Original Article

Impact of placental location matter in placenta accreta spectrum disorders

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Background: Multiple magnetic resonance imaging (MRI) features suggestive of placenta accreta spectrum (PAS) disorders exist. However, the impact of placental location on clinical characteristics and MRI features in PAS has not been fully explored. The aim of this study was to explore the difference of MRI signs in different placental position in PAS disorders.

Methods: We retrospectively reviewed surgically or pathologically confirmed PAS cases at Sichuan Provincial People's Hospital from 2016 to 2021. Placental location was categorized based on MRI as anterior, posterior, or anterior/posterior. MRI features were thoroughly reviewed and compared.

Results: A total of 262 patients were included in the study, comprising 38 (14.50%) with placenta accreta, 120 (45.80%) with placenta increta, 21 (8.02%) with placenta percreta, and 83 (31.68%) with normal placentas. The distribution of placental location was as follows: 32.06% posterior, 48.09% anterior, and 19.85% anterior/posterior. Placental location varied significantly between patients with and without PAS disorders and among patients with different PAS subtypes ($P<0.05$). The prevalence of placental bulge was higher in anterior and anterior/posterior placentas than in the posterior placentas ($P<0.05$). Moreover, T2 dark bands, placental heterogeneity, abnormal intraplacental vascularity, focal exophytic mass, and bladder wall interruption varied among different subtypes of PAS disorders ($P<0.05$).

Conclusions: Placental bulge emerged as the only MRI sign that exhibited differences based on placental location. Furthermore, MRI features demonstrated variations across different subtypes of PAS.

Keywords: Placenta accreta spectrum (PAS); magnetic resonance imaging (MRI); placental location

Submitted Mar 05, 2024. Accepted for publication Oct 12, 2024. Published online Nov 29, 2024.
doi: 10.21037/qims-24-443
View this article at: https://dx.doi.org/10.21037/qims-24-443

Introduction

Placenta accreta spectrum (PAS) disorders are severe complications of pregnancy characterized by abnormal villous attachment to the myometrium due to a primary or secondary uterine pathology (1). A national report conducted in 2021 reported an incidence of 1 in 313 women undergoing cesarean delivery due to PAS (2). Depending on the extent of trophoblast invasion, PAS is further classified into placenta accreta (where chorionic villi are attached to the myometrium), placenta increta (where chorionic villi invade the myometrium) and placenta percreta (a complete or partial uterine rupture, dehiscence or adhesions mainly

between the anterior lower uterine segment and the posterior wall of the bladder) (3).

In PAS disorders, myometrial invasion disrupts the normal placental detachment process from the uterus, leading to complications such as postpartum hemorrhage, injuries to surrounding organs, hysterectomy, and potentially death (4-9). Therefore, accurate prenatal diagnosis and multidisciplinary planning are crucial in managing PAS, contributing to improved maternal outcomes characterized by reduced blood loss and decreased need for blood product transfusions (10).

During the second trimester, PAS disorders are typically screened using ultrasound (US), with magnetic resonance imaging (MRI) reserved for cases with ambiguous US results. Although MRI and US demonstrate similar predictive accuracy for PAS disorders, MRI excels in detailing the depth and topography of these conditions (11). Even when US findings strongly indicate the diagnosis, MRI remains valuable in treatment planning by outlining the extent of placenta percreta diagnosed via US (12,13). Additionally, it is recommended to use MRI in cases with a posterior placenta. Previous literature has proposed a series of MRI signs indicative of PAS disorders (14-16). However, the association between placental location and the differences in MRI signs and the variations in each MRI sign suggestive of different severity of PAS disorders remain to be elucidated. PAS with a posterior location continues to pose diagnostic challenges. No studies have examined whether the subtypes of PAS and MRI signs for PAS vary based on placental location. This is crucial, as it would enable a more accurate stratification of patients suspected of having PAS disorders.

Due to the lack of examination concerning the role of placental location in PAS cases, this study aimed to illustrate different MRI signs associated with varying placental locations in PAS disorders. Additionally, it sought to explore whether MRI signs differ across different severities of PAS disorders. We present this article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-24-443/rc).

