Original Article

Comparisons of the diagnostic accuracy of the ultrasonic sign-score method and MRI for PA, PI and PP in high-risk gravid women: a retrospective study

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Background: The diagnosis and management of placenta accrete spectrum (PAS) is a great challenge to obstetricians. Ultrasound (US) and magnetic resonance imaging (MRI) are two main methods to detect PAS. MRI has high resolution, but the examination fee is expensive. US machine and examination fee is cheap, but the resolution is relatively low. Balancing the cost and accuracy for PAS diagnosis is very important.

Methods: The ultrasonic sign-score method and MRI findings for 49 pregnant women at high risk of placental implantation were retrospectively analyzed. Inclusion criteria: (I) at high risk for PA as described in the Guidelines to Placenta Accreta Spectrum Disorders issued by the American College of Obstetricians and Gynecologists (ACOG) in 2018; (II) complete records of ultrasonic sign-scoring method and MRI data; (III) cesarean section; (IV) definite surgical and/or pathological findings. The results were validated by the gold-standard surgical or postoperative pathological findings, and the efficacy of the 2 imaging approaches in diagnosing placenta PAS was compared. Kappa test was used to analyze the consistency. Receiver operating characteristic (ROC) curves were used to compare the sensitivity and specificity.

Results: The mean maternal age was 32.6±4.4 years. The mean gestational week was 35.9±2.0 weeks. The mean gravidity was 3.3±1.1. The surgical or histopathological findings revealed PA in 26, placenta increta (PI) in 19 and placenta percreta (PP) in 4 of the 49 women. The diagnosis accuracy of PA, PI, and PP was higher using the ultrasonic sign-scoring method than MRI (75.51%, 73.47%, and 97.96% *vs.* 61.22%, 57.14% and 91.84%, respectively). The areas under the ROC curve for the sensitivity and specificity of the ultrasonic sign-scoring method and MRI in the diagnosis of PA, PI, and PP were 0.757 [95% confidence interval (CI): 0.613, 0.868], 0.725 (95% CI: 0.579, 0.843), 0.989 (95% CI: 0.907, 1.000), and 0.607 (95% CI: 0.457, 0.743), 0.544 (95% CI: 0.395, 0.687), 0.614 (95% CI: 0.464, 0.749), respectively.

Conclusions: Although the sensitivity and specificity were lower than 0.8, the ultrasonic sign-scoring method was still superior to MRI in the detection of PI and PP. US can be used to help identify high-risk gravid women.

Keywords: Ultrasonic sign-score; magnetic resonance imaging (MRI); placenta accrete; depth of invasion; comparative study

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Introduction

In recent decades, the diagnosis and management of placenta accrete spectrum (PAS) has represented a great challenge to obstetricians in clinical practice (1,2). Due to the obscure clinical manifestations and lack of laboratory tests for PAS, there is no method currently available that allows the depth of invasion of PAS to be predicted before surgery or that can distinguish among PA, placenta increta (PI), and placenta percreta (PP) (3).

Ultrasound (US) and magnetic resonance imaging (MRI) are still the most commonly used imaging techniques for the diagnosis of PA. Due to its wide application and low cost, US is one of the most used diagnostic methods for PAS (1). A model with 4 US markers could predict the possibility and severity of PAS with high accuracy (4). However, the resolution ratio of US is lower compared with MRI. Some deep tissue may not show clearly, like posterior location of the placenta or obese maternal body. MRI could be applied to preoperative diagnosis and surgical planning (1). MRI can clearly show the spatial position of the placenta, and clearly show the relationship between the uterus and adjacent organs and tissues. An MRI based study showed intraplacental T2-hypointense bands is an efficient method to diagnose PAS (1). However, the MRI machine and exam fee are very high compared with US. Over-diagnosis or under-diagnosis of this condition may be inevitable, as the conclusions drawn can be affected by the experience of the examiner and the resolution of the device. Which detection is the best method to diagnose PAS still needs to be explored. Consequently, it is also difficult for obstetricians to formulate sound and reasonable delivery plans.

