REVIEW

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An update of diagnostic efficacy of ultrasound and magnetic resonance imaging in the diagnosis of clinically significant placenta accreta spectrum disorders

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Purpose of review
Systematic screening and diagnosis of placenta accreta spectrum disorder (PAS) either by ultrasound or magnetic resonance imaging (MRI) would allow referral of high-risk women to specialized multidisciplinary teams. We aimed to report recent findings regarding the diagnostic accuracy of ultrasound and magnetic resonance imaging in the diagnosis of PAS.

Recent findings
Recent evidence from the literature shows that both ultrasound and MRI are good tests to identify PAS in high-risk populations. Ultrasound can also be used safely to guide management decisions, concentrating greater resources in patients with the higher risk of clinically significant PAS requiring complex peripartum management. Moreover, there are increasing data showing that routine contingent screening for PAS disorders based on the finding of a placenta implanted low in the uterine cavity and previous uterine surgery is effective in a public healthcare setting. A contingent screening strategy for PAS is feasible if placental location is routinely assessed during routine scans, and may even start from the first trimester of pregnancy.

Summary
Ultrasound is an effective tool to screen pregnancies at high risk of PAS. In such pregnancies, ultrasound and MRI are effective imaging modalities for guiding management.

Keywords
accreta, MRI, prenatal diagnosis, screening, ultrasound

INTRODUCTION

Placenta accreta spectrum disorder (PAS) is a pregnancy complication occurring when the chorionic villi invade the myometrium. It is associated with maternal morbidity and mortality arising from massive peripartum hemorrhage [1]. Placenta previa and a history of caesarean delivery are the two main risk factors for PAS, with the incidence of PAS increasing exponentially with the number of cesarean sections [2,3].

It has been shown that morbidity can be significantly reduced if the diagnosis of PAS is made prior to delivery [4]. Systematic screening and diagnosis of PAS either by ultrasound or magnetic resonance imaging (MRI) would allow referral of high-risk women to tertiary hospitals with specialized multidisciplinary teams experienced in the management of pregnancies complicated by PAS.

The aim of this review is to report recent findings regarding the diagnostic accuracy of ultrasound and magnetic resonance imaging in the diagnosis of PAS.

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KEY POINTS

- Both ultrasound and MRI are good tests to identify PAS in high-risk populations.
- Ultrasound can safely guide management decisions, concentrating greater resources in patients with the higher risk of clinically significant PAS disorder requiring complex peripartum management.
- In high-risk women, the choice between ultrasound and MRI should be based on availability of equipment as well as on expertise of the center.
- An ultrasound-based contingent screening strategy for PAS disorders is feasible if placental location is routinely assessed during routine scans in women with previous uterine surgery.

PLACENTA ACCRETA SPECTRUM

Over the last few years, there has been an increasing interest on the topic of PAS. Guidelines regarding its diagnosis and management have been published by a number of national and international societies, such as the International Federation of Gynecology and Obstetrics [5], the Royal College of Obstetricians and Gynaecologists [6], and the Society for Maternal-Fetal Medicine [7]. Earlier pathological classifications differentiated PAS in placenta accreta (chorionic villi attach directly to the surface of the myometrium with no decidual layer), increta (chorionic villi penetrate deeply into the myometrium), and percreta (chorionic villi reach and penetrate through the uterine serosa) [8,9]. More recently, it has been suggested to differentiate between abnormally adherent placenta (accreta) and abnormally invasive placenta (including increta and percreta), as the latter is associated with increased morbidity and then need for different management strategies [10].

