors.
- Placental masses are most commonly identified during the routine fetal ultrasound examinations. Imaging evaluation should focus on the effect of the mass on fetal well-being in this scenario.

INTRODUCTION

Placenta is a vital organ that allows exchange of nutrients and gases between the mother and the developing fetus.[1] The placenta develops by 10 to 14 weeks of pregnancy and is fully functional by the end of the first trimester to support the hormonal needs of continuing the pregnancy and the metabolic needs of the developing fetus. As such, disease states that affect the placenta can have important consequences for both the mother and the fetus.[1,2]

Ultrasound (US) is the first line of imaging for most placental diseases. Per guidelines, all pregnancies should have an "anatomy scan," also called as a level one scan, at 18 to 20 weeks of gestation.[3] Although most of this scan focuses on assessing the anatomic development of the fetus, evaluating the placenta is a crucial component of this examination.[3] MR imaging has an increasingly important role as an adjunct modality for imaging for placental disease processes as well and can be particularly helpful for troubleshooting and advanced evaluation.[4,5]

The most common placental pathologies for which imaging is necessary include placenta accreta spectrum disorders (PASD) and placental masses. Both processes are relatively uncommon; however, the adverse consequences to both the fetus and the mother are substantial and hence should be specifically sought after and never overlooked. This review addresses the normal anatomy of the placenta, imaging technique and protocols, imaging findings and summarizes the key information that needs to be conveyed to the clinical providers.

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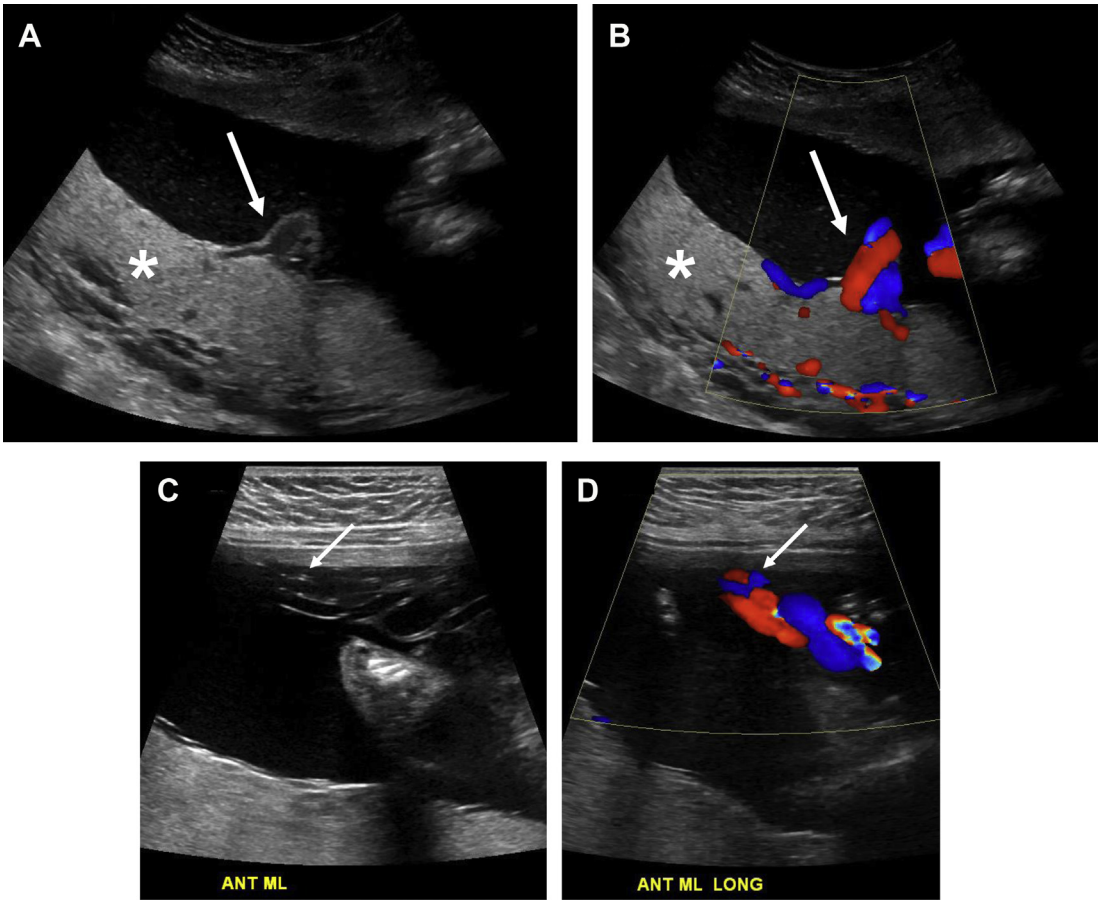

Fig. 1. Different types of cord insertion. (*A*) Grayscale and (*B*) color Doppler images demonstrate central cord insertion (*arrow*) to posterior placenta (*asterisk*). (*C*) Transabdominal grayscale and (*D*) color Doppler images demonstrate cord insertion into the chorioamniotic membranes and uterus away from the placenta (*arrow*). The cord travels within the membranes toward the placenta diagnostic of a velamentous cord insertion. (*E*, *F*) When fetal MR imaging is performed for other reasons, cord insertion may be easily detectable as on these coronal T2-weighted images demonstrating velamentous cord insertion (*arrow*) into the uterus and the cord traveling in the fetal membranes (*short arrows*) toward the placenta. (*G*, *H*) Transabdominal grayscale and color Doppler images demonstrate marginal cord insertion at the edge (*arrow*) of the posterior placenta (*asterisk*).

NORMAL ANATOMY AND IMAGING TECHNIQUE

The normal placenta is a discoid structure with tapering edges, which attaches to the myometrium in a uniformly layering fashion. It measures up to 4 cm in maximum thickness. The umbilical cord mostly inserts centrally into the placenta but can be marginal or velamentous as well (**Fig. 1**). Normally, the lower placental edge should be at least 2 cm from the margin of the internal cervical os.[6] If less than 2 cm from the internal os, this counts as placenta previa. When the placenta covers the internal os, this constitutes complete previa (**Fig. 2**). Sometimes, variant anatomy such as succenturiate lobe (portion of the placenta separate from the main placental mass) and vasa previa (**Fig. 3**) are present, which are extremely important to detect and relay to the clinicians because of the risk of retention of this lobe during delivery and both conditions being at high risk for significant hemorrhage.[7]

The normal placenta is homogeneous, slightly hyperechoic relative to the myometrium on grayscale US (**Fig. 4**).[1] On high-frequency and high-resolution images, the placenta may seem slightly less hyperechoic and overall the myometrium seems more closer in echogenicity to the placenta. Hence, this relative difference in echogenicity is based on sonographic technical parameters (see **Fig. 4**). Very few lakes may be present, especially adjacent to the placental cord insertion.[8] On color Doppler imaging, few