Highlight box

Key findings

- The ultrasonic sign-scoring method was superior to magnetic resonance imaging (MRI) in the detection of placenta increta (PI), and placenta percreta (PP).

What is known and what is new?

- Obstetricians usually use MRI to screen soft tissue because of its high resolution.
- The prenatal ultrasonic sign-scoring method is superior to MRI in the detection of all types of placenta accreta spectrum (PAS).

What is the implication, and what should change now?

- The ultrasonic sign-scoring method is an effective method for detecting PAS and could be implemented at primary and tertiary hospitals.

To boost the diagnostic accuracy, particularly for suspected PAS, many obstetricians request MRI examinations in addition to US examinations, as MRI has a higher resolution in the screening of soft tissues (2,5). However, it is not yet known whether MRI is more accurate and informative than the ultrasonic sign-scoring method in the diagnosis of PAS. This study sought to compare the ultrasonic sign-scoring method and MRI in the diagnosis of PA in high-risk pregnant women and verify the value of the 2 imaging techniques in differentiating among diverse types of PAS. We present the following article in accordance with the STARD reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-6508/rc).

Methods

Subjects

This was a single center retrospective study. A retrospective analysis was performed in the imaging data of 49 patients with high-risk factors for placental implantation, who had been admitted to and treated at our hospital between September 2018 and July 2021. To be eligible for inclusion in this study, the patients had to meet the following inclusion criteria: (I) be at high risk for PA as described in the Guidelines to Placenta Accreta Spectrum Disorders issued by the American College of Obstetricians and Gynecologists (ACOG) in 2018 (6); (II) have complete records of their ultrasonic sign-scoring method and MRI data; (III) have had a pregnancy terminated by a cesarean section; and (IV) have definite surgical and/or pathological findings. Patients were excluded from the study if they met any of the following exclusion criteria: (I) had multiple pregnancies; and/or (II) had severe pregnancy complications or comorbidities, such as preeclampsia with hyperemesis, or with cerebrovascular disease in pregnancy.

The maternal age of the patients ranged from 22 to 44 years (mean 32.6±4.4 years). The gestational weeks ranged from 27.4 to 39.2 weeks (mean 35.9±2.0 weeks). The gravidity ranged from 2 to 6 times (mean 3.3±1.1). All the patients had a history of cesarean delivery and uterine operation. The diagnostic findings of the ultrasonic sign-scoring method and MRI were compared to those documented during the cesarean section and/or histopathological studies, and the surgical and/or pathological findings were used as the gold standard to evaluate the type of PAS. True negative/false positive results for PA were defined as the complete detachment of the

Table 1 US-scoring scale for PA

Evaluation index	0	1	2
Placenta location	Normal	Edge or low	Full coverage
Placental thickness	<3 cm	≥3–5 cm	>5 cm
Retroplacental hypoechoic zone	Continuous	Focal interruption	Vanished
Bladder line	Continuous	Interrupted	Vanished
Placental lacuna	Absent	Fused	Formation with boiling water sign
Placental basal blood flow	Regular	Increased blood flow	Mass-like elevations and "cross-border" blood vessels appeared
Cervical blood sinus	Absent	Present	Fusion into flakes with boiling water sign
Cervical morphology	Intact	Incomplete	Vanished
Additional items: history of cesarean section	None	1 time	≥2 times

Diagnostic criteria: ≤5 as PA, 6–9 as PI, ≥10 as PP. US, ultrasound; PA, placenta accreta; PI, placenta increta; PP, placenta percreta.

placenta from the uterine wall without massive bleeding, and a placenta that appeared normal under histological examination. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Institutional Review Board of Yijishan Hospital (No. 2022031). All the study subjects provided informed consent.