Methods

This cross-sectional study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study obtained approval from the Institutional Review Board of Sichuan Provincial People's Hospital (No. 2021288) and written informed consent was provided by all participants. A retrospective review of clinical data from pregnancies managed at Sichuan Provincial People's Hospital was conducted over 5 years from 2016 to 2021.

Patient sample

The inclusion criteria were as follows: (I) patients who underwent placental MRI examination due to suspected PAS disorders; (II) patients with a singleton pregnancy; (III) patients diagnosed with PAS disorders confirmed during cesarean section (CS) or pathological examination. US was conducted before MRI for all patients but not reviewed for this study.

The exclusion criteria were as follows: (I) MRI images that exhibited artifacts (n=15); (II) patients who delivered outside of Sichuan Provincial People's Hospital (n=96); (III) incomplete surgical or pathological results (n=16). A flow chart of the study design is illustrated in *Figure 1*.

Clinical characteristic analysis

Patient demographics, including maternal age, gestation period, gestational age at examination, gestational age at delivery, obstetric history, and specimen histopathology reports, were evaluated by reviewing the clinical records of the patients.

MRI imaging protocols

The MRI scans were conducted using a 1.5-T MR scanner (Aera; Siemens Healthineers, Erlangen, Germany). The following 2 imaging protocols were mainly used: (I) half-Fourier acquisition single-shot turbo spin echo (HASTE) in axial, coronal, and sagittal planes. The field of view (FOV) was 420 mm × 80 mm, with 5-mm-thick sections and a 20% gap. The matrix size was 272×320, with a repetition time (TR) of 1,300 ms, echo time (TE) of 93 ms, and a scan duration of 50 s. (II) True fast imaging with steady-state precession (True-FISP) in axial, coronal, and sagittal planes: The FOV was 420 mm × 80 mm, with 5-mm-thick sections and a 30% gap. The matrix size was 234×384, with a TR of 4.11 ms, a TE of 1.63 ms, and a scan duration of 48 s.

Imaging analysis

The images were independently evaluated by two experienced radiologists, each with 5 and 15 years of expertise in placental MRI. Any disagreement was resolved through consensus. The reviewers were blinded to previous MRI reports, US

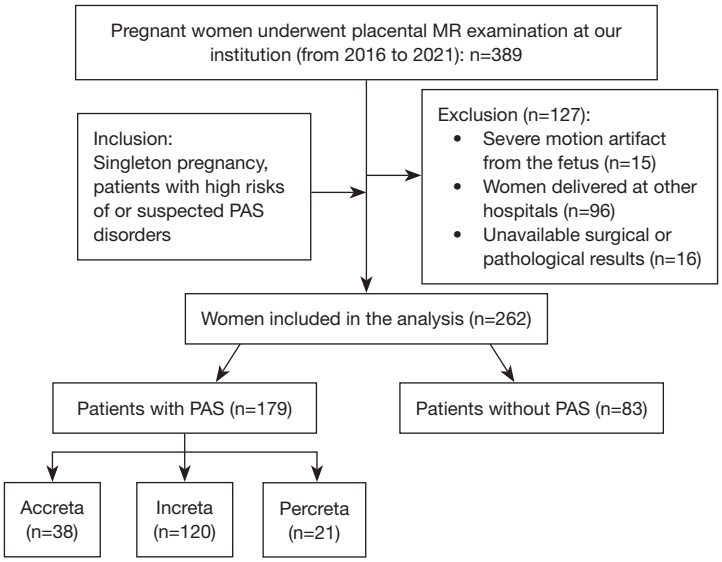

Figure 1 Flowchart of the study design. MR, magnetic resonance; PAS, placenta accreta spectrum.