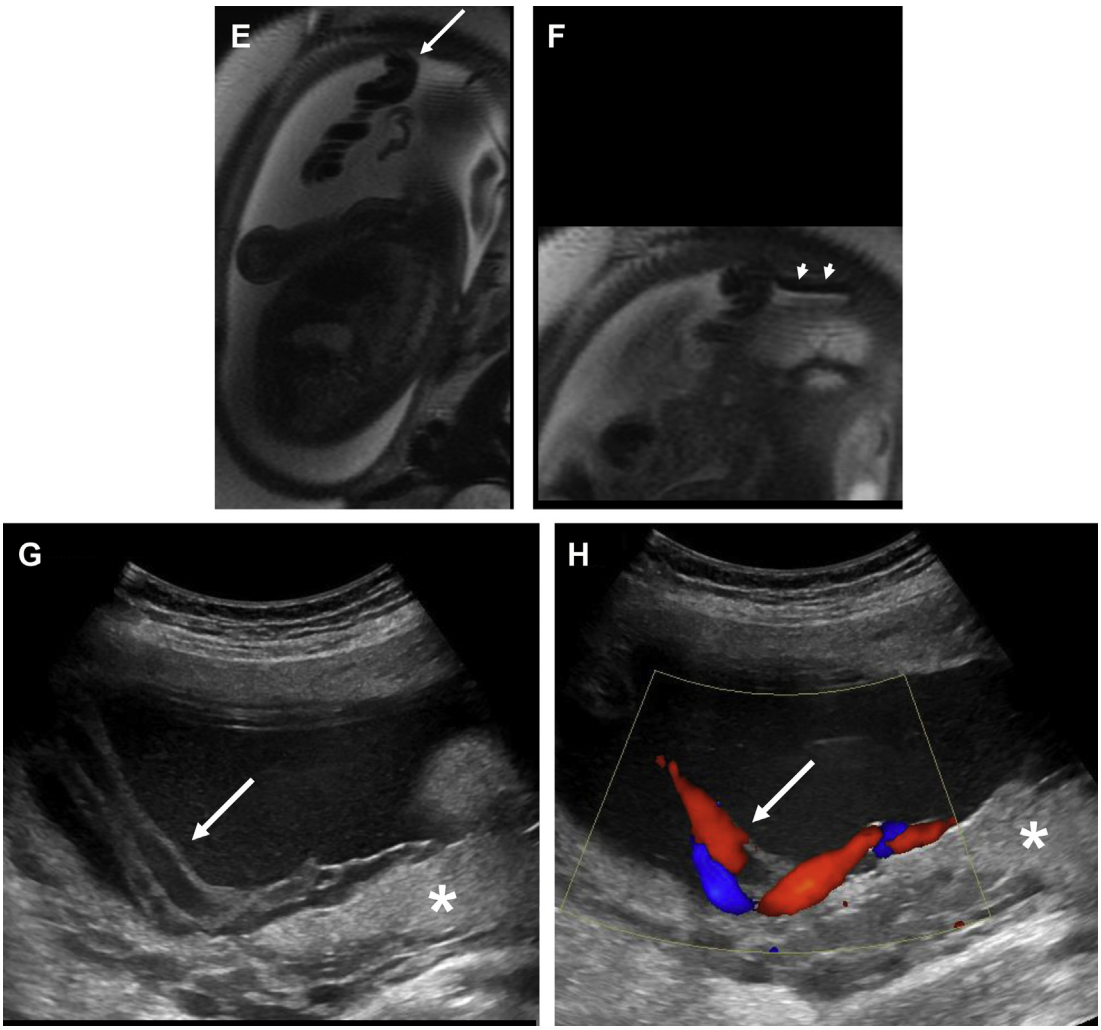

Fig. 1. (*continued*)

small caliber intraplacental vessels and subplacental vascularity can be seen.[8] On MR imaging, placenta is mostly isointense to the myometrium on T1-weighted images and hyperintense to the myometrium on T2-weighted (T2W) images (**Fig. 5**). Sometimes, the pregnant uterus can develop vascular congestion, in which case the myometrium demonstrates T2-hyperintense appearance. In such cases, the placenta relatively seems iso- to hypointense to the myometrium (see **Fig. 5**). With increasing gestational age, structure of the cotyledons becomes more apparent and results in decreased signal intensity to intermediate signal intensity compared with the surrounding myometrium (**Fig. 6**).[9,10] First and second trimester placentas are very homogeneous in their appearance but with development of this lobular pattern, the placenta becomes less homogeneous in appearance, as thin hypointense septa become apparent between the lobules on T2W images (see **Fig. 6**). Placental septa and cotyledons are more often visible when MR imaging is performed with a 3 T system.[7]

The placental-myometrial interface is demonstrated as a retroplacental clear space on US and as T2-hypointense interface on MR imaging. Given the isointensity of the placenta to the myometrium on T1-weighted images, the interface is not well seen and is best evaluated on T2W sequences. The normal subplacental vascularity can be seen as multiple flow voids in this subplacental space. A few flow voids can be present within the placenta adjacent to the umbilical cord insertion. The myometrium has a variable thickness and thins as the pregnancy progresses. The underlying myometrial wall thins as the pregnancy advances, and

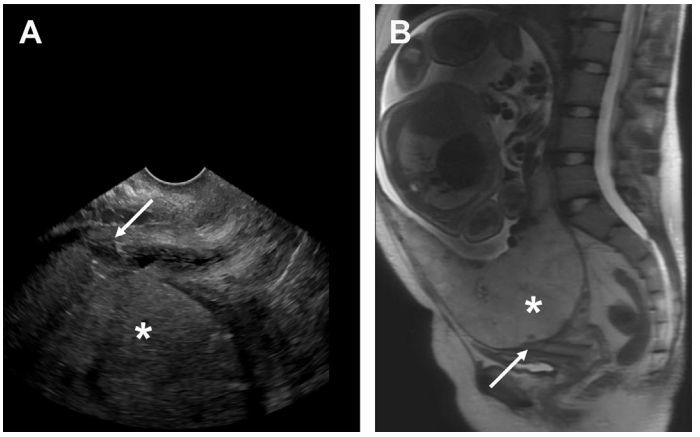

Fig. 2. Complete placenta previa. (*A*) Endovaginal image of placenta (*asterisk*) completely covering internal os (*arrow*). (*B*) Sagittal T2-weighted MR image demonstrates placenta (*asterisk*) completely covering the internal os (*arrow*).

this finding alone does not imply PASD.[11] The myometrium naturally thins at sites of compression, such as adjacent to the maternal spine and aorta, appearing as a single thin layer of uniform signal on T2W images. In addition, the myometrium is expected to thin as the gestation progresses, especially at the site of previous scars.[12]

IMAGING PROTOCOLS

Ultrasound

US images should evaluate the entire placenta, and images should be acquired documenting that the entire placenta has been evaluated. Grayscale as well as Doppler imaging should be used. Based on body habitus and depth of the placenta, evaluation with a curvilinear 2 to 6 Megahertz (mHz) and 9 mHz linear transducers can be performed.[13,14] In all pregnancies, placenta should be evaluated for the location of implantation, proximity to the cesarean section scar (if applicable), placenta previa or vasa previa, succenturiate lobe, and shape and thickness of the placenta. After this general evaluation, particularly in patients with history of uterine intervention such as cesarean section, myomectomy, embolization, or Asherman syndrome, attention should be drawn to specific findings of PASD such as placental heterogeneity, irregular lacunes or placental lakes, loss of retroplacental clear space/subplacental lucency, myometrial thinning, abnormal subplacental and intraplacental vascularity, placental bulge, and extrauterine invasion (such as that into the bladder or the parametrium). Studies have shown improved patient outcomes when targeted evaluation of the placenta is performed in patients with suspected PASD.[15] Details of these findings are discussed later in this article. In addition, with placental evaluation, it is imperative to evaluate the area of the internal os with color Doppler imaging to evaluate for any aberrant vessels at this location. If any vessels are present, they can be further evaluated with spectral Doppler to look for their maternal versus fetal origin, based on heart rate observations. Vessels demonstrating arterial waveforms at fetal heart rate are highly suspicious for vasa previa.

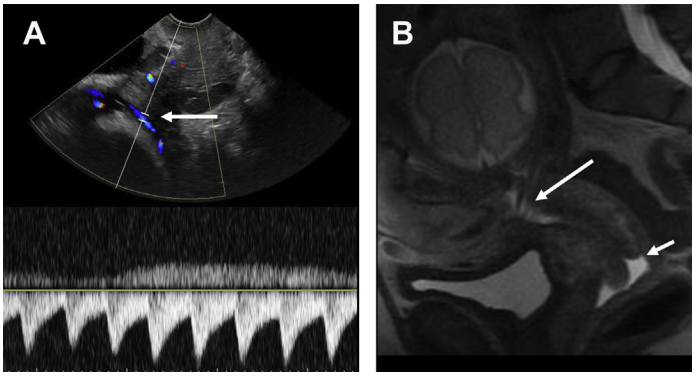

Fig. 3. Vasa previa. (*A*) Endovaginal image demonstrates a crossing vessel over internal os (*arrow*) with fetal heart rate diagnostic of vasa previa. (*B*) MR imaging sagittal ssFSE performed on the same day correlated with this finding (*arrow*). Patient had ruptured membranes, and fluid around the vessels outlined the finding. Fluid is seen in the upper vagina from ruptured membranes (short *arrow*). ssFSE, single-shot fast spin echo.

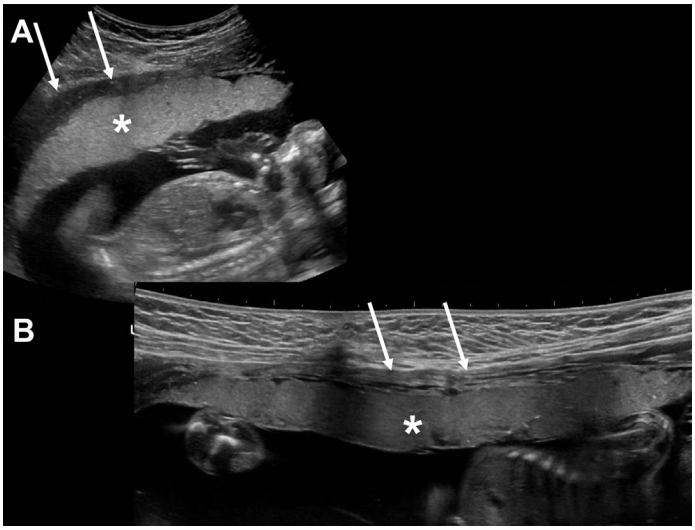

Fig. 4. Normal sonographic appearance of the placenta. (*A*) Transabdominal US demonstrated homogeneously hyperechoic second trimester placenta (*asterisk*) in relationship to hypoechoic myometrium (*arrows*). (*B*) High-resolution image performed with a linear transducer shows the normal placenta (*asterisk*) to be slightly less hyperechoic, and the myometrium (*arrows*) does not seem as hypoechoic in comparison to the placenta. The overall relative signal of these structures depends on imaging parameters.