Devices and methods

Ultrasonography

Ultrasonography was performed on the GE VOLUSON E8 imaging machine (General Electric Co., USA) and the Philips EPIQ7 imaging machine (Philips Electronics NV, The Netherlands) using 4–10 MHz transducers. In addition to the 2-dimensional grayscale imaging and transabdominal ultrasonography, color Doppler and transvaginal ultrasonography were used. After the routine detection of the fetus and its appendages, the following special ultrasonographic parameters were observed: placenta location, hypoechoic retroplacental zone, placental lacunas, vascularity at the uterus-bladder interface, bladder line, and cervical morphology. At least 2 experienced sonographers performed the detection.

MRI detection

MRI was performed using a GE Signa HDx 1.5T scanner (General Electric Co., USA) with a phased-array body coil. The following MRI sequences were applied: fast spin-echo sequence T2WI (TR3000–2500 ms, TE100110 ms), and T1WI (TR400900 ms, TE520 ms). For the scan, the pregnant woman was placed in the supine position, with moderate distention of the bladder to reduce the effects of fetal movement and fetal position on the examination results. The total MRI scanning time was around 20 min. The MRI results were interpreted by experienced radiologists.

Diagnostic criteria

Gold standard for clinical diagnosis of PAS

A clinical diagnosis of PAS was made in compliance with the intraoperative findings or observation at delivery, or the pathological findings after delivery as per the diagnostic procedures described previously (7). The 3 classifications of PAS were as follows: PA, the placental villi are attached to the myometrium; PI, the placental villi are invading the myometrium; and PP, the placenta villa are fully penetrating the myometrium, and may even be breaching the serosa and invading the surrounding structures, such as the bladder, broad ligament, or sigmoid colon (8).

Ultrasonic sign-scoring scale

The ultrasonic sign-scoring scale used in this study complied with the previous protocol, and details of the scored components (1) can be found in *Table 1* and *Figure 1*.

Diagnostic criteria for MRI

The criteria for the diagnoses were as follows: (I) PA, fuzzy placenta-uterine junction with clear signal of the

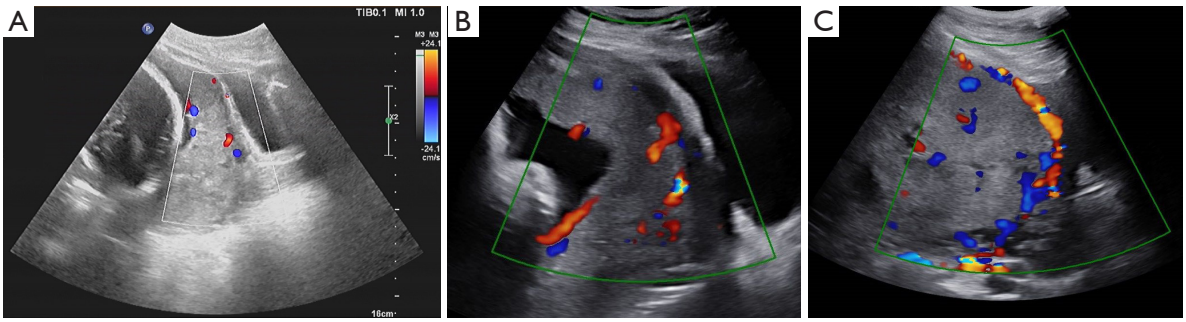

Figure 1 Ultrasonic sign-scoring method for the diagnosis of PA: (A) PA; (B) PI; (C) PP. TIB, thermal index for bone; MI, mechanical index; PA, placenta accreta; PI, placenta increta; PP, placenta percreta.

