




# Diagnostic Value of Ultrasonography and MR in Antenatal Diagnosis of Placenta Accreta Spectrum

Zahra Allameh<sup>1</sup> · Somayeh Hajjahmadi<sup>2</sup>  · Atoosa Adibi<sup>2</sup> · Zahra Ebrahimi Oloun Abadi<sup>2</sup> · Shaghayegh Mahmoodian Dehkordi<sup>1</sup>

Received: 12 August 2020 / Accepted: 14 October 2020 / Published online: 19 November 2020  
© Society of Fetal Medicine 2020

**Abstract** The aim of this study was to compare the accuracy of ultrasonography and magnetic resonance imaging (MR) in the antenatal diagnosis of placenta accreta. We also determined the most relevant sonographic and MR features associated with the diagnosis of placenta accreta. In a prospective observational study approved by the Ethical Board of the Radiology Department, 109 pregnant women who were at high risk for Placenta Accreta were enrolled. The placentas of all cases were scanned using both gray-scale and color Doppler transabdominal sonography. MR was performed when sonographic findings were equivocal or inconclusive. The sonographic and MR features were compared with the final pathologic or clinical findings. The sensitivity and specificity were calculated for both sonography and MR. The role of each sonographic and MR feature was calculated by logistic regression.  $P < 0.05$  was considered as the significance level. The sensitivity and specificity of ultrasonography for the diagnosis of Placenta Accreta spectrum were 87% and 85% ( $P < 0.001$ ), while those of MR were 100% and 42% ( $P = 0.1$ ), respectively. In ultrasonography, myometrium thickness  $\leq 1$  mm with a sensitivity of 83% (95 CI: 0.765, 0.927) and loss of retroplacental clear space with a sensitivity of 81% (95 CI: 0.755, 0.920) had the best sensitivity for the detection of the placental invasion. On MR, the heterogeneous signal intensity of placenta and uterine bulging with a sensitivity of 87% (95 CI: 0.698, 1.04) had

the best sensitivity. Placenta accreta can be successfully detected prenatally using ultrasound. MR is useful in equivocal cases.

**Keywords** Placenta accreta spectrum · Ultrasonography · MR

## Abbreviations

US	Ultrasonography
MR	Magnetic resonance imaging
PAS	Placenta accreta spectrum
Se	Sensitivity
Sp.	Specificity

## Introduction

Placenta Accreta Spectrum (PAS) Disorders are an important life-threatening obstetric problem. The incidence of these disorders has increased from 0.12% to 0.31%; these are mainly secondary to the increased number of cesarean deliveries, with up to 1/3 of all births being performed via cesarean section nowadays [1–4].

PAS occurs when chorionic villi abnormally invade myometrium secondary to an underlying defect within the decidua basalis. The entity is further classified according to the depth of trophoblastic invasion into the myometrium. Placenta accreta vera is the mildest form of PAS in which there is attachment of villi to the myometrium without myometrial invasion. In placenta increta, partial invasion of the myometrium is discerned. The most severe form of PAS is placenta percreta. It occurs when there is complete penetration of trophoblastic villi into the

✉ Somayeh Hajjahmadi  
sohajjahmadi@gmail.com

<sup>1</sup> Department of Obstetrics and Gynecology, Isfahan University of Medical Sciences, Isfahan, Iran

<sup>2</sup> Department of Radiology, Isfahan University of Medical Sciences, Isfahan, Iran

entire myometrial thickness or there is an extension of trophoblastic villi beyond the uterine serosa [5].

PAS is associated with major complications. Clinical consequence of PAS include massive bleeding during placental separation, which can lead to Disseminated Hypovolemic Shock, Disseminated Intravascular Coagulation, Adult Respiratory Distress Syndrome and even death. Hysterectomy is frequently necessary in uncontrolled bleeding, which can be associated with accidental cystostomy, ureteral injury and pulmonary embolism. 26.6% of patients need intensive care [3, 6].

Major risk factors for PAS are placenta previa and prior cesarean section. There is a synergistic relation between placenta previa and the increased number of cesarean sections. Minor risk factors include a history of dilation and curettage, uterine surgery, the presence of a uterine anomaly, advanced maternal age, smoking and hypertension [2, 6, 7].