MR Imaging

The authors' institutional MR imaging protocol for placental imaging is summarized in **Table 1**. In brief, a combination of T2 (not fat suppressed) and T1 images are necessary. Most of the findings for PASD and placental masses are evident on nonfat-suppressed T2W images. T1 images are essential to evaluate for intrinsic hyperintensity secondary to hemorrhage in PASD and to detect the presence of fat in placental masses. Occasionally, fat-suppressed T1 images may be needed, when evaluating for the presence of fat in placental masses. The role of diffusion-weighted imaging in placental imaging is still evolving. In the author's experience, DWI is particularly helpful in cases with severe myometrial vascular congestion, to help delineate the placental-myometrial interface. In this scenario, the placenta demonstrates hyperintensity, whereas the myometrium does not and hence making their interface better visualized. Technical details of MR imaging for the placenta are summarized in Michael A. Ohliger and Hailey H. Choi's article, "Imaging Safety and Technical Considerations in the Reproductive Age Female," in this issue.

IMAGING FINDINGS/PATHOLOGY

Placenta Accreta Spectrum

PASD is a spectrum of disorders where the placenta adheres to the underlying myometrium and hence does not separate at the time of delivery, leading to massive hemorrhage, which can be life threatening to the mother. The spectrum includes accreta (where the placenta is attached directly to the myometrium, without intervening decidua), increta (with myometrial invasion), and percreta, where the placenta extends outside the uterine serosa and possibly into adjacent organs such as the bladder and the parametrium. International Federation of

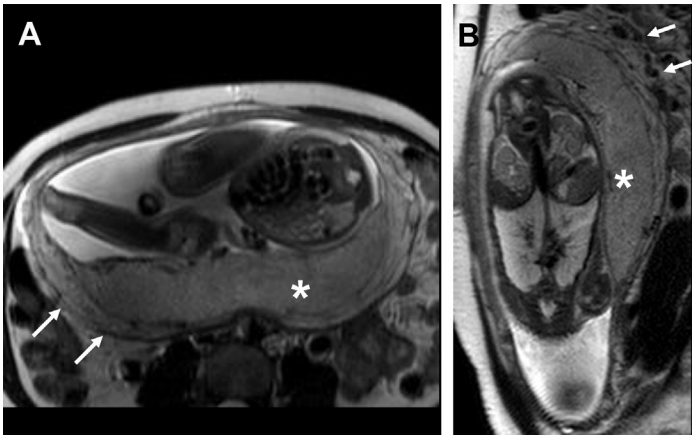

Fig. 5. Normal MR imaging appearance of the placenta. (*A*) Sagittal and (*B*) axial T2W MR images in second trimester demonstrate a homogeneous placenta (*asterisk*), slightly hyper to isointense to myometrium (*arrows*). The signal of myometrium varies on T2W images that depend on the degree of physiologic vascular engorgement. As seen in (*B*), numerous flow voids may be present in the physiologically engorged myometrium (*arrows*).

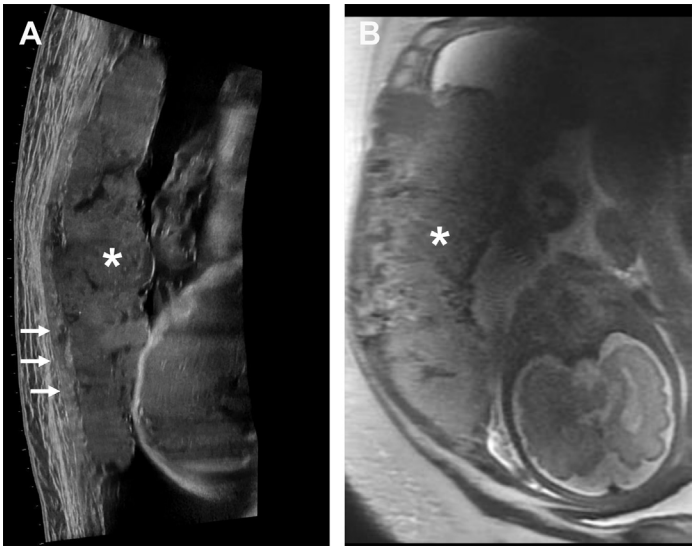

Fig. 6. Normal appearance of a "mature" placenta in late gestation. (*A*) Transabdominal image performed with high-resolution linear transducer of a patient in the third trimester demonstrates the placenta (*asterisk*) to be hyperechoic relative to the myometrium (*arrows*) and overall more heterogeneous in appearance. (*B*) Sagittal T2W MR image in a patient in her third trimester demonstrates the placenta (*asterisk*) to be more heterogeneous in signal as well.

Gynecology and Obstetrics has proposed a combined clinical-pathologic classification, which includes both intraoperative observations as well as findings on gross pathology.[16] Often relying on pathology alone can lead to erroneous estimation of the severity of the findings, leading to this combined system.[16] No single imaging feature has been shown to be diagnostic for PASD, and usually a combination of multiple findings exists, alerting the reviewers to the correct diagnosis.

Ultrasound

On US some of the commonly reported signs are the presence of multiple placental lakes with irregular margins (**Fig. 7**), the loss of retroplacental clear space, between the placenta and the myometrium (see **Fig. 7**), and presence of placenta previa (see **Fig. 7**). Other features include heterogeneous placenta, asymmetry of placental thickness, myometrial thinning, bladder wall interruption, myometrial, and bladder wall hypervascularity (see **Fig. 7**).

Prominent placental lacunes This is the most commonly reported US finding of abnormal placentation, which is present irrespective of the depth of invasion (see **Fig. 7**).[14,17] Placental lacunes are vascular anechoic or hypoechoic structures located within the center of the cotyledons. Although a few of these are often present in normal placentae, imaging findings of PASD represent a spectrum of worsening appearance, as they become larger, irregular, and concentrated in the area of invasion and can demonstrate slow internal flow on real-time imaging.[14,17] These are also often referred as "placental lakes" and give the placenta the classic "moth-eaten" appearance.[14,17]

Loss of retroplacental clear space The normal placental-myometrial interface seems hypoechoic on gray-scale US, which represents the normal decidua basalis. With PASD, this clear space is obliterated (see **Fig. 7**),[13,17–19] and approximately 70% of cases will show this finding.[17] In some cases, this area can have prominent subplacental vascularity.

Myometrial thinning In cases of PAS, myometrium may be thinned to submillimeter levels and actually becomes undetectable in more severe cases (see **Fig. 7**).[14,17] It is reported to occur in about 50% of cases, which may be reflective of US changes that happen at the more invasive end of the spectrum.[14,17]

Placental bulge sign With deeper depths of invasion, the placenta may bulge outward, creating an hourglass or snowman configuration of the uterine contour. Along with myometrial thinning, this finding highly suggests myometrial invasion (**Figs. 8** and **9**).

Bladder wall interruption Bladder wall interruption is defined as the interruption of the hyperechoic fat plane between the uterus and the bladder, which can involve the bladder wall and extend into the bladder lumen in the most severe cases.[14,20,21] Prominent vessels may be identified at the bladder wall, but these are not specific for invasion (see **Fig. 7**).[14] Spectral interrogation of these vessels can be performed, and if fetal heart

Table 1
MR imaging protocol for placental imaging at 3 T

	Coverage	TR	TE	Flip	NEX	Slice	Matrix	FOV	Phase	Oversample
Patient should drink water before commencing study										
Coronal, axial, and sagittal single-shot fast spin echo (ssFSE)	Uterus to below cervix	2000	100	X	X	4/0	384x256	36	R > L	PE FOV 1.0
Axial LAVA FLEX or mDIXON DUAL ECHO	Center over the placenta	4.2	1.2	15	1	3/0	260x256	34	A > P	PE FOV 1.1
Coronal ssFSE (nonpropeller)	High-resolution imaging (reduced field of view), center over the placenta	2000	100	X	X	4/0	384x256	26–28	R > L	PE FOV 1.0
Axial T2 FSE (nonpropeller)	No fat saturation, high-resolution imaging (reduced field of view), center over the placenta	4000	120	120	2	4/0	320x256	24	R > L	NPW
Sagittal T2 FSE propeller	No fat saturation, high-resolution imaging (reduced field of view), center over the placenta	11,000	74		2	4/0	256x256	24		
Axial and sagittal diffusion-weighted imaging (DWI)	Multiple b-values of 0, 50, 500, 1000: ADC maps Routine field of view	5000	30.5		2	6/0	80x80	34		PE FOV 1

Abbreviations: ADC, apparent diffusion coefficient; FOV, field of view; NEX, number of excitations; TE, the echo time; TR, the repetition time.