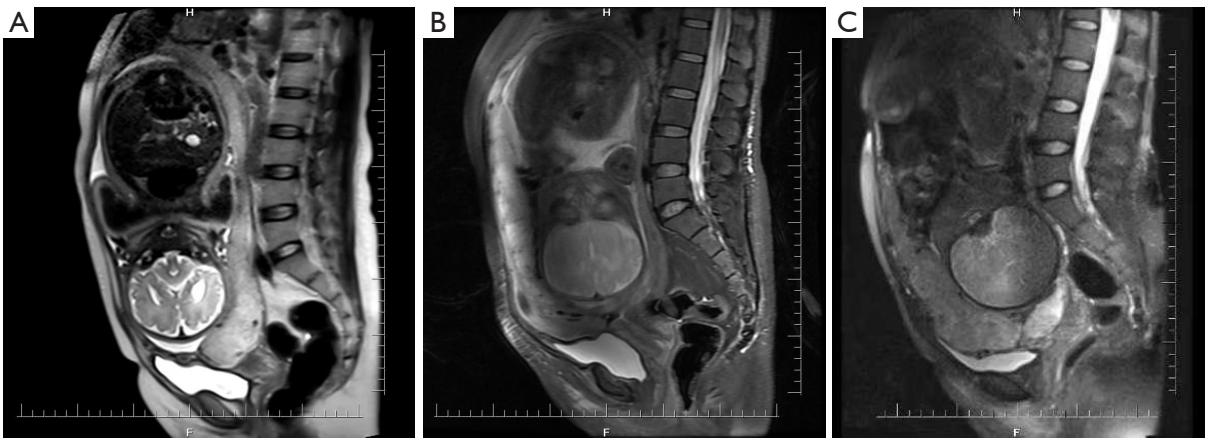

Figure 2 Types of PAS by MRI detection: (A) PA; (B) PI; (C) PP. PAS, placenta accrete spectrum; MRI, magnetic resonance imaging; PA, placenta accreta; PI, placenta increta; PP, placenta percreta.

myometrium detected; (II) PI, interrupted signal at the placenta-uterine junction, with thinned myometrium and an irregular signal, and a vascular shadow that could be observed through the myometrium; and (III) PP, completely vanished myometrial signal, abnormal signal penetrating through the uterine muscle wall, irregular changes in the signal at the bladder wall, placenta herniation into the bladder, protrusion into the broad ligament, and an abnormal cervical anatomy (9). The results are shown in *Figure 2*.

Statistical analysis

Software SPSS 20.0 for Windows (SPSS, Chicago, IL, USA) was used, and the Kappa test was used to analyze the consistency of the diagnosis of the 2 imaging methods. McNemar's test was used to analyze specificity and sensitivity of US and MRI. Receiver operating characteristic (ROC) curves were used to compare the sensitivity and specificity of the 2 techniques. A P value <0.05 (two-sided) was considered statistically significant.

Results

The results for the ultrasonic sign-scoring method and MRI detection

The ultrasonic sign-scoring method identified PA in 24 cases (a score of ≤5), PI in 20 (a score of 6–9), and PP in 5 (a score of ≥10), and the MRI identified PA in 29 cases, PI in 18 cases, and PP in 2 cases.

Pregnancy outcomes of patients

All the 49 patients underwent cesarean section to terminate their pregnancies. The surgical records or histopathological

Table 2 Comparison of the diagnostic agreement between the ultrasonic sign-scoring method and MRI diagnoses (n=49)

MRI	US			Total
	PA	PI	PP	
PA	17	10	2	29
PI	7	9	2	18
PP	0	1	1	2
Total	24	20	5	49

MRI, magnetic resonance imaging; US, ultrasound; PA, placenta accreta; PI, placenta increta; PP, placenta percreta.

Table 3 Comparison of the efficacy of ultrasonic sign-scoring method and MRI in determining the type of placental implantation

Variables	US, % (n/N)			MRI, % (n/N)		
	PA	PI	PP	PA	PI	PP
SEN	73.08 (19/26)	68.42 (13/19)	100.00 (4/4)	69.23 (18/26)	42.11 (8/19)	25.00 (1/4)
SPE	78.26 (18/23)	76.67 (23/30)	97.78 (44/45)	52.17 (12/23)	66.67 (20/30)	97.78 (44/45)
PPV	79.17 (19/24)	65.00 (13/20)	80.00 (4/5)	62.07 (18/29)	44.44 (8/18)	50.00 (1/2)
NPV	72.00 (18/25)	79.31 (23/29)	100.00 (44/44)	60.00 (12/20)	64.52 (20/31)	93.62 (44/47)
ACC	75.51 (37/49)	73.47 (36/49)	97.96 (48/49)	61.22 (30/49)	57.14 (28/49)	91.84 (45/49)