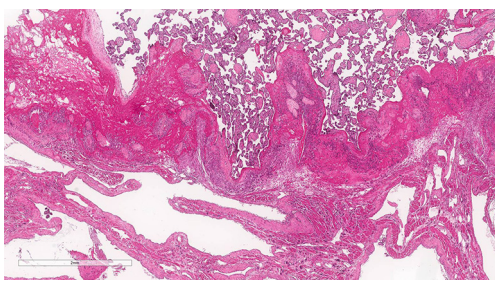

Figure 2 Histologic (hematoxylin and eosin, ×20) section showed the villi penetrated the uterine smooth muscle without intervening decidual cells.

findings, surgical details, and pathological reports. They assessed placental location, the presence or absence of placenta previa, and various recognized imaging features of PAS disorders, including dark intraplacental bands on T2 weighted (T2W) images, placental heterogeneity, abnormal intraplacental vascularity, focal exophytic mass, placental bulge, abnormal vascularization of the placental bed (uterine serosal hypervascularity, 'bladder vessel' sign, and 'parametrial vessel' sign), myometrial thinning/interruption, and bladder wall interruption ('tenting' of the bladder wall). 'Uterine serosal hypervascularity', 'bladder vessel' sign, and 'parametrial vessel' sign were grouped under 'abnormal vascularization of the placental bed' due to the extension of abnormal vascular architecture from the uterine serosa to the vesicouterine space or within the parametrial adipose tissue. 'Tenting' of the bladder wall was included in bladder wall interruption as they were both signs related to the invasion of the bladder. Placental location was categorized as anterior, posterior, or anterior/posterior for cases involving both sites on imaging.

Reference standard

Gross intraoperative findings were used as the primary reference standard for PAS according to Federation International of Gynecology and Obstetrics (FIGO) classification (17). The final diagnosis was agreed upon by two experienced obstetricians in Sichuan Provincial People's Hospital. Placenta percreta was diagnosed when placental tissue invaded the uterine serosa and/or surrounding organs, including the broad ligament, vaginal wall, and bladder, observed visually. Placenta increta was diagnosed when bluish/purple coloring, distension, or increased vascularity of the placental bed was observed, and the placenta failed to separate with gentle cord traction and the uterus being pulled inwards. Placenta accreta was diagnosed when the placenta firmly adhered to the endometrium, causing uncontrollable bleeding at the time of abruption. Pathological examination was conducted on uterine specimens in hysterectomy cases or tissue samples obtained from areas with macroscopic evidence suspicious of PAS also according to FIGO classification (17). Placenta percreta was diagnosed when a hysterectomy specimen showed villous tissue within or breaching the uterine serosa

Table 1 Patients' demographics and clinical characteristics

Characteristics	Non-PAS (N=83)	PAS (N=179)	P value
Maternal age (years)	30.75±4.08	32.27±4.64	0.011
<35	68 (81.93)	121 (67.60)	0.016
≥35	15 (18.07)	58 (32.40)	
Gravidity	3	4	0.053
Parity	1	1	0.058
GA at examination (weeks)	33	33	0.153
GA at delivery (weeks)	37	36	<0.001
Prior C-section			0.003
Yes	48 (57.83)	136 (75.98)	
No	35 (42.17)	43 (24.02)	
Number of prior C-sections			0.024
0	35 (42.17)	46 (25.70)	
1	40 (48.19)	106 (59.22)	
≥2	8 (9.64)	27 (15.08)	
Prior uterine dilation and curettage			0.142
Yes	59 (71.08)	142 (79.33)	
No	24 (28.92)	37 (20.67)	
Number of prior uterine dilation and curettage			0.227
0	24 (28.92)	35 (19.55)	
1	19 (22.89)	50 (27.93)	
≥2	40 (48.19)	94 (52.51)	
Placenta previa			<0.001
Yes	38 (45.78)	156 (87.15)	
No	45 (54.22)	23 (12.85)	
Placental position			0.001
Anterior	41 (49.40)	85 (47.49)	
Posterior	36 (43.37)	48 (26.82)	
Posterior and anterior	6 (7.23)	46 (25.70)	

Data are presented as mean ± standard deviation, number, or n (%). PAS, placenta accreta spectrum; GA, gestational age; C-section, cesarean section.

and invading surrounding organs (*Figure 2*). Placenta increta was diagnosed when hysterectomy or partial myometrial resection specimen showed villous tissue in the muscular fibers or in the lumen of deep uterine vasculature. Placenta accreta was diagnosed when hysterectomy specimen showed placental villi attached superficially to the myometrium.