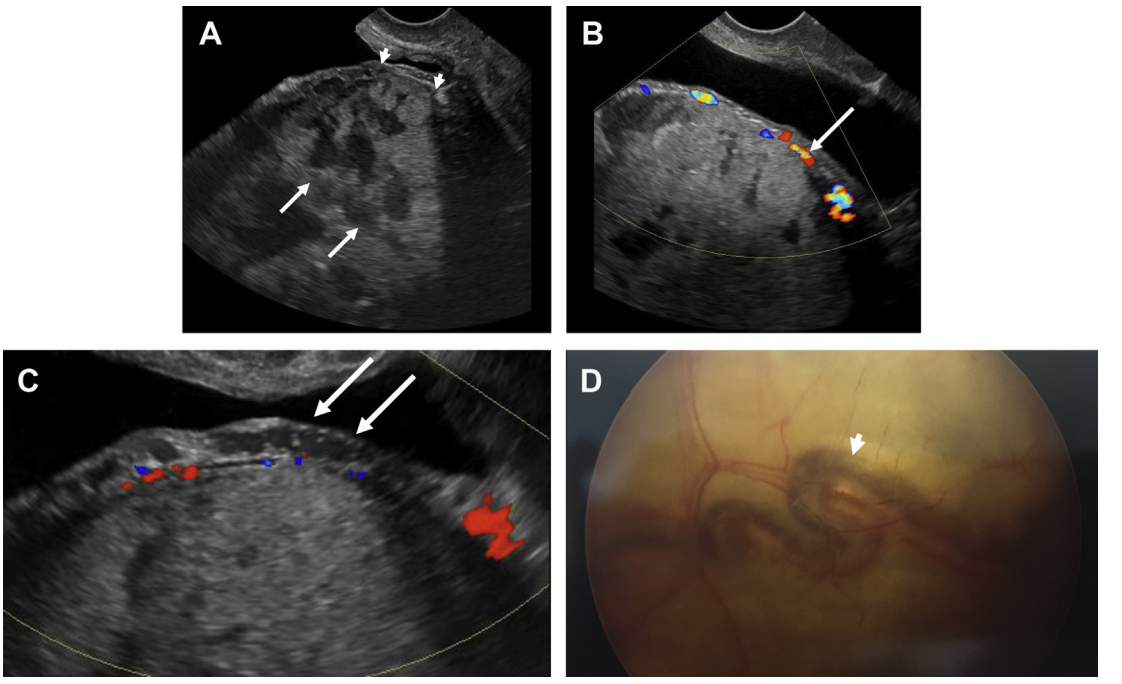

Fig. 7. US features of placenta accreta spectrum (PAS). (*A*) Endovaginal grayscale image demonstrates complete placenta previa with multiple placental lakes with irregular margins (*arrows*) and loss of retroplacental clear space (*short arrows*). (*B*) Endovaginal image with color Doppler demonstrates loss of retroplacental clear space and increased retroplacental vascularity (*arrow*). (*C*) Endovaginal image demonstrates extensive bladder wall hypervascularity (*arrows*). (*D*) Intraoperative cystoscopy image obtained during delivery demonstrates prominent submucosal vascularity (*arrowhead*).

rate can be demonstrated, it highly suggests bladder invasive PASD.

Asymmetric thickness Invasive placentas often appear thickened in the portion implanted on the cervix, and overall the placental thickness is increased in the areas involved by PASD.[22]

MR imaging

MR imaging is now recognized for its strengths in assessment of invasive placentation.[4] MR imaging provides supplemental knowledge in addition to US, particularly in cases of posterior and lateral invasion, areas that may be technically challenging for US imaging[23,24] (see **Fig. 8**). At the authors' institution, any patient with suspicion for

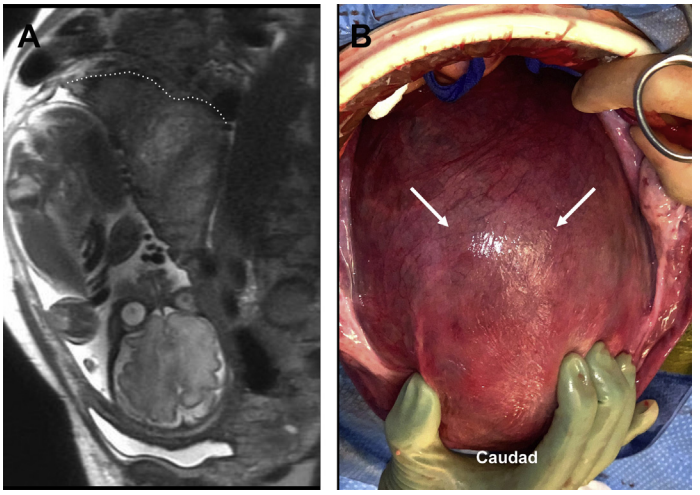

Fig. 8. MR imaging appearance of placenta accreta spectrum. (*A*) Sagittal T2W image demonstrates posterior placenta with bulge (*dotted line*) into the myometrium. (*B*) During the surgery a subtle blue bulge was noted on the posterior uterus (*arrows*). Cesarean hysterectomy specimen confirmed placenta increta on pathology.

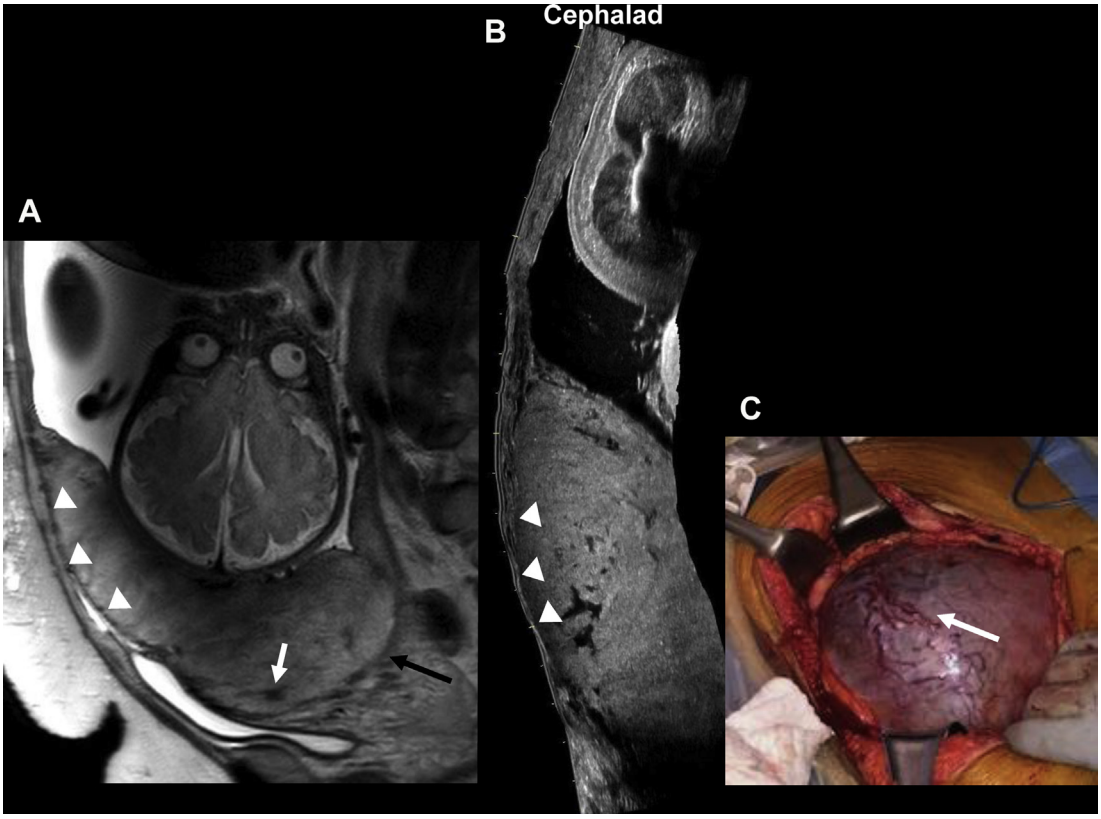

Fig. 9. MR imaging appearance of placenta accreta spectrum with intraoperative correlation. (*A*) Sagittal T2W MR image demonstrates complete placenta previa (*black arrow*) with bulging of lower uterine segment and barely visible retroplacental myometrium (*arrowheads*). T2-dark bands are present in the placenta (*white arrow*). (*B*) Intraoperative US confirms the bulge and retroplacental thinning of myometrium (*arrowheads*). (*C*) Intraoperative picture demonstrates a uterine bulge with blue tinge (*arrow*) corresponding to imaging findings. Gross pathology confirmed placenta increta.

invasive placenta based on US findings undergoes MR imaging of the placenta and uterus.[23,24] If normal placentation is confidently diagnosed with US, patients may not be referred for additional imaging. Although MR imaging has similar overall sensitivity and specificity to US, it has been shown to have a high predictive accuracy in assessing both the depth and topography of placental invasion.[4] It has also been beneficial in cases with clinical suspicion for accreta and discordant US findings and in cases in which percreta is suspected.[23] MR imging is also helpful for surgical planning. Knowing the location of the placenta and its relationship to cervix, bladder, and pelvic sidewall allows for preoperative planning for stents, embolization, and extent of dissection anticipated. Recent work by Bourgioti and colleagues[25,26] has demonstrated MR imaging to be capable of assessing extrauterine spread as well as predict adverse maternal and neonatal outcomes. Similar to US, myometrial thinning, asymmetric placental thickening, and bladder wall interruption are also present on MR imaging. Most commonly reported MR imaging findings for PASD, in addition to findings recognized on US, are described below.