ULTRASOUND DIAGNOSIS

The prenatal identification of PAS is primarily achieved by ultrasound. In high-risk cases, the placenta should be evaluated systematically in orthogonal planes using both gray scale and color Doppler imaging. Transvaginal in addition to transabdominal ultrasound should be performed for patients with placenta previa or low-lying placenta. A high frequency probe should be selected, and imaging can be optimized by partial filling of maternal bladder. The transducer should be oriented perpendicularly to the area of interest, and attention should be taken in minimizing the pressure applied with the probe. Society for Maternal-Fetal Medicine consensus guidelines suggest that color Doppler assessment should generally be performed with velocity scale <15 cm/s, low wall filters and high gain to optimize detection of abnormal flow [7]. Three-dimensional (3D) ultrasound can also be used in addition to two-dimensional (2D) imaging. 3D ultrasound allows to identify the appearance of the normal uterine-bladder interface as a 'tram line' in the sagittal plane; partial or complete obliteration of such tram line is associated with complexity in surgery at delivery and need for peripartum hysterectomy [11▪].

According to a systematic review and meta-analysis including 23 studies with 3707 pregnancies at risk for PAS ultrasound has an overall sensitivity of 91%, specificity of 97% and diagnostic odds ratio of 98.6 for PAS [12]. Another similar analysis including 14 cohort studies and 3889 pregnancies focused on pregnancies with previa or low-lying placenta and at least one caesarean delivery reported a similar diagnostic accuracy, and found a better prenatal detection of PAS was in prospective rather than in retrospective studies [13]. Despite a general consensus among guidelines that women with previous caesarean section and a low-lying placenta have an increased risk of PAS, few studies have evaluated the effectiveness of systematic screening for PAS.

Panaiotova *et al.* [14] prospectively screened 22 604 singleton pregnancies undergoing first trimester ultrasound at 11–13 weeks of gestation. Those with a low-lying placenta and a history of uterine surgery were classified as being at high risk for PAS and referred to a specialist PAS clinic for further follow-up. A total of 1298 (6%) pregnancies were considered at high risk of PAS; the diagnosis of PAS was suspected prenatally in 14 cases, and in 13 was confirmed at delivery. On the contrary, there were no cases of PAS in the rest of the population.

Coutinho *et al.* [15▪▪] performed a retrospective study on 57 179 women undergoing a routine second trimester fetal anatomy scan; of them 220 (0.4%) had a third-trimester diagnosis of placenta previa. Of these, 75 were referred to a dedicated PAS clinic because of a history of uterine surgery. Targeted ultrasound assessment for PAS included two-dimensional grayscale and color Doppler ultrasound, and the following markers were systematically assessed: the presence of multiple irregular placental lacunae with turbulent blood flow on Doppler ultrasonography (peak systolic velocity >10 cm/s); loss of the normal hypoechoic line between the placenta and the myometrium; myometrial thinning in the retroplacental area; increased placental thickness; and bladder wall interruption, defined as loss or irregularity of the hyperechoic line between the uterine serosa and bladder. Color Doppler was used according to the examiner's preference, mainly to differentiate

placental lakes from lacunae. If two or more of these ultrasound signs were present, a diagnosis of PAS was made. With just one isolated sign, the case was considered equivocal; if no ultrasound signs were present, the case was classified as negative for PAS. Overall, 21 of 22 cases of PAS were diagnosed correctly [sensitivity, 95% (95%) and specificity 100%]. At univariate analysis, the strongest risk factors for PAS were parity $\geq$ 2 (odds ratio 36), $\geq$ 2 previous caesarean sections (odds ratio 94), and the presence of placenta previa (odds ratio 21). In the whole cohort, 173 pregnancies were referred to the PAS clinic, with one false-positive and three false-negative diagnoses: the overall sensitivity for PAS was 96.6% with a specificity of 98.8%. This study shows the effectiveness of a policy of routine contingent screening for PAS disorders in a public healthcare setting, targeting a population with placenta previa in the third trimester and previous uterine surgery.

Fratelli *et al.* [16▪] performed a multicenter prospective observational study showing that gray-scale ultrasound is a good test to identify pregnancies at low risk of PAS disorder in high-risk populations. They evaluated the diagnostic performance of third trimester ultrasound for the diagnosis of clinically significant PAS in women with a low-lying placenta (less than 20 mm from the internal cervical os) or placenta previa (covering the internal cervical os).