Statistical analysis

Numerical data following a normal distribution were expressed as mean ± standard deviation. Data conforming to a non-normal distribution were presented as median (interquartile range). Categorical variables were expressed as numbers (proportions, %). Student's *t*-test, Mann-Whitney *U*-test, χ^2 test, and Kruskal-Wallis *H*-test were used to compare clinical features and different MRI signs between patients with PAS disorders and normal placentas and among patients with different subtypes of PAS.

The inter- and intra-reader agreement for different MRI signs was assessed using the intraclass correlation coefficient (ICC) with a 95% confidence interval (CI). An ICC of less than 0.20 indicated slight agreement, between 0.21 and 0.40 indicated fair agreement, between 0.41 and 0.60 indicated moderate agreement, between 0.61 and 0.80 indicated substantial agreement, and between 0.81 and 1.00 indicated almost perfect agreement. A significance level of P<0.05 was considered statistically significant. Statistical analyses were conducted using the software SPSS 21.0 (IBM Corp., Armonk, NY, USA).

Results

Study cohort

A total of 389 patients consequently underwent placental MRI over 5 years for suspected PAS disorders. Among them, 127 patients were excluded, leaving 262 patients included in our study (*Figure 1*). Among the 262 patients, the mean maternal age was 32 years (range, 19–45 years), and the mean gestational age at examination was 33 weeks (range, 22–39 weeks). The clinical characteristics of the two groups are shown in *Table 1*. Of the 262 patients, 21 (8.02%) underwent vaginal delivery and 241 (91.98%) underwent CS; 179 (68.32%) were diagnosed with PAS disorders, comprising 38 cases (14.50%) of placenta accreta, 120 cases (45.80%) of placenta increta, and 21 cases (8.02%) of placenta percreta.

Characteristics of PAS

The results are presented in *Table 1*. Patients diagnosed with PAS disorders were older compared to those without PAS

(P<0.05). Additionally, a higher percentage of patients with PAS disorders exhibited placenta previa and had a history of prior CS (P<0.05). Patients with PAS also more frequently underwent CS (P<0.05). However, no significant differences were observed in the number of prior dilation and curettage procedures, gravidity, and parity between patients with PAS and those without PAS (P>0.05).

The distribution of placental location was as follows: 32.06% posterior, 61.17% anterior, and 25.24% anterior/posterior. Placental location significantly varied between patients with PAS and those without PAS (P<0.05). Moreover, a higher prevalence of PAS disorders was observed when the placentas covered both the anterior and the posterior uterine walls (P<0.05).

Among the 179 PAS patients, 48 (26.82%) had posterior PAS.

Characteristics per PAS subtypes

The results are presented in *Table 2*. Women diagnosed with placenta increta were older compared to those with placenta accreta or non-PAS (P<0.005). In comparison to non-PAS, women in the placenta increta/percreta groups were more likely to have a history of prior CS (P<0.05). Additionally, women with placenta percreta more frequently underwent CS than did those with non-PAS (P<0.05). Furthermore, compared to the non-PAS and placenta accreta groups, women in the placenta increta/percreta groups were more likely to have placenta previa and delivered earlier (all P<0.05).

Patients with anterior placenta exhibited a higher incidence of placenta percreta than those with posterior placenta (P<0.05). However, placental location did not differ significantly between patients with placenta accreta and placenta increta (P>0.05). Regarding the PAS subtypes among women affected by posterior PAS, 9 (18.75%) had placenta accreta, 37 (77.08%) had placenta increta, and 2 (4.17%) had placenta percreta.

MRI signs per PAS subtypes

The results are presented in *Tables 3*,*4*. Placental bulge emerged as the sole MRI sign that varied across different placental locations (P<0.05) (*Figures 3*,*4*). Placental bulge was dominant in cases of anterior placenta and anterior/posterior placenta compared to posterior placenta (P<0.05) (*Figures 3-6*). Various MRI signs, including dark intraplacental bands on T2W images, placental heterogeneity, abnormal intraplacental vascularity, focal exophytic mass, and bladder wall interruption, differed significantly among different subtypes of PAS disorders (P<0.05). Dark intraplacental bands on T2W images and focal exophytic mass were more common in patients with placenta percreta than those with placenta accreta and placenta increta (P<0.05). Abnormal intraplacental vascularity was more prevalent in patients with placenta increta and percreta than those with accreta (P<0.05). Moreover, placental heterogeneity was more frequently observed in patients with placenta percreta than those with placenta accreta (P<0.05).