T2-dark bands Dark intraplacental bands are linear or polygonal areas of very low signal intensity on T2W images (see **Fig. 9**).[12,27] They can be of variable thickness with a maximum diameter ranging from 6 mm to 20 mm or more and are thought to represent areas of fibrin deposition due to repetitive intraplacental hemorrhage or infarcts.[4,12,27–29] Small intraplacental dark bands may occasionally be noted in mature noninvasive placentas (>30 weeks of gestation), typically on the fetal surface of the placenta, whereas the abnormal T2-dark bands usually contact the maternal surface of the placenta.[30] This feature is considered one of the most consistent abnormal MR imaging findings in patients with PASD.[6,25,28–31]

Placental bulge sign One of the most commonly reported MR imaging signs of PASD is abnormal uterine bulging. When an abnormal placenta implants in the lower uterine segment, the uterus develops an hourglass or snowman configuration, rather than the typical inverted pear shape (see **Figs. 8** and **9**). This finding is best seen in coronal and sagittal images but can be seen on axial images too when the bulging is lateral in location.[11,30,32] The presence of uterine bulging has been shown to be associated with deeper depths of invasion.[6,27,32–34] The investigators have noted the presence of the bulge in patients with increta[5] as well as placenta percreta[35] on MR imaging.

Loss of retroplacental T2-hypointense line The hypointense interface between placenta and myometrium on T2W images corresponds to the retroplacental hypoechoic zone described in obstetric US and is best seen on T2W sequences.[12] This interface is lost in cases of PASD. This finding is usually present along with focal myometrial defects and thinning.[31] In cases of placenta percreta, placental tissue can be seen extending through the myometrium with disruption of this T2-hypointense line.[36]

Myometrial thinning Myometrium can be thinned at the placental attachment to less than 1 mm in thickness and even essentially becomes imperceptible with PASD.[37] This is also best assessed on T2W sequences.[11,38,39] However, because there is some expected thinning of the myometrium as pregnancy progresses, myometrial visualization becomes difficult as the pregnancy progresses.[11,12] When the myometrium is well demonstrated, focal interruptions of the wall are seen at sites of invasion with placental tissue extending through the breach in case of percreta (**Fig. 10**).[4,33,40]

Abnormal intraplacental vascularity and subplacental vascularity Abnormal vessels are located in the placental parenchyma along with a prominent network of vessels in the placental bed with disruption of the uteroplacental interface in cases of PASD. These vessels may extent to the underlying myometrium, can reach up to the uterine serosa, and may be accompanied by extensive neovascularization around the bladder, uterus, and vagina. A novel "stripped fetal vessel" sign has been proposed, which refers to a large caliber intraplacental vessel that travels between the fetal and maternal placental surfaces without change in caliber.[41]

The term "placental bed" refers to that part of the decidua and adjacent myometrium that underlies the placenta and whose primary function is the maintenance of an adequate blood supply to the intervillous space of the placenta.[42] Although it is common to see flow voids here even in normal pregnancies, in PASD these vessels are seen to directly enter the placenta and can even course up to the umbilical cord insertion.

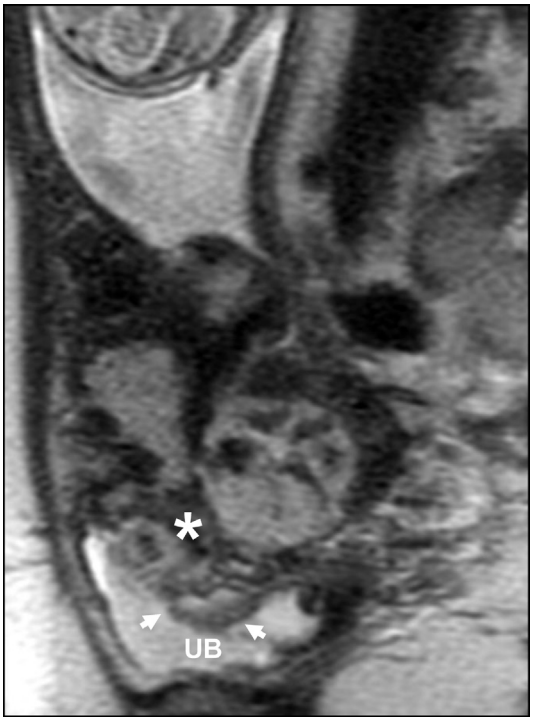

Fig. 10. MR imaging appearance of placenta accreta spectrum with placenta percreta. T2W sagittal image demonstrates extremely heterogeneous placenta (*asterisk*) invading (*short arrows*) into the lumen of urinary bladder (UB).

PLACENTAL ABRUPTION

Placental abruption represents premature separation of the placenta from the uterine wall. Although rare (affecting <1% of pregnancies), third-trimester abruption is associated with an increased risk of preterm delivery and fetal death. Imaging appearance of placental abruption can be classified based on the location of the hematoma as retroplacental, marginal subchorionic, preplacental, and intraplacental (**Fig. 11**).

US is frequently performed to confirm the presence of abruption and assess the extent of subchorionic or retroplacental hematoma.[43] However, in up to 50% of cases of abruption US is negative for different reasons: (1) acute hemorrhage echo texture is very similar to that of the adjacent placenta and is therefore very

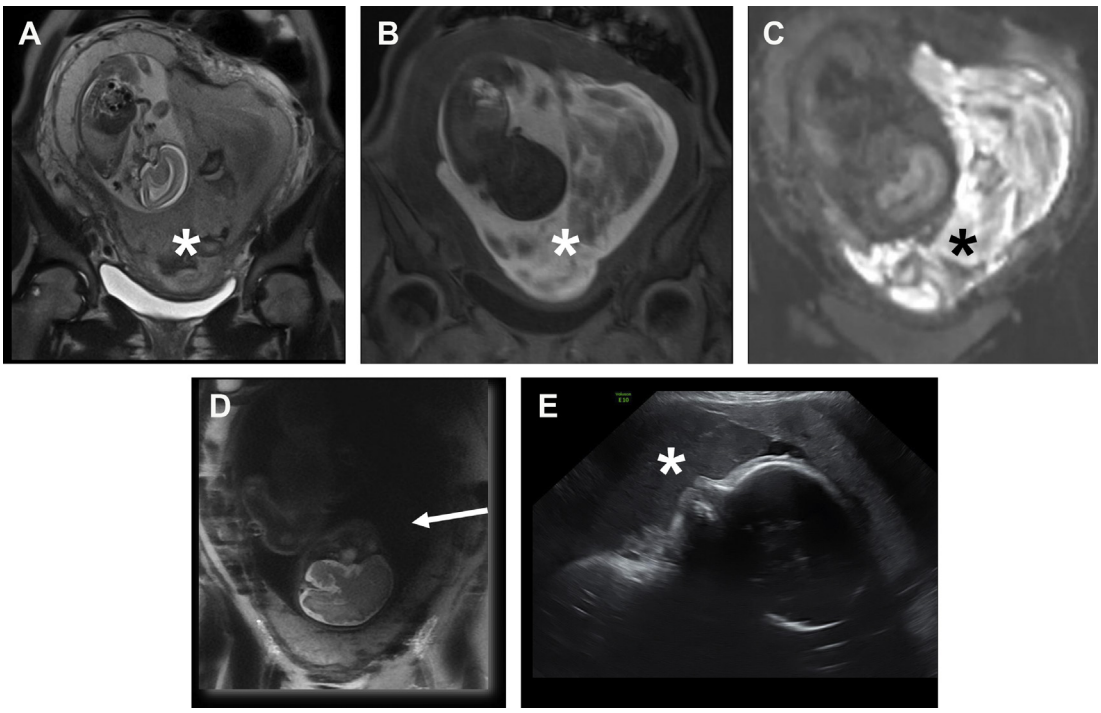

Fig. 11. Coronal MR (*A*) T2-weighted, (*B*) T1-weighted, and (*C*) DWI demonstrate hyperacute placental abruption (*asterisk*) with intermediate signal intensity on T2-weighted images, high signal intensity on T1-weighted images, and reduced diffusion on high B-value images. (*D*) In a different patient, hemorrhage can be of very low signal intensity on T2-weighted images as seen on this case of intraamniotic hemorrhage of subacute chronicity (*arrow*). (*E*) Corresponding transabdominal US demonstrates diffuse echoes throughout the amniotic sac, correlating to large amount of intraamniotic hemorrhage (*asterisk*).

difficult to detect; (2) the imaging appearance of an abnormally thick and heterogeneous placenta is rare, being present only in large acute clots; and (3) many subacute clots result in falsely negative because blood dissects out from beneath the placenta and drains through the cervix.[44,45] MR images have intrinsic high soft tissue contrast and can accurately depict placental-related hemorrhage with a reported high sensitivity of 95% to 100% and high specificity of 100%.[45] By considering the signal intensity changes on T1-weighted, T2W, and diffusion-weighted images, with special reference to the paramagnetic effects of methemoglobin, it is possible to estimate the age of the bleeding (see **Fig. 11**).[46] Hyperacute hemorrhage is usually hyperintense on T2W and diffusion-weighted images, being iso- to hypointense on T1-weighted images (see **Fig. 11**).[46] Acute hemorrhage remains iso- to hypointense on T1-weighted images but now becomes hypointense on T2W and diffusion-weighed images.[46] Subacute hemorrhage is T1-hyperintense due to presence of methemoglobin. Chronic hemorrhage is hypointense on all T1-weighted, T2W, and diffusion-weighted images.[46]