MRI, magnetic resonance imaging; US, ultrasound; PA, placenta accreta; PI, placenta increta; PP, placenta percreta; SEN, sensitivity; SPE, specificity; PPV, positive predictive value; NPV, negative predictive value; ACC, accuracy.

findings indicated PA in 26 cases, PI in 19 cases, and PP in 4 cases. Of the 3 patients who underwent a subtotal hysterectomy, 2 had PI, and 1 had PP. Postoperative bleeding of ≥1,000 mL was reported in 22 women, 4 of whom had PA, 14 of whom had PI, and 4 of whom had PP.

Comparison of the diagnostic agreement between the ultrasonic sign-scoring method and MRI

The consistency test results between the ultrasonic sign-scoring method and MRI indicated that the diagnostic agreement between the 2 imaging methods was poor (kappa =0.193) (*Table 2*).

Comparison of the efficacy of the ultrasonic sign-scoring method and MRI in diagnosing PAS

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of the ultrasonic sign-scoring method were higher than those of MRI in the diagnosis of the 3 types of PAS (*Table 3*). ROC curves were used to compare the sensitivity and specificity of the ultrasonic sign-scoring method and MRI in differentiating among the different types of PAS. The results showed that the areas under the ROC curves of the sensitivity and specificity of different types of PAS diagnosed by the ultrasonic sign-scoring method and MRI were 0.757 [95% confidence interval (CI): 0.613, 0.868], 0.725 (95% CI: 0.579, 0.843), 0.989 (95% CI: 0.907, 1.000), and 0.607 (95% CI: 0.457, 0.743), 0.544 (95% CI: 0.395, 0.687), 0.614 (95% CI: 0.464, 0.749), respectively (*Figure 3*).

Comparison of the missed- and mis-diagnosis of the placental location by the ultrasonic sign-scoring method and MRI

According to the location of the placenta attached to the uterine wall in the 49 patients, 30 had an anterior placenta (61.22%, 30/49), 16 had a posterior placenta (32.65%, 16/49), and 3 had a lateral placenta (6.12%, 3/49). The ultrasonic sign-scoring method failed to diagnose 4 cases (2 anterior placenta cases and 2 posterior placenta cases) and misdiagnosed 8 cases (6 anterior placenta cases and 2 posterior placenta cases). MRI failed to diagnose 11 cases (7 anterior placenta cases, 2 posterior placenta cases, and 2 lateral placenta cases), and misdiagnosed 10 cases (4 anterior

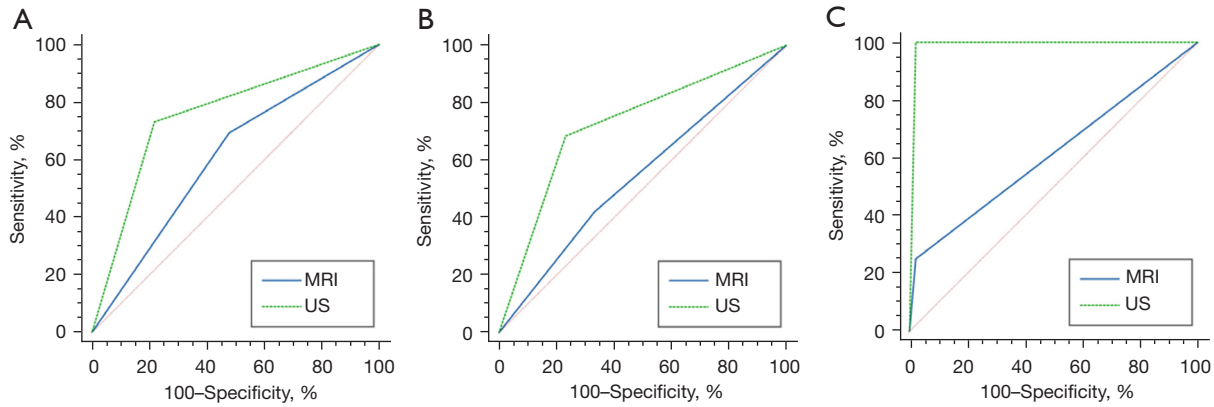

Figure 3 ROC curves of the sensitivity and specificity of different types of PAS diagnosed by the ultrasonic sign-scoring method and MRI: (A) PA; (B) PI; and (C) PP. MRI, magnetic resonance imaging; US, ultrasound; ROC, receiver operating characteristic; PAS, placenta accrete spectrum; PA, placenta accreta; PI, placenta increta; PP, placenta percreta.