The suspicion of PAS was raised in the presence of at least one of these ultrasound signs: obliteration of the hypoechoic space between the uterus and the placenta; interruption of the hyperechoic interface between the uterine serosa and the bladder wall; abnormal placental lacunae, defined as the presence of numerous lacunae including some that are large and irregular (Finberg grade 3) containing turbulent flow visible in grayscale imaging. In this cohort, the median gestational age at the time of first ultrasound in their cohort was 31.4 weeks (interquartile range 28.6 to 34.4 weeks). All women had a further scan at 34–36 weeks to re-evaluate placental location. PAS was considered clinically significant if, further to histological confirmation, any additional procedure was performed at delivery among intrauterine balloon placement, uterine/hypogastric artery ligation, compressive uterine suture, uterine embolization, peripartum hysterectomy. Out of 473 women for whom placental pathology was available, clinically significant PAS was observed in 99 (21%). A normal hypoechoic space between the uterus and the placenta reduced from 21% to 5% the posttest probability of PAS with low-lying placenta or placenta previa; such probability decreased from 62% to 9% in the subgroup of women with anterior placenta and at least one previous cesarean section. The absence of lacunae reduced posttest probabilities of PAS from 21% to 9% in women with low-lying placenta or placenta previa, and from 62% to 36% in those with and anterior placenta and at least one previous caesarean section. Conversely, the posttest probability increased from 21% to 59% in the whole study population and from 62% to 78% in women with placenta previa, previous caesarean section and anterior placenta, when lacunae were seen on ultrasound.

MAGNETIC RESONANCE IMAGING DIAGNOSIS

Ultrasound and MRI are both noninvasive and nonionizing imaging methods and each has peculiar technical and practical advantages for placental imaging. Importantly, the advantages of each technique complement the limitations of the other. The major advantages of ultrasound are the higher spatial and temporal resolution compared to MRI, ease of functional vascular assessment with Doppler, and the possibility of intraoperative use. Disadvantages of ultrasound, such as operator-dependence and limited penetration and field of view, are compensated by MRI's reproducible large field of view imaging. The most evident advantage of MRI is its superior contrast resolution and tissue specific characterization, allowing a detailed visualization of the entire placental-myometrial interface. MRI is also superior for the assessment of extra-uterine invasion and in delineating relationships with the pelvic vasculature. The limited availability and high cost are well-known disadvantages of MRI, which is also dependent on operator experience [17].

De Oliveira Carniello *et al.* [18▪▪] performed a systematic review and meta-analysis of the diagnostic test accuracy of ultrasound and MRI, also comparing the performance of the two techniques in the diagnosis of PAS. They included observational studies evaluating diagnostic accuracy in women with risk factors for PAS who had undergone both ultrasound and MRI. Their search was restricted to articles published in English between 2011 and 2021. A total of 1301 women from 17 studies was included; MRI and ultrasound data were available for all. In 457 cases PAS was diagnosed either intraoperatively or at histopathological analysis. The meta-analysis revealed a sensitivity of 0.83 and a specificity of 0.83 for ultrasound. For MRI, the sensitivity was 0.84 and specificity was 0.83. The authors concluded that there was no statistically significant difference between the two techniques in a setting with a high prevalence of risk factors. Therefore, the choice of the initial imaging modality for PAS assessment should depend on the availability of equipment and the examiner's experience.

Cavalli *et al.* [19▪] performed a prospective observational study assessing the performance of ultrasound and MRI signs for antenatal detection of placenta accreta spectrum disorders in women with placenta previa with and without a history of previous caesarean section. A total of 39 women were included: 7/39 had clinically significant PAS. On ultrasound hypoechoic space interruption and placental lacunae were the most sensitive sonographic signs (83%), whereas abnormal hyperechoic interface was the most specific (83%). On MRI, focal myometrial interruption and T2 intraplacental dark bands showed the best sensitivity (83%), bladder tenting had the best specificity (100%). There was substantial agreement between ultrasound and MRI in patients with anterior placenta (κ=0.78). The authors concluded that ultrasound and MRI agreement in antenatal diagnosis of clinically significant PAS was maximal in high-risk women.