Accurate prenatal diagnosis of PAS is essential for optimal management in a tertiary care center with a multidisciplinary approach [5].

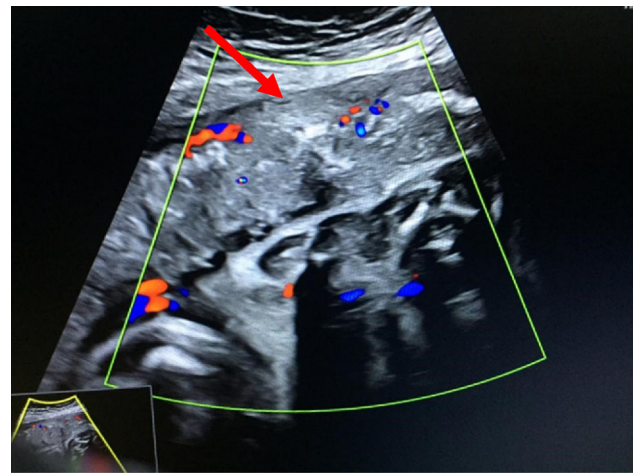
Ultrasonography (US) is the primary diagnostic modality for PAS. It has a reported detection rate of 50–80% of cases [8].

Findings of PAS on US include placental lacunae with turbulent flow, irregular bladder wall with extensive associated vascularity, loss of retroplacental clear space, myometrial thickness  $< 1$  mm (Fig. 1) or loss of visualization of the myometrium and the gap in the retroplacental blood flow (Fig. 2).

In recent years, Magnetic Resonance Imaging (MR) has emerged as a complementary tool in the diagnosis of PAS, especially in posterior placenta. It has been found to be useful when sonographic findings are equivocal or



**Fig. 1** 27 years old female, transabdominal US shows placenta previa. Myometrial thickness is  $\leq 1$  mm. The diagnosis was focal placenta accreta



**Fig. 2** 30 years old female, transabdominal color Doppler US shows a gap in retroplacental blood flow (arrow). The diagnosis was placenta increta

inconclusive. However, there are few studies providing specific MR findings. The most useful features on MR include uterine bulging, heterogeneous signal intensity within the placenta (Fig. 3), and dark intraplacental bands on T2-weighted images (Figs. 3, 4) [9].

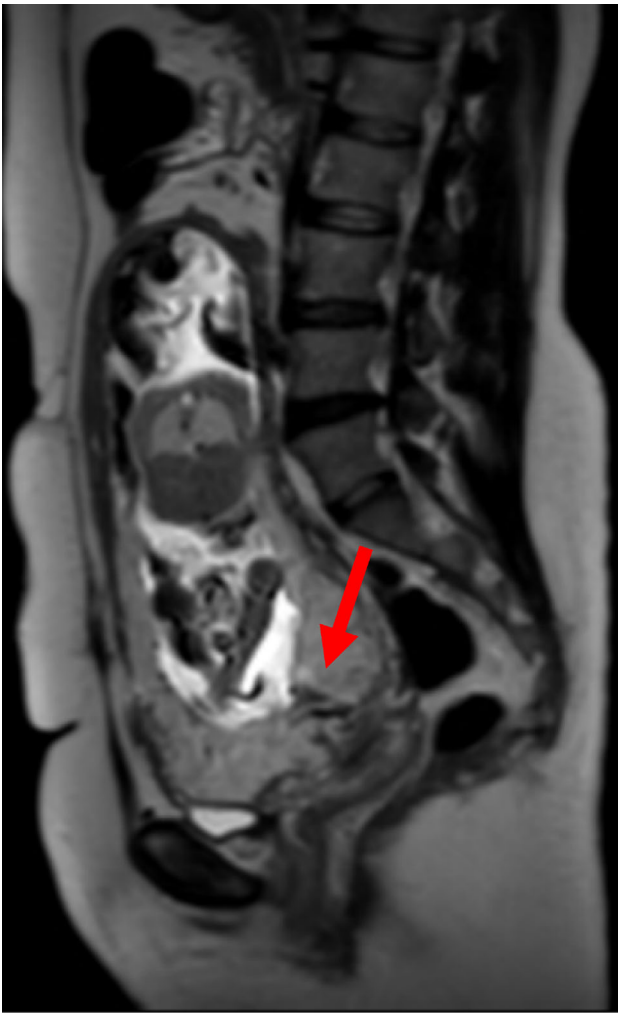
The aim of this study was to evaluate the accuracy of sonographic and MR findings in predicting the PAS and to determine the most relevant specific ultrasound and MR features in predicting placental invasion.