Interrater agreement of MRI features of PAS

Substantial interobserver agreement (k>0.7) was observed for T2 dark bands, abnormal intraplacental vascularity, and bladder wall interruption ('tenting' of the bladder wall). Moderate interobserver agreement (k>0.4) was observed for placental heterogeneity, myometrial interruption, placental bulge, and focal exophytic mass (*Table 5*).

Discussion

Our study results align with previously identified risk factors for PAS, notably placenta previa, prior CS, and increasing maternal age (7,18). Previous analyses have shown increases in PAS rates from 1/625 in 2001 to 1/500 in 2011 among women with prior CS (19) and from 1/370 to 1/313 among CS cases from 2015 to 2017 (2). Maurea *et al.*'s study further showed that the number of previous CS was an independent clinical predictor of PAS (20). Placenta previa stands out as another significant risk factor for PAS. A cohort study in Nordic countries revealed an estimated prevalence of 41.8 cases per thousand among patients with placenta previa, significantly higher than the general prevalence of 0.3 cases per thousand pregnancies or 8.8 cases per thousand among those with three previous cesarean deliveries (21). Lu *et al.* also showed that placenta previa was an independent risk factor for predicting postpartum hemorrhage in PAS patients (22).

Our study also observed an increased association of placenta increta/percreta among patients with prior CS and placenta previa and an increasing association of placenta increta among individuals with increasing maternal age, consistent with findings from previous studies (7,18-21,23).

Women diagnosed with placenta increta/percreta delivered earlier than those with placenta accreta and non-

Table 2 Patients' demographics and clinical characteristics per PAS subtypes

Characteristics	None (N=83)	Accreta (N=38)	Increta (N=120)	Percreta (N=21)	P value
Maternal age (years)	30.75±4.08	30.89±4.57	32.78±4.59	31.86±4.73	0.008
<35	68 (81.93)	9 (23.68)	44 (36.67)	5 (23.81)	0.028
≥35	15 (18.07)	29 (76.32)	76 (63.33)	16 (76.19)	
Gravidity	3	3.5	3.5	4	0.081
Parity	1	1	1	1	0.095
GA at examination (weeks)	33	34	33	30	0.048
GA at delivery (weeks)	37	37	36	36	0.008
Prior C-section					0.007
Yes	48 (57.83)	26 (68.42)	91 (75.83)	19 (90.48)	
No	35 (42.17)	12 (31.58)	29 (24.17)	2 (9.52)	
Number of prior C-sections					0.029
0	35 (42.17)	12 (31.58)	32 (26.67)	2 (9.52)	
1	40 (48.19)	23 (60.53)	70 (58.33)	13 (61.90)	
≥2	8 (9.64)	3 (7.89)	18 (15.00)	6 (28.57)	
Prior uterine dilation and curettage					0.682
Yes	59 (71.08)	29 (76.32)	95 (79.17)	18 (85.71)	
No	24 (28.92)	9 (23.68)	25 (20.83)	3 (14.29)	
Number of prior uterine dilation and curettage					0.674
0	24 (28.92)	9 (23.68)	23 (19.17)	3 (14.29)	
1	19 (22.89)	9 (23.68)	34 (28.33)	7 (33.33)	
≥2	40 (48.19)	20 (52.63)	63 (52.50)	11 (52.38)	
Placenta previa					<0.001
Yes	38 (45.78)	27 (71.05)	110 (91.67)	19 (90.48)	
No	45 (54.22)	11 (28.95)	10 (8.33)	2 (9.52)	
Placental position					0.001
Anterior	41 (49.40)	16 (42.11)	54 (45.00)	15 (71.43)	
Posterior	36 (43.37)	9 (23.68)	37 (30.83)	2 (9.52)	
Posterior and anterior	6 (7.23)	13 (34.21)	29 (24.17)	4 (19.05)	

Data are presented as mean ± standard deviation, number, or n (%). PAS, placenta accreta spectrum; GA, gestational age; C-section, cesarean section.