PLACENTAL MASSES

Uncommonly, the placenta can develop masses, the most common of which is a chorioangioma. Broadly, placental masses can be classified as nontrophoblastic or trophoblastic in origin.[47] Trophoblastic masses include molar pregnancy, intraplacental choriocarcinoma, and complete hydatidiform mole with twin fetus. Nontrophoblastic masses include chorioangioma, placental teratoma, and placental mesenchymal defect.[47] Placenta can get metastases from maternal primaries such as lung and breast cancer but also fetal malignancy such as neuroblastoma.[47]

Nontrophoblastic Placental Masses

Chorioangioma

The most common nontrophoblastic mass to develop in the placenta is a chorioangioma.[47] As the name suggests, this is a benign proliferation of the vascular channels supported by chorionic stroma.[48] Interestingly, these masses occur at an unusual frequency in higher altitudes, and hypoxic origin of these masses has been postulated.[48] Most of these masses are small and

asymptomatic, being incidentally identified on US performed for fetal well-being. The masses are contiguous with fetal circulation, and resultant arteriovenous shunting within the placenta can be linked to several pregnancy complications, including fetal anemia, thrombocytopenia, nonimmune fetal hydrops, polyhydramnios, antepartum hemorrhage with premature placental detachment, preterm labor, intrauterine fetal growth restriction (IUGR), and increased perinatal mortality.[48]

On US, chorioangiomas appear as echogenic masses, which are characteristically located adjacent to the placental cord insertion and protrude into the amniotic cavity (**Fig. 12**). On Doppler interrogation, internal vascularity pulsating at fetal heart rate can be demonstrated, which is a hallmark for this diagnosis.[48] Larger masses start developing cystic areas and can even cause chorioamniotic separation, secondary to profuse mucin secretion (see **Fig. 12**).[47] Once diagnosed, careful assessment for polyhydramnios and fetal anemia using middle cerebral arterial Doppler assessment should be performed. On MR imaging, these masses are isointense to the placenta on T1-weighted images and are heterogeneous being mostly hyperintense to the placenta on T2W images (see **Fig. 12**).[47] Intrinsic T1 hyperintensity can develop at the periphery of the tumor related to hemorrhage.

Placental teratoma

Teratomas are extremely rare benign tumors of the placenta with a very favorable outcome. These masses include components from all 3 germ cell lines and always lie between the amnion and the chorion, usually on the fetal surface of the placenta.[49] The sonographic and MR imaging findings include demonstration of tissues of variable echogenicities or signal intensities demonstrating intratumoral fat, calcifications, and fluid.[50] On US, fat in a teratoma is hyperechoic to the normal placenta, whereas intratumoral calcifications are echogenic and demonstrate shadowing.[50] Gestational trophoblastic disorders can too present as hyperechoic masses but are unlikely to demonstrate calcification.[50] One of the major differentials for a teratoma includes a fetus acardiac amorphous (*fetus in fetu*). This entity demonstrates well-formed elements such as partial or complete formation of a vertebral column, ribs, pelvis, and skull base and sometimes a short umbilical cord may be present connecting this to the placenta.[50]

Placental mesenchymal defect

Placental mesenchymal defect (PMD) is a rare vascular anomaly of the placenta presenting as placentomegaly, multicystic mass, and villous hyperplasia.[51] Although this finding may be completely incidental, preterm delivery, IUGR, fetal anomalies (such as fetal liver cysts or vascular malformations), fetal overgrowth with Beckwith-Wiedemann syndrome, and even fetal demise have been associated with this abnormality.[51,52] Sonographic features include a multicystic mass, which can closely mimic a partial mole appearing given the presence of an enlarged placenta with multiple cystic masses (**Fig. 13**).[53] Differentiation from a molar pregnancy is important for appropriate management so that the pregnancy is not erroneously terminated. On color Doppler imaging, some of these cystic spaces demonstrate slow color flow, also called as a "stained-glass" appearance to the placenta (see **Fig. 13**).[54] In early pregnancy, lack of flow or slow flow can help differentiate PMD from chorioangioma and molar pregnancies, but this distinction can be difficult in later trimester due to overall increased flow to the placenta. MR imaging also shows corresponding findings of thickened placenta with multiple cystic spaces (see **Fig. 13**). Ultimately, chromosomal abnormality helps differentiate these entities, with PMD usually having a 46 XX karyotype, where partial moles are triploid.[47]

Trophoblastic placental masses

Trophoblastic masses include hyaditiform mole and intraplacental choriocarcinoma. Unusual cases such as complete hyaditiform mole with coexisting twin live fetus can also mimic a placental mass. All the masses on the trophoblastic spectrum are associated with disproportionally elevated beta-human chorionic gonadotropin (β-hCG) levels.

Intraplacental choriocarcinoma This is a rare variant of the choriocarcinoma spectrum, which is known to be associated with massive fetomaternal hemorrhage, likely due to villous erosion by the growing tumor, leading to fetal anemia and eventual fetal demise.[55] It should be considered in the differential for massive fetomaternal hemorrhage of unknown cause in the setting of an elevated β-hCG. On US, small intraplacental choriocarcinomas can be occult and isoechoic to the placenta.[55] They can also present as hyperechoic masses, whereas some may have cystic changes.[55] Retroplacental hemorrhage with placental abruption can develop, which is responsible for the associated fetomaternal hemorrhage.[56] Metastases to both mother and fetus can be present.[56]

Complete hydatidiform mole with twin live fetus This is a rare entity in which a normal

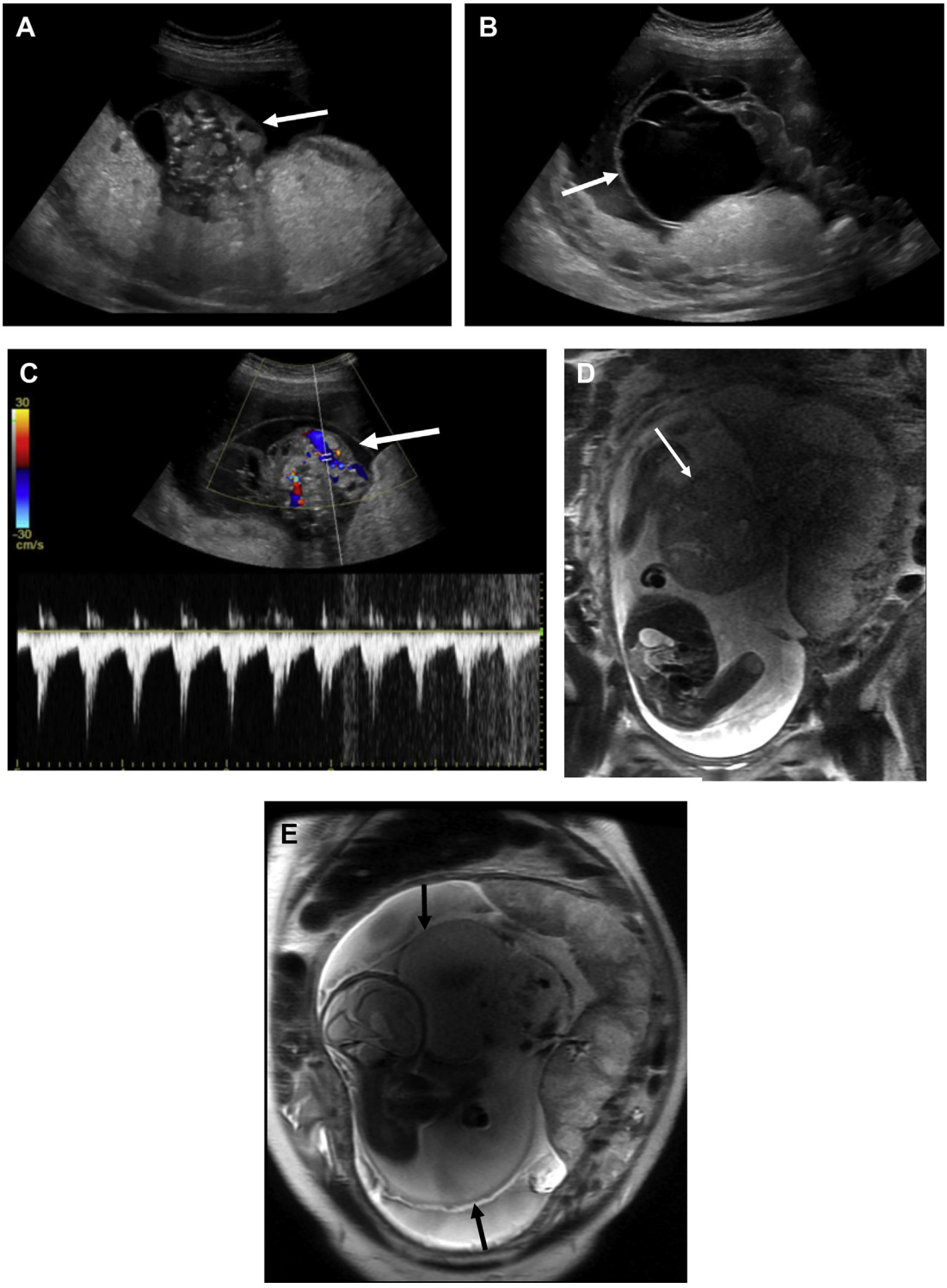

Fig. 12. Chorioangioma. (*A*) Large mixed, solid, and cystic mass (*arrows*) is seen arising from the placenta and protruding into the amniotic cavity. Echogenic foci throughout the mass represent scattered calcifications. (*B*) The mass is characteristically located adjacent to the placental cord insertion. (*C*) On spectral Doppler interrogation, the mass demonstrates internal vascularity pulsating at the fetal heart rate, also characteristic of a chorioangioma. (*D*, *E*) Coronal T2W images demonstrate a heterogenous, exophytic mass (*arrow*) arising from the placenta. (*E*) Separated amnion (*black arrows*) is seen consistent with chorioamniotic separation resulting from excessive mucin secretion by chorioangiomas.