## Materials and Methods

### Patients Selection

This prospective observational study was conducted between May 2017 and August 2018. The study was approved by the Ethical Board of the Radiology Department. The aim of this study was explained to the patients and informed consent was obtained. One hundred and nine pregnant women who were at high risk for PAS during their second and third trimester of pregnancy were enrolled in this study. Participants with at least one or more of the following risk factors would be considered as high risk for PAS: Placenta previa, prior uterine surgery, previous cesarean section, history of dilatation and curettage, uterine anomalies, myomectomy, and advanced maternal age ( $> 35$  years). Patients who refused to participate in the study were excluded.

A transabdominal US was performed for all patients and when sonographic results were equivocal or inconclusive, MR was conducted as well.



**Fig. 3** 34 years old female, sagittal T2 w MR image shows placenta previa with a dark intraplacental band (arrow) and focal interruption of the myometrial wall. The diagnosis was placenta accreta

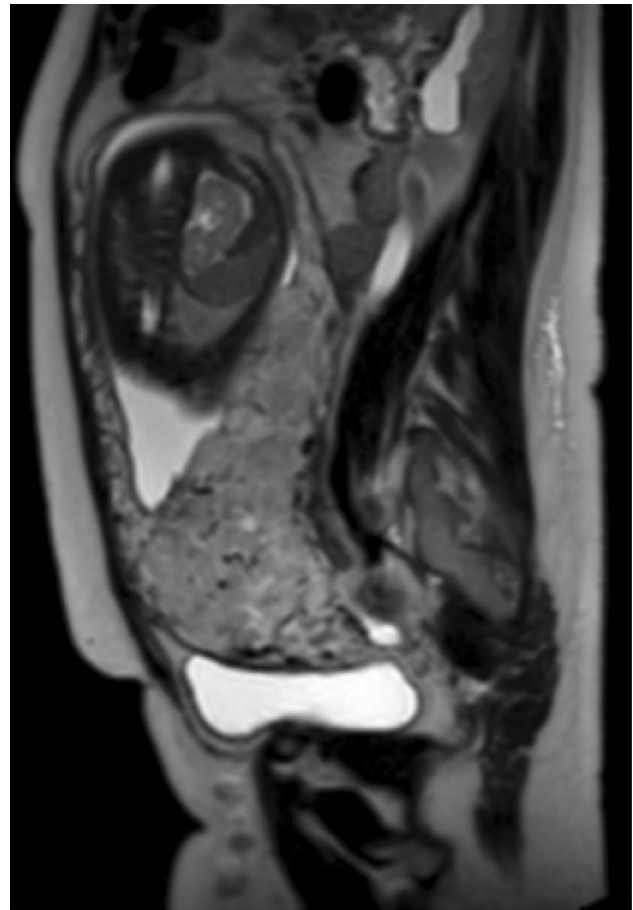
### Ultrasonography

Transabdominal scan with color and pulsed wave Doppler was used for placental evaluation. The placenta was imaged with a sufficient bladder volume to clearly visualize the serosa–bladder interface. A GE Voluson Expert 730 system (GE Electric Medical System, Milwaukee, WI, USA) was used with an abdominal convex probe of 3.5 MHz. All these specific scans were conducted by an operator with greater than 10 years, of experience in obstetric US.

In each patient location of the placenta and the presence of placenta previa was identified.