placenta cases, 5 posterior placenta cases, and 1 lateral placenta case).

Discussion

Placental villi invading the myometrium can lead to abnormal adhesion between the placenta and myometrium because of a defect of the uterine decidua. The clinical management of the different types of PAS can differ and may result in different pregnancy outcomes. Thus, the accurate and early identification of the implantation type could be significant in the clinic in management of patients during pregnancy, the formulation of reasonable delivery plans, and also improve the prognosis of both the mother and infant in women at high risk of PAS.

Previous study has found that the greatest risk factors for the severity of placenta implantation include a previous history of cesarean section and placenta previa (10). PI and PP can result in postpartum hemorrhage and hysterectomy in pregnant women, and the risks and complications tend to increase as the depth of placenta invasion increases. Thus, it is particularly important to estimate the invasion depth of severe PAS before delivery.

The women included in our study were all high-risk pregnant women, as they had history of placenta previa, and most of them (90%) had undergone at least 1 cesarean section before. At present, the prenatal diagnosis of PAS primarily relies on an imaging examination combined with consideration of the related high-risk factors, and ultrasonography is still prioritized for the diagnosis of PAS. However, MRI is routinely used to diagnose PAS in the clinic because of its advantages, which include multi-sequencing, the non-invasive nature of the procedure, the lack of radiation, and the high imaging resolution, which is able to differentiate among the soft tissues and can show the position of the fetus and placenta (11). MRI is also used clinically as an approach for verifying PAS, especially in high-risk patients and those highly suspected to have PAS in the initial ultrasonography. Previous studies (12) have described MRI as the optimal tool for estimating PAS in patients with placenta previa, and it is highly accurate in diagnosing the severity of PAS (13,14).

D'Antonio *et al.* (15) conducted a meta-analysis of 18 related studies, comprising 1,010 pregnant women at risk for PAS, and found that MRI had a higher accuracy in the detection of PAS than US. Previous study has suggested that the accuracy of MRI is higher than that of US in the detection of PAS (15). This is probably due to the fact that MRI is mostly used to further confirm the diagnosis in patients highly suspected to have PAS based on their US examination. Findings that the accuracy of MRI is higher than that of US have resulted in obstetricians being inclined to make an MRI diagnosis of PAS in the clinic, and most obstetricians insist that MRI is much more sensitive than US, and are more willing to accept MRI findings.

Conversely, the current Recommendations of the Obstetric Care Consensus for PAS Report (6) suggest that it is still unclear whether MRI is superior to US in the diagnosis of PAS, and, do not recommend MRI for the preliminary examination of patients suspected to have PAS. Khalaf *et al.* (16) reported that MRI is not reliable in the detection of PA or measuring the depth of invasion.

Einerson *et al.* (17) suggested that while the interobserver reliability of MRI for a diagnosis of PAS is substantial, the accuracy and predictive value are more modest than previously reported.

Previous study on the use of US for PAS was generally based on simplex observations of the US imaging signs. To boost the efficiency of US in the diagnosis of PAS, many research institutes (18) developed scoring standards for PAS in compliance with different specific signs generated in US diagnosis of real PAS and a consideration of the high risk factors in pregnancies through mathematical modeling, which has significantly improved the prediction accuracy.