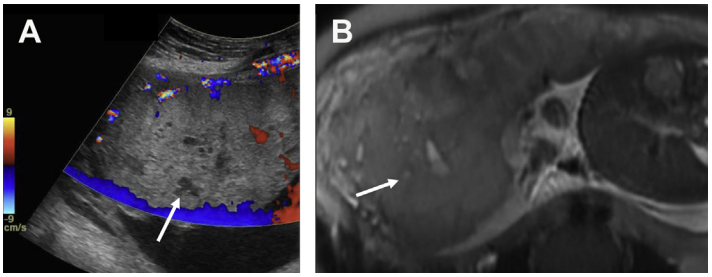

Fig. 13. Placental mesenchymal dysplasia. (*A*) On color Doppler US, the placenta is noted to be thickened with multiple tiny cystic spaces (*arrow*), which suggests PMD. (*B*) T2W MR imaging redemonstrates the thickened placenta with diffuse scattered T2-hypointense cystic spaces (*arrow*).

karyotype fetus develops along with an abnormal molar pregnancy.[57] This entity poses a significant clinical challenge, leading to both maternal and fetal morbidity. Maternal risks include preeclampsia, hyperthyroidism, and possibly malignancy; fetal complications include elevated risk of spontaneous abortion and neonatal thyrotoxicosis.[47,57] Although the normal fetus can have a favorable outcome, nearly 33% of the mothers develop persistent gestational trophoblastic disease after delivery.[58]

US findings include a multilocular cystic mass on grayscale images. On Doppler US, overall hypervascularity is seen without demonstrable flow in the cystic components (**Fig. 14**), a finding that helps differentiate from PMD.[11,23] Identifying this mass as separate from the placenta of the normal twin is very important and helps establish the diagnosis. This distinction is best established in the early gestational period and gets progressively more difficult with advancing gestation. PMD on the other hand is integrally intraplacental in location. MR imaging also demonstrates the cystic nature of the mass and can show the membrane separating the molar pregnancy from the normal pregnancy (see **Fig. 14**).[47] T1-weighted images best depict the hyperintensity associated with hemorrhage, which is common with molar pregnancies, and often poorly identified on US (see **Fig. 14**). Typically, there is significant increase in size of this cystic mass of CHMTF from second to third trimester, in contrast to PMD, which most commonly decreases in size as the pregnancy evolves.[47]

PEARLS, PITFALLS, VARIANTS

Imagers should be aware of common pitfalls that can happen in imaging for PASD. Loss of retroplacental clear space from excess probe pressure is a well-known scenario, which can lead to overcalling accreta. Hence, when this finding is present in isolation without other features of PASD, probe pressure should be reduced and reimaging performed. Myometrial contractions can mimic masses (**Fig. 15**). In addition, the presence of contractions can lead to obscuration of this clear space (see **Fig. 15**).

MR imaging pitfalls include the presence of bulging of the uterus in patients without PASD. Similar to other scenarios, this should be interpreted in combination with other findings.[5] A relatively homogeneous placenta without T2-dark bands or abnormal vascularity may be placenta implanted in the region of scar that is ballooning with the pressure of gestation, without the presence of PASD. Occasionally,

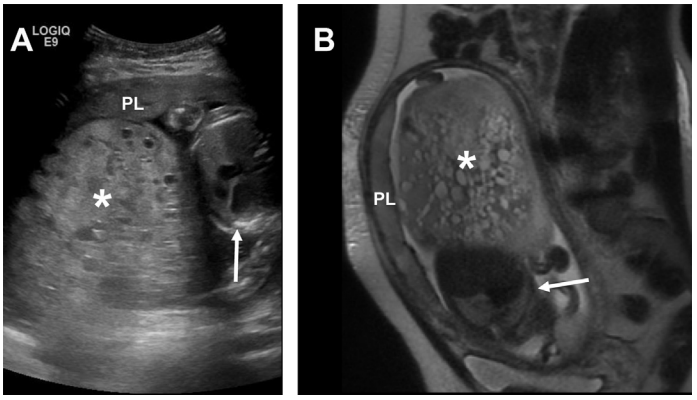

Fig. 14. Complete hyaditiform mole with twin fetus. (*A*) Transabdominal US at 24 weeks and (*B*) corresponding sagittal T2W MR image demonstrates a large cystic mass (*asterisk*), separate from placenta and a normally developed cotwin (*arrow*).

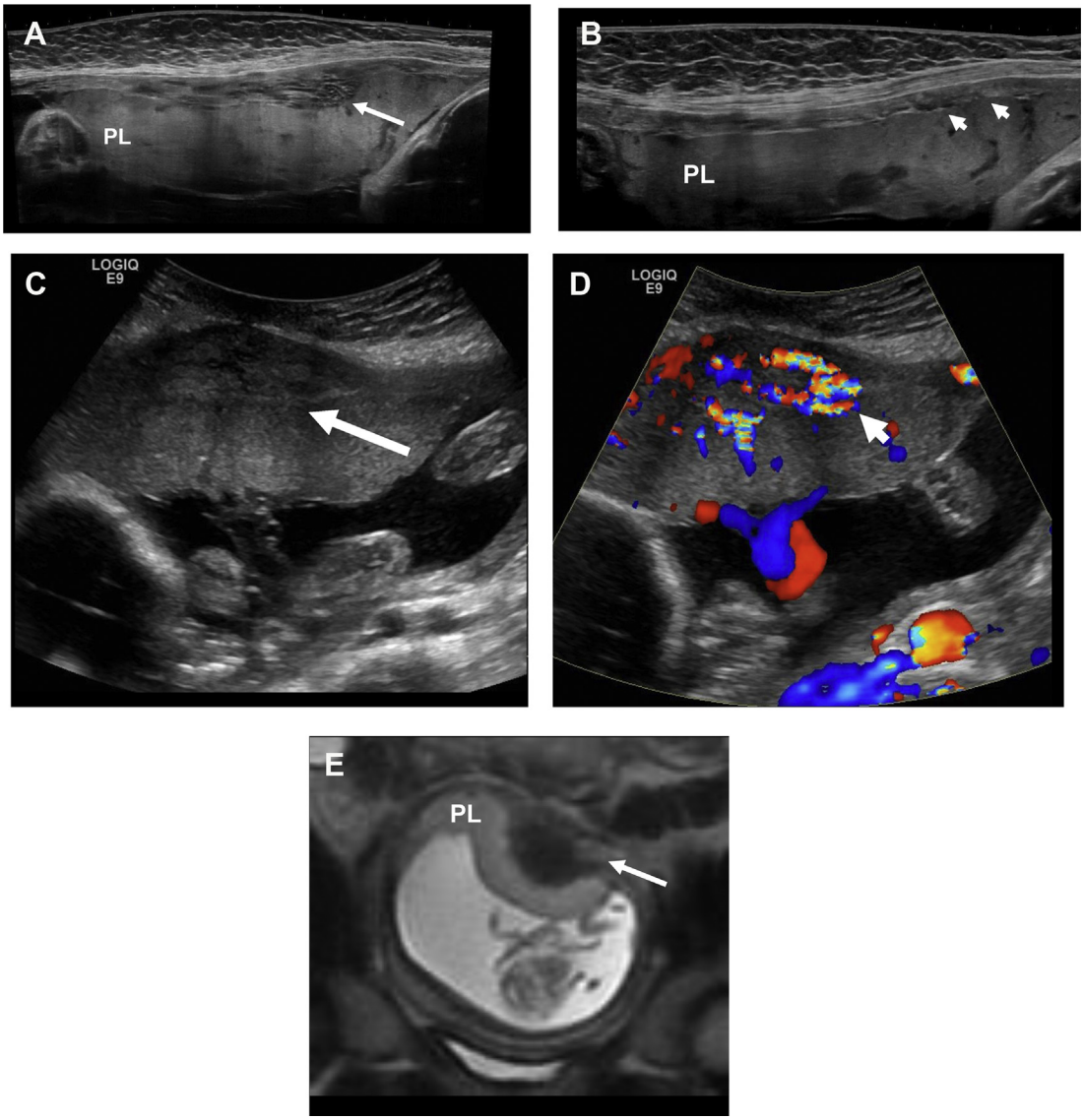

Fig. 15. Myometrial contraction as a mimic of PASD and focal mass. (*A*) Longitudinal US sweep of the placenta (PL) demonstrates retroplacental ill-defined focal masslike area (*arrow*), mimicking a retroplacental mass and obscuring the retroplacental interface. (*B*) This finding resolved later in the study (*arrowheads*) compatible with a contraction. (*C*, *D*) Transabdominal US grayscale image demonstrates focal retroplacental irregular mass-like area (*arrow*), which demonstrated focal area of hypervascularity (*short arrow*) on color Doppler image. This finding suggests focal contraction and can be misinterpreted as a mass. (*E*) Coronal T2W MR image demonstrates a retroplacental low-signal irregular mass (*arrow*) in keeping with a typical MR imaging appearance of focal myometrial contraction, which is a physiologic finding throughout the pregnancy.