The presence of the following data was recorded for each patient and considered consistent for the diagnosis of PAS:

- 1 placental lacunae with turbulent flow



**Fig. 4** 28 years old female; sagittal T2 w MR image shows placenta previa, dark intraplacental band, heterogeneous placental appearance and focal interruption in the myometrial wall. The diagnosis was placenta increta

- 2 loss of retroplacental clear space
- 3 myometrial thickness  $\leq 1$  mm or loss of visualization of the myometrium
- 4 retroplacental blood flow gap
- 5 irregular bladder wall with extensive associated vascularity

### MR Technique

MR was performed with Philips Ingenia 1.5 T with the following image parameters:

T2-weighted images in all three planes (axial, sagittal, and coronal) with half-Fourier rapid acquisition with relaxation enhancement (RARE) sequences and axial fat-saturated fast spin-echo T2-weighted and T1-weighted in-phase sequences were obtained.

Breath-holding techniques were used whenever patient tolerance made them possible. Patients were routinely given oxygen via a nasal cannula to reduce fetal motion. To better evaluate urinary bladder involvement with placenta

**Table 1** Demographic and clinical characteristics

Characteristics	
Average age (in years)	32.8 ± 4.4
Gravidity	3
Previous cesarean delivery	75 (70%)
Average gestational age at the time of diagnosis (weeks)	32
Placental insertion (%)	
Previa	51 (47.6%)
Low-lying	1 (.93%)
Non low-lying	55 (51.4%)
Final diagnosis (%)	
Focal accrete	12 (11.2%)
Accrete/increta	16 (14.9%)
Percreta	19 (17.7%)

percreta, the patients' bladder was ensured to be at least partially filled. Contrast media were not administered.

#### MR Image Analysis

All images were viewed by the Onis 2.6 software in the MR workstation and transferred to the picture archiving and communication system (PACS). Image analysis was performed in consensus by two radiologists, each with 8 and 12 years of experience in women's imaging. Any disagreement was resolved by a senior investigator with 15 years of experience in interpreting pelvic MR images.

The presence of the following data was recorded for each patient and considered consistent for the diagnosis of PAS:

- 1 Uterine bulging
- 2 Heterogeneous signal intensity within the placenta
- 3 Dark intraplacental bands on T2-weighted images
- 4 Focal interruptions in the myometrial wall
- 5 Tenting of the urinary bladder
- 6 Direct visualization of the invasion of the pelvic structures by the placental tissue.

#### Diagnosis of Placenta Accreta

Placenta accreta was defined by clinical criteria at the time of delivery, according to the pathologic findings. If the placenta was easily removed during cesarean delivery without any bleeding complications, it would be considered normal. The gold standard for the confirmation of abnormal adherence of the placenta is pathologic confirmation after hysterectomy. However, hysterectomy is not always clinically indicated or possible, and management should be conservative. In such situations, the diagnosis was based on the clinical information provided at the time of delivery

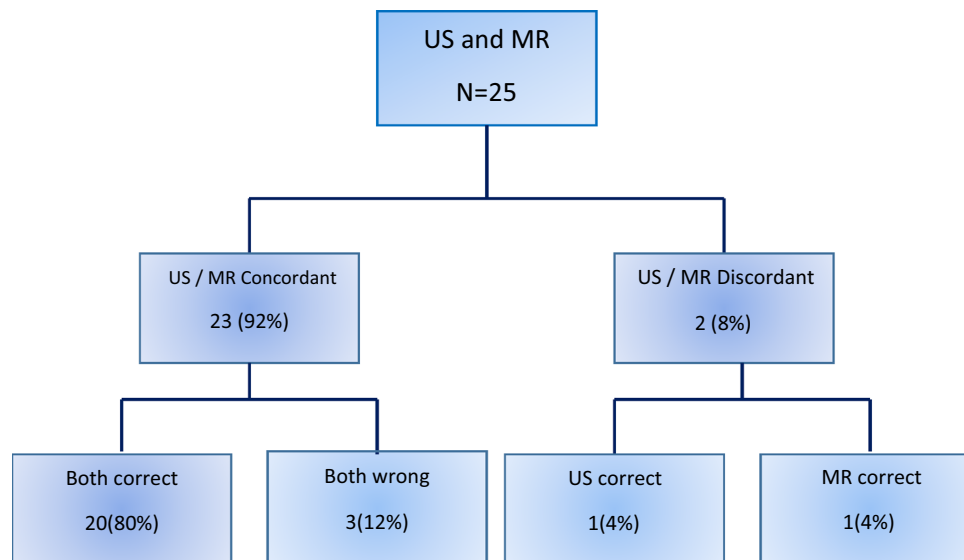
and surgery. The placenta was considered as accreta when the delivery was impossible and as percreta when it was evident that the placenta had reached the uterine serosa or the adjacent organs.