In this study, we created our own scoring criteria by combining the 8 ultrasonic signs for PAS with a history of cesarean section, and found that: (I) the sensitivity, specificity, PPV, NPV, and diagnostic coincidence rate of the ultrasonic sign-scoring method in the diagnosis of the 3 types of PAS were higher than those of MRI; (II) there were no significant differences in the areas under the ROC curves in the detection of PA when comparing MRI and US (P>0.05), but a comparison of the sensitivity and specificity of the ultrasonic sign-scoring method and MRI in diagnosing PAS via ROC curves revealed that the areas under the ROC curves were greater in the diagnosis of PI and PP by US than by MRI (P<0.05). These findings suggest that the prenatal ultrasonic sign-scoring method is superior to MRI in diagnosing PA and PP, and MRI is not helpful in diagnosis of severe PAS cases; and (III) the missed diagnosis rate was lower for the ultrasonic sign-scoring method than MRI (8.16% *vs.* 22.44%, P<0.05), especially for the PP that was identified by the ultrasonic sign-scoring method in 5 cases, 4 of which were confirmed by postoperative pathology, However, only 2 cases of PP were detected by MRI, and its missed diagnosis rate was 50%. Additionally, 5 cases of PI diagnosed by US scoring method were suggested to be PA by MRI, but confirmed to be PI after surgery. Luo *et al.* (3) also estimated the severity of PAS using the ultrasonic sign-scoring method and observed that this approach not only improved the detection rate in pregnant women with severe PA, but also specifically differentiated among the 3 types. It is also believed that this scoring method can not only improve the recognition rate of pregnant women with severe placenta accreta, but also can specifically distinguish penetrative placenta accreta.

D'Antonio (15) has noted that MRI was more advantageous than US in the posterior and lateral placental location and could be used to estimate the degree and extent of implantation and parametrial involvement. The diagnostic sensitivity and specificity of MRI were reported to be as high as 94.4% and 98.8%, respectively.

ACOG also confirmed in 2017 that MRI can be used as an auxiliary diagnosis method in the context of failure detection of implantation at the posterior placental location or if difficulties arise in determining the suspected condition. Nevertheless, MRI failed to boost the diagnostic accuracy compared to ultrasonography in the 18 cases of posterior or lateral placental location included in the current study, which suggests that the efficiency of MRI in diagnosing PAS was not affected by the placental location. We did not observe any higher diagnostic accuracy for the posterior or lateral placental implantation by MRI, which suggests that MRI would not be useful in the diagnosis of this type of PAS. These results are consistent with other study (19). Moreover, MRI was mostly performed in the third trimester in the pregnancies included in this study, and the myometrium gradually grows thinner as gestational age increases, which may have also reduced the accuracy of MRI (20).

Conclusions

This study had some limitations. First, as this was a retrospective analysis, selection bias may exist. Second, the sample size was not large enough to counteract the bias. Third, other factors, including the imaging differences in MRI scans, subjective conclusions drawn by physicians and image interpretation affected by the experience of radiologists, may to a certain extent impair the diagnostic performance of MRI. Although the sensitivity and specificity of US were better than MRI, they were lower than 0.8. Studies with larger sample sizes are needed. In addition, this study was conducted in a high-risk population, both the ultrasonic sign-scoring method and MRI had relatively high sensitivity and low specificity. In conclusion, this study demonstrated that the prenatal ultrasonic sign-scoring method was superior to MRI in the detection of all types of PAS, especially severe PAS, and was not affected by the placental position. In view of the high costs and other factors that limit the clinical use of MRI, such as interference due to fetal movement during examination and the number of gestational weeks, we cannot recommend that MRI be use as a routine examination for PAS.

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Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-6508/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-6508/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-6508/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Institutional Review Board of Yijishan Hospital (No. 2022031). All the study subjects provided informed consent.