nongravid uterus may also have this appearance. Cervical varices are another common pitfall that can be misinterpreted as placental pathology. These patients present with vaginal bleeding, which can be profuse. Often the indication for imaging is suspicion for vasa previa and placenta previa. On US, varices are seen as tubular, anechoic to hypoechoic structures, which should connect to maternal vasculature (**Fig. 16**). Most commonly, these can be traced to connect to maternal myometrial vessels. Given the physiologic venous engorgement during pregnancy, some of these vessels become variceal and can even prolapse into the cervix and upper vagina. Spectral interrogation demonstrates venous waveforms. MR imaging features are those of a vessel, seen as a flow void in the region of the cervix and connecting to myometrial

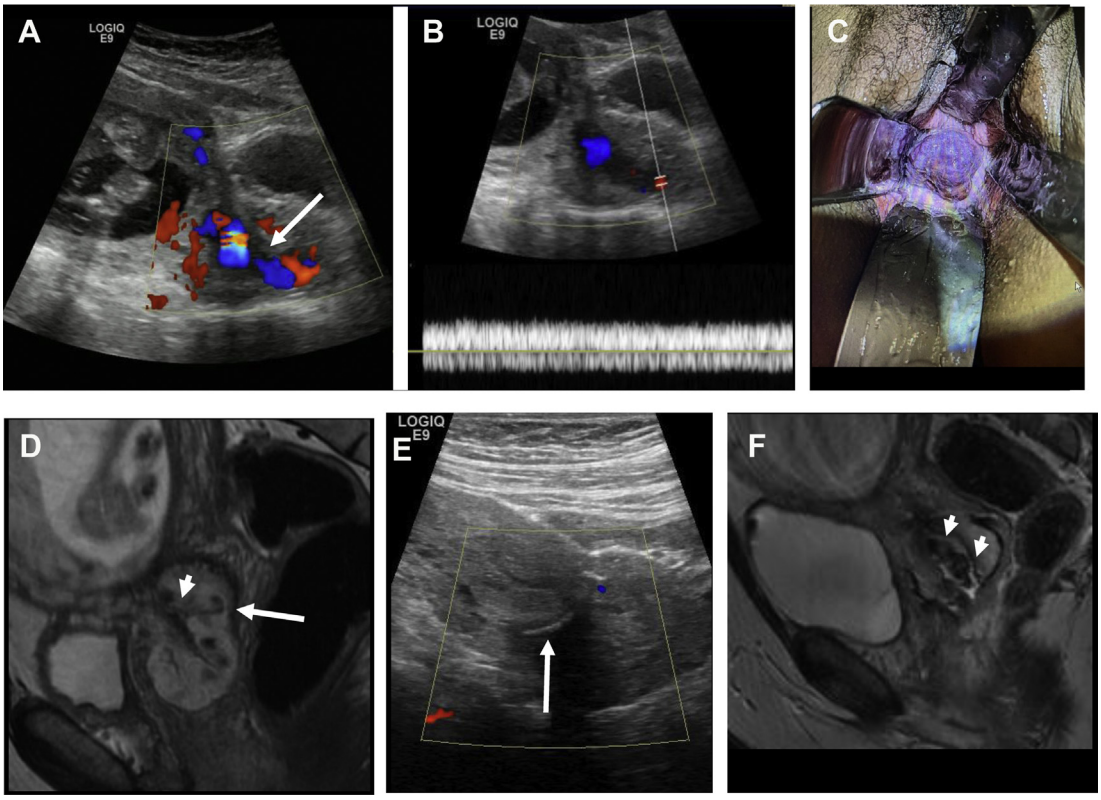

Fig. 16. Cervical varix. (*A*) Transabdominal color Doppler US of lower uterine segment and cervix in a pregnant woman presenting with multiple episodes of vaginal bleeding demonstrates prolapsed vascular structure in the cervical canal (*arrow*). (*B*) Spectral Doppler confirms venous flow that suggests a cervical varix. (*C*) On speculum examination a "blue bag of worms" appearance of the cervix was noted. (*D*) Sagittal T2W MR image shows edematous cervical stroma (*arrow*) with central flow voids (*short arrow*). (*E*) After transvaginal cerclage placement (*arrow*), color Doppler US shows no demonstrable color Doppler flow in the cervical canal. (*F*) Corresponding MR images shows decreased stromal T2 signal and collapsed vascular structures, which supports a thrombosed varix post cerclage placement.

vessels (see **Fig. 15**). Differential includes the marginal vein of the placenta, which is located at the edge of the placental disc and does not connect to myometrial vasculature. Varices can develop throughout the pelvis during pregnancy and can develop in unusual locations such as along the round ligaments, where they can present as palpable abnormalities and mimic an inguinal hernia (**Fig. 17**).

Thrombohematomas, also known as Breus mole, can mimic a placental mass.[47] Presence of myometrial contractions can also lead to globular appearance of subjacent placenta, which can mimic a placental mass; however, the "masslike" area will be very similar to the placenta in echogenicity.[47] Doppler imaging can be useful in this circumstance where the underlying area has similar vascularity. This should be addressed by the reimaging after the contraction has resolved.

WHAT THE REFERRING PHYSICIAN NEEDS TO KNOW

Imaging of PASD is focused on diagnosing the presence and extent of involvement, depth of placental invasion, if possible, extrauterine extension, and presurgical planning. Once the presence of PASD has been established, the radiologist should focus on assessing the location of the placenta and depth of invasion. Presence of placental bulge sign has been shown to be a marker for at least myometrial invasive disease. When combined with serosal hypervascularity, findings are highly suspicious for placenta percreta with extrauterine extension. Assessment of the extent of abnormal serosal vascularity can help predict the needs for additional hemostatic measures such as interventional radiology embolization. Proximity of the placenta with the bladder, specially posteriorly,

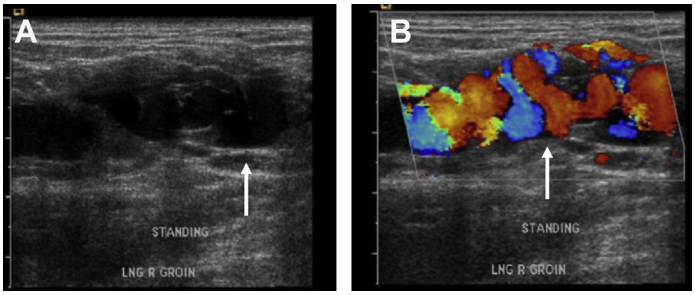

Fig. 17. Round ligament varices in a patient presenting with right groin lump, which developed and progressed during pregnancy. Clinical concern was for inguinal hernia. (*A*) Transabdominal US showed tubular structures (*arrow*), which demonstrated flow on (*B*) color Doppler images (*arrow*). Findings in keeping with pregnancy-related round ligament varices.

prompts cystoscopy at the time of delivery, possible placement of ureteral stents, creation of bladder patch at surgery, and urology involvement with worse involvement.

MR imaging allows to distinguish hematomas from other causes of antepartum bleeding and pain, such as vasa previa, degenerated uterine fibroid, cervical pathology, and placental tumors. Moreover, MR imaging helps to determine the age of the blood products based on MR signal characteristics of hemoglobin. Consequently, placental bleeding can be categorized into hyperacute, acute, early subacute, late subacute, and chronic hematomas. Hyperacute and acute placental hematomas are considered unstable hematomas with higher risk of rapid progression or rebleeding, which may require change in management.

In cases with placental masses, the goal of imaging is to characterize the mass and evaluate fetal well-being. Chorioangiomas can cause fetal anemia, polyhydramnios, chorioamniotic separation, and even hydrops. The larger the size of the mass, the higher the risk of complications. If a fetal intervention is anticipated, as in the setting of fetal anemia, knowing the location of the placenta and cord insertion is helpful to assess the feasibility and access for in utero transfusion.

SUMMARY

In summary, the placenta should be evaluated at the time of fetal evaluation with US. Potential risk factors for PASD should be elicited and if present, features of PASD should be evaluated for their presence. Prenatal diagnosis of PASD is essential for appropriate management and activation of multidisciplinary teams. Placental masses are uncommon and can be divided into trophoblastic and nontrophoblastic masses. Molar pregnancies and choriocarcinomas are trophoblastic masses. Although most nontrophoblastic placental masses are benign, the management focuses on the fetal well-being.

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