#### Statistical Analysis

The final collected data were entered into SPSS 25 (Chicago, SPSS Inc.) All quantitative data were reported as mean ± standard deviation and the qualitative ones were reported as percentages and counts. The sensitivity (Se) and specificity (Sp), as well as the 95% confidence interval, were calculated for both sonography and MR. The diagnostic values of MR were limited to the patients who had undergone both modalities. The role of each sonographic and MR feature in the prediction of PAS was calculated by logistic regression. Also,  $P < 0.05$  was considered as the significance level.

#### Results

The present study included 109 pregnant women suspected to have PAS with a mean age of  $32.8 \pm 4.4$  years, and an age range of 22 to 43 years, respectively. In the case of two participants, missing data were present. Transabdominal US was performed in 107 patients for the evaluation of the PAS disorders. In equivocal or inconclusive sonographic findings, MR was conducted (25 patients). Clinical and demographic information are shown in Table 1. Cesarean delivery was performed for 107 patients, and 47 (43.9%) were identified as PAS. There were 12 cases of focal accreta (11.2%), 16 accreta/increta (14.9%) and 19 placenta percreta (17.7%).



**Fig. 5** Concordance between US and MR

### Ultrasonography and MR Sensitivity and Specificity

In 107 patients, transabdominal US was performed; in 92 (85.98%) patients, the sonographic findings were in concordance with clinical-pathologic findings at the time of delivery; however, in 15 patients (14.01%), sonographic impression was incorrect; in 6 patients (5.6%), despite normal sonography, the clinical-pathologic findings of the PAS were discerned; however, in 9 patients (8.4%), sonography wrongly diagnosed the PAS.

MR was performed in 25 patients; in 21 (84%) patients, MR findings were in concordance with clinical-pathologic findings at the time of delivery, but in 4 patients (16%) MR, wrongly diagnosed the non-adherent placenta as PAS.

Sensitivity and specificity of US for the diagnosis of the PAS were 87% and 85% ( $P < 0.001$ ), while those of MR were 100% and 42% ( $P$  value 0.1), respectively.

### Concordance Between Ultrasound and MR

In 25 patients, both imaging modalities were performed. There was an agreement between US and MR results in 23 patients (92%); in 20 patients (80%), the results were in concordance with clinical-pathologic findings at the time of delivery; and, in 3 ones (12%), imaging had the incorrect diagnosis.

On the other hand, there was disagreement between US and MR in 2 patients (8%); in one case, ultrasound cor-

rectly diagnosed the PAS and in other ones, MR suggested the correct diagnosis of the PAS (Fig. 5).

### Ultrasound and MR Features

In order to determine the most sensitive sonographic and MR feature that could predict PAS, we evaluated each feature by logistic regression for predicting a final PAS diagnosis.

In US, myometrium thickness  $\leq 1$  mm with a sensitivity of 83% (95 CI: 0.765, 0.927) and loss of retroplacental clear space with a sensitivity of 81% (95 CI: 0.755, 0.920) had the best sensitivity for the detection of placental invasion.

On MR, heterogeneous signal intensity of placenta and uterine bulging with a sensitivity of 87% (95 CI: 0.698, 1.04) had the best sensitivity, but only the former was statistically significant, Other features did not show a statistically significant value for the prediction of PAS (Table 2).

### The Role of Risk Factors

The presence of placenta previa is the most important risk factor in the diagnostic performance with an AUC of 0.883 (95 CI: 0.811, 0.95), a sensitivity of 0.91 and a specificity of 0.86 ( $P < 0.001$ ).

Other risk factors were not statistically significant in predicting placenta accreta.