Finazzo *et al.* [20] evaluated the level of agreement in the prenatal MRI assessment of the presence and severity of placenta accreta spectrum disorders between four examiners with expertise in the diagnosis and management of these conditions. A total of 46 women with placenta previa or low-lying placenta and at least one prior caesarean delivery or uterine surgery were included in this secondary analysis of a prospective study. The median gestational age at MRI was 33.8 (interquartile range, 33.1 – 34.0) weeks. A final diagnosis of placenta accreta, increta, and percreta was made in 15.2%, 17.4%, and 50.0% patients, respectively. Depth of invasion was defined as the degree of adhesion and invasion of the placenta into the myometrium and uterine serosa (placenta accreta, increta, or percreta) and the histopathological examination of the removed uterus was considered the reference standard. Topography of the placental invasion was defined as the site of placental invasion within the uterus in relation to the posterior bladder wall (posterior upper bladder wall and uterine body, posterior lower bladder wall, and lower uterine segment and cervix or no visible bladder invasion) and the site of invasion at surgery was considered the reference standard. There was excellent agreement between the four examiners in the assessment of the overall presence of a PAS disorder (interrater agreement 92%, Cohen's κ 0.90). However, there was significant heterogeneity in interrater agreement when assessing the different MRI signs suggestive of a PAS disorder. There was excellent agreement between the examiners in the identification of the depth of placental invasion on MRI (interrater agreement 99%, Cohen's κ 0.95). However, agreement in assessing the topography of placental invasion was only moderate (interrater agreement 73%, Cohen's κ 0.56). More importantly, when assessing parametrial invasion, a very important factor affecting the complexity of peripartum management, the agreement was substantial and moderate in assessing the presence of invasion in the coronal (interrater agreement 87%, Cohen's κ 0.69) and axial (interrater agreement 79%, Cohen's κ 0.56) planes, respectively. Likewise, interobserver agreement in evaluating the presence and the number of newly formed vessels in the parametrial tissue was moderate (interrater agreement 88.0%, Cohen's κ 0.59) and fair (interrater agreement 67%, Cohen's κ 0.22), respectively. This study suggests that MRI has excellent interobserver agreement in identifying the presence and depth of PAS disorders. However, interobserver agreement is lower for assessment of the topography of invasion, especially for the detection of parametrial invasion and the presence of newly formed vessels within the parametrial tissue, which can significantly affect maternal outcome.

CONCLUSION

Recent evidence from the literature shows that ultrasound is a good test to identify pregnancies at low risk of PAS disorder in high-risk populations. Ultrasound can also be used safely to guide management decisions, concentrating greater resources in patients with the higher risk of clinically significant PAS disorder requiring complex peripartum management. Moreover, there is increasing data showing that routine contingent screening for PAS disorders based on the finding of a placenta implanted low in the uterine cavity and previous uterine surgery is effective in a public healthcare setting. A contingent screening strategy for PAS disorders is feasible if placental location is routinely assessed during routine scans, and may even start from the first trimester of pregnancy. When linked to an effective and possibly dedicated diagnostic and surgical management service, such screening strategy has the potential to significantly reduce the maternal morbidity and mortality associated with PAS.

Ultrasound and MRI have similar sensitivity and specificity for the diagnosis of PAS in high-risk women. The choice between these modalities should be based on availability of equipment as well as on expertise of the center. MRI has a particularly good interobserver agreement in identifying the presence and depth of PAS disorders. However, interobserver agreement is lower for the detection of parametrial invasion and the presence of newly formed vessels within the parametrial tissue, factors that can significantly affect the complexity of management and maternal outcomes.

There is a need for an effective and objective standardized system for the antenatal assessment of the topography of placental invasion, and for a reproducible prenatal staging system for the stratification of surgical risk in pregnancies with PAS disorders.

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Conflicts of interest

There are no conflicts of interest.

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- ■ of special interest
- ■■ of outstanding interest

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