References

1. Hu Y, Wang Y, Weng Q, et al. Intraplacental T2-hypointense bands may help predict placental invasion depth and postpartum hemorrhage in placenta accrete spectrum disorders in high-risk gravid patients. Magn Reson Imaging 2022;94:73-9.
2. Xu J, Shao Q, Chen R, et al. A dual-path neural network fusing dual-sequence magnetic resonance image features for detection of placenta accrete spectrum (PAS) disorder. Math Biosci Eng 2022;19:5564-75.
3. Luo L, Sun Q, Ying D, et al. Scoring system for the prediction of the severity of placenta accrete spectrum in women with placenta previa: a prospective observational study. Arch Gynecol Obstet 2019;300:783-91.
4. Sargent W, Gerry S, Collins SL. A Risk-Prediction Model for Placenta Accreta Spectrum Severity From Standardized Ultrasound Markers. Ultrasound Med Biol 2023;49:512-9.
5. Polizio RP, Yamauchi FI, Mendes RFP, et al. Magnetic resonance imaging and previous cesarean section in placenta accrete spectrum disorder: Predictor model. Clinics (Sao Paulo) 2022;77:100027.
6. American College of Obstetricians and Gynecologists; Society for Maternal-Fetal Medicine. Obstetric Care Consensus No. 7: Placenta Accreta Spectrum. Obstet Gynecol 2018;132:e259-e275.
7. Jauniaux E, Ayres-de-Campos D, Langhoff-Roos J, et al. FIGO classification for the clinical diagnosis of placenta accreta spectrum disorders. Int J Gynaecol Obstet 2019;146:20-4.
8. Wortman AC, Alexander JM. Placenta accreta, increta, and percreta. Obstet Gynecol Clin North Am 2013;40:137-54.
9. Baughman WC, Corteville JE, Shah RR. Placenta accreta: spectrum of US and MR imaging findings. Radiographics 2008;28:1905-16.
10. Silver RM. Abnormal Placentation: Placenta Previa, Vasa Previa, and Placenta Accreta. Obstet Gynecol 2015;126:654-68.
11. Masselli G, Brunelli R, Casciani E, et al. Acute abdominal and pelvic pain in pregnancy: MR imaging as a valuable adjunct to ultrasound? Abdom Imaging 2011;36:596-603.
12. Romeo V, Verde F, Sarno L, et al. Prediction of placenta accreta spectrum in patients with placenta previa using clinical risk factors, ultrasound and magnetic resonance imaging findings. Radiol Med 2021;126:1216-25.
13. Familiari A, Liberati M, Lim P, et al. Diagnostic accuracy of magnetic resonance imaging in detecting the severity of abnormal invasive placenta: a systematic review and meta-analysis. Acta Obstet Gynecol Scand 2018;97:507-20.
14. Maher MA, Abdelaziz A, Bazeed MF. Diagnostic accuracy of ultrasound and MRI in the prenatal diagnosis of placenta accreta. Acta Obstet Gynecol Scand 2013;92:1017-22.
15. D'Antonio F, Iacovella C, Palacios-Jaraquemada J, et al. Prenatal identification of invasive placentation using magnetic resonance imaging: systematic review and meta-analysis. Ultrasound Obstet Gynecol 2014;44:8-16.
16. Khalaf LMR, Zeid HA, Othman ER. Reliability of Magnetic Resonance Imaging in diagnosis and assessment

the depth of invasion of placental accreta in high risk gravid women. Clin Imaging 2019;58:5-11.
17. Einerson BD, Rodriguez CE, Silver RM, et al. Accuracy and Interobserver Reliability of Magnetic Resonance Imaging for Placenta Accreta Spectrum Disorders. Am J Perinatol 2021;38:960-7.
18. Marsoosi V, Ghotbizadeh F, Hashemi N, et al. Development of a scoring system for prediction of placenta accreta and determine the accuracy of its results. J Matern Fetal Neonatal Med 2020;33:1824-30.
19. Einerson BD, Rodriguez CE, Kennedy AM, et al. Magnetic resonance imaging is often misleading when used as an adjunct to ultrasound in the management of placenta accreta spectrum disorders. Am J Obstet Gynecol 2018;218:618.e1-7.
20. Horowitz JM, Berggruen S, McCarthy RJ, et al. When Timing Is Everything: Are Placental MRI Examinations Performed Before 24 Weeks' Gestational Age Reliable? AJR Am J Roentgenol 2015;205:685-92.

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