**Table 2** Sensitivity and specificity of ultrasound and MR features

	Sensitivity	Specificity	P value	AUC
<i>Ultrasound feature</i>				
Placental lacunae with turbulent flow	0.489	0.9	0.001	0.695
Loss of retroplacental clear space	0.81	0.87	< 0.001	0.838
Myometrial thickness < 1 mm	0.83	0.87	< 0.001	0.846
Gap in the retro-placental blood flow	0.77	0.87	< 0.001	0.816
Irregular bladder wall	0.39	0.98	0.001	0.687
<i>MR features</i>				
Uterine bulging	0.89	0.57	0.07	0.730
Heterogeneous signal intensity of placenta	0.89	0.86	0.004	0.873
Dark intra-placental bands	0.50	0.57	0.78	0.536
Focal interruption in myometrial wall	0.72	0.28	0.97	0.504
Tenting bladder	0.94	0.43	0.15	0.687

## Discussion

Although ultrasound is the mainstay of imaging of placenta accreta, MR has been used as an adjunct in diagnosis when ultrasound results are equivocal and/or clinical suspicion is high. In our study, we compared the diagnostic accuracies of US and MR in the diagnosis of PAS in 107 pregnant women suspected to have PAS and took clinical information provided at the time of delivery and surgery as the gold standard.

In this study, US correctly diagnosed PAS in 85.9% of cases. The correct diagnosis was made in 84% of cases for MR. The sensitivity and specificity of US for the diagnosis of the PAS were 87% and 85% ( $P < 0.001$ ), while those of MR were 100% and 42% ( $P$  value 0.1) respectively. Also, we showed that the presence of placenta previa is the most important risk factor in diagnostic performance for PAS. Our findings are similar to those of other studies. Meng et al. [10] also showed that US sensitivity was 83%, and its specificity was 95%, as compared to those for MR, which were 82% and 88%, respectively. Daney et al. [11] showed the sensitivity and specificity of 92% and 67% for US, and 84% and 78% for MR, respectively. The study done by Maher et al. [12] was also in agreement with our results, showing the sensitivity of 95.1% and the specificity of 95.5% for US, while these were 85.7% and 76.9% for MR, respectively.

In this study, there was an agreement between US and MR results in 23 patients (92%). In 20 patients (80%), the results were in concordance with clinical-pathologic findings at the time of delivery. In 3 patients (12%), however, imaging had an incorrect diagnosis. In ultrasound, myometrium thickness  $\leq 1$  mm (sensitivity: 83%) and loss of retroplacental clear space (sensitivity: 81%) had the best sensitivity for the detection of placental invasion.

In a study done by Anne Sophie Riteau et al., US and MR were in agreement for 68.3% of cases; these were in

concordance with clinical-pathologic findings at the time of delivery in 56.1% of cases. In this study, according to US, intraplacental lacunae and loss of the normal retroplacental clear space, had better sensitivity for the detection of placental invasion (sensitivity 88%); thinning or disappearance of the myometrium on MR showed the best sensitivity (91%) [13].

In this study, based on MR, heterogeneous signal intensity of placenta and uterine bulging had the best sensitivity (87%), but only the former was statistically significant, and other features did not show any statistically significant value in the prediction of the PAS. These results were contradictory to some previous findings. Studies carried out by D'Antonio et al. and [14] and Lax et al. [15], for example, showed the best PPV (90%) of MR when dark intraplacental bands were associated with the disappearance of the myometrium and uterine bulging. These differences could be due to small number of MR studies performed in our study.

Finally, if US and MR were used conjunctively, the detection rate of placenta accreta would be increased. Since US is more easily available, it should be included in the initial screening of the high risk patients for the early detection and timely management of PAS and MR can be reserved as a complementary imaging tool. It is also possible that transvaginal US may yield additional delineation. We did not use this.

The limitations of our study were the small number of patients who underwent MR. Also, if, in MR protocols, Gradient echo sequences were included, more reliable differentiation of the true intra placental dark bands from disorganized vessels could be performed.

## Conclusions

PAS can be successfully detected prenatally using US. MR is useful in equivocal cases.

**Acknowledgments** We thank Somayeh Shirazinejad MD assistant professor of radiology for her assistance with the data collection.

**Funding** This research did not receive any specific grant

**Availability of Data and Material** Available. Code Availability Not applicable for that section.

## Compliance with Ethical Standards

**Conflict of interest** I (as corresponding author) declare that the authors number: (1) Zahra Allameh, (2) Somayeh Hajiahmadi, (3) Atoosa Adibi are faculty members of Isfahan University of Medical Sciences, and authors number: (4) Zahra Ebrahimi Oloun abadi and (5) Shaghayegh Mahmoodian Dehkordi are radiology and Obstetric & Gyn residents respectively.

**Ethical Approval** Research Ethics Board of the Radiology Department, Isfahan University of Medical Sciences, Iran No. IR.MUI.REC.1396.3.735.

## References

- Zhang D, Yang S, Hou Y, Su Y, Shi H, Gu W. Risk factors, outcome and management survey of placenta accreta in 153 cases: a five-year experience from a hospital of Shanghai, China. *Int J Clin Exp Med*. 2017;10(8):12509–16.
- El Gelany S, Mosbeh MH, Ibrahim EM, Khalifa EM, Abdelhakium AK, Yousef AM, et al. Placenta Accreta Spectrum (PAS) disorders: incidence, risk factors and outcomes of different management strategies in a tertiary referral hospital in Minia, Egypt: a prospective study. *BMC Pregnancy Childbirth*. 2019;19(1):313.
- Silver RM, Landon MB, Rouse DJ, Leveno KJ, Spong CY, Thom EA, et al. Maternal morbidity associated with multiple repeat cesarean deliveries. *Obstet Gynecol*. 2006;107(6):1226–32.
- Kilcoyne A, Shenoy-Bhangle AS, Roberts DJ, Sisodia RC, Gervais DA, Lee SI. MRI of placenta accreta, placenta increta, and placenta percreta: pearls and pitfalls. *Am J Roentgenol*. 2017;208(1):214–21.
- Kayem G, Grange G, Schmitz T. Clinical aspects and management of morbidly adherent placenta. *Eur Clin Obstet Gynecol*. 2006;2(3):139–45.
- Usta IM, Hobeika EM, Musa AAA, Gabriel GE, Nassar AH. Placenta previa-accreta: risk factors and complications. *Am J Obstet Gynecol*. 2005;193(3):1045–9.
- Fitzpatrick KE, Sellers S, Spark P, Kurinczuk JJ, Brocklehurst P, Knight M. Incidence and risk factors for placenta accreta/increta/percreta in the UK: a national case-control study. *PLoS ONE*. 2012;7(12):e52893.
- Comstock C. Antenatal diagnosis of placenta accreta: a review. *Ultrasound Obstet Gynecol*. 2005;26(1):89–96.
- Baughman WC, Corteville JE, Shah RR. Placenta accreta: spectrum of US and MR imaging findings. *Radiographics*. 2008;28(7):1905–16.
- Meng X, Xie L, Song W. Comparing the diagnostic value of ultrasound and magnetic resonance imaging for placenta accreta: a systematic review and meta-analysis. *Ultrasound Med Biol*. 2013;39(11):1958–65.
- de Marillac Daney F, Molière S, Pinton A, Weingertner A, Fritz G, Viville B, et al. Accuracy of placenta accreta prenatal diagnosis by ultrasound and MRI in a high-risk population. *J Gynecol Obstet Biol Reprod*. 2016;45(2):198–206.
- 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(9):1017–22.
- Riteau A-S, Tassin M, Chambon G, Le Vaillant C, de Laveaucoupet J, Quere M-P, et al. Accuracy of ultrasonography and magnetic resonance imaging in the diagnosis of placenta accreta. *PLoS ONE*. 2014;9(4):e94866.
- D'antonio F, Iacovella C, Palacios-Jaraquemada J, Bruno C, Manzoli L, Bhide A. Prenatal identification of invasive placentation using magnetic resonance imaging: systematic review and meta-analysis. *Ultrasound Obstet Gynecol*. 2014;44(1):8–16.
- Lax A, Prince MR, Mennitt KW, Schwebach JR, Budorick NE. The value of specific MRI features in the evaluation of suspected placental invasion. *Magn Reson Imaging*. 2007;25(1):87–93.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.