PAS, primarily due to most deliveries being scheduled before 36 weeks of gestation to mitigate the risk of bleeding in women with placenta increta/percreta.

Our study revealed that women with placenta percreta had a higher prevalence of anterior placentas (71.43%) than posterior placentas (9.52%). This distribution of placental location mirrors findings from Morgan *et al.*'s study, which reported a lower incidence of percreta with a posterior location compared to the anterior and anterior/posterior groups (24). This phenomenon may be attributed to the abnormal implantation of the gestational sac and subsequent placental invasion when an anterior placenta previa overlays

Table 3 Different MRI signs by different placental location in placenta accreta spectrum cases

MRI signs	Placental position			P value
	Anterior (N=85)	Posterior (N=48)	Posterior and anterior (N=46)	
Dark intraplacental bands on T2W images				0.893
Yes	41 (48.24)	23 (47.92)	24 (52.17)	
No	44 (51.76)	25 (52.08)	22 (47.83)	
Placental heterogeneity				0.899
Yes	23 (27.06)	12 (25.00)	12 (26.09)	
No	62 (72.94)	36 (75.00)	34 (73.91)	
Abnormal intraplacental vascularity				0.151
Yes	52 (61.18)	26 (54.17)	20 (43.48)	
No	33 (38.82)	22 (45.83)	26 (56.52)	
Focal exophytic mass				0.922
Yes	20 (23.53)	10 (20.83)	11 (23.91)	
No	65 (76.47)	38 (79.17)	35 (76.09)	
Placental bulge				0.024
Yes	24 (28.24)	4 (8.33)	9 (19.57)	
No	61 (71.76)	44 (91.67)	37 (80.43)	
Abnormal vascularization of the placental bed				0.120
Yes	22 (25.88)	6 (12.50)	7 (15.22)	
No	63 (74.12)	42 (87.50)	39 (84.78)	
Myometrial thinning/interruption				0.988
Yes	22 (25.88)	13 (27.08)	12 (26.09)	
No	63 (74.12)	35 (72.92)	34 (73.91)	
Bladder wall interruption ('tenting' of the bladder wall)				0.48
Yes	2 (2.35)	0	1 (2.17)	
No	83 (97.65)	48 (100.00)	45 (97.83)	

Data are presented as n (%). MRI, magnetic resonance imaging; T2W, T2-weighted.

a prior large CS scar.

In our study, the incidence of PAS in women with a posterior placenta was 26.82%, significantly higher than the 4.8% reported in Tinari *et al.*'s analysis (25). The increased detection rate of posterior PAS observed through MRI in our study may be attributed to the inclusion of cases from a highly selected cohort of women who had already undergone US screening, potentially introducing bias. Diagnosing PAS with a posterior placental location is often delayed and challenging, even with MRI. The signs observed on MRI may vary when the abnormal placenta invasion occurs towards the posterior uterine wall. No studies have investigated whether MRI signs of PAS vary based on placental location. However, recognizing differences in MRI signs according to placental location may enhance clinical awareness, aid in accurately interpreting MRI features, improve diagnosis, and facilitate management.

Dark intraplacental bands on T2W images, placental heterogeneity, abnormal intraplacental vascularity, focal exophytic mass, placental bulge, abnormal vascularization of the placental bed (including uterine serosal

Table 4 Different MRI signs by different PAS subtypes

MRI signs	PAS subtypes			P value
	Accreta (n=38)	Increta (n=120)	Percreta (n=21)	
Dark intraplacental bands on T2W images				0.008
Yes	16 (42.11)	55 (45.83)	17 (80.95)	
No	22 (57.89)	65 (54.17)	4 (19.05)	
Placental heterogeneity				0.007
Yes	4 (10.53)	33 (27.50)	10 (47.62)	
No	34 (89.47)	87 (72.50)	11 (52.38)	
Abnormal intraplacental vascularity				<0.001
Yes	10 (26.32)	74 (61.67)	14 (66.67)	
No	28 (73.68)	46 (38.33)	7 (33.33)	
Focal exophytic mass				0.001
Yes	4 (10.53)	26 (21.67)	11 (52.38)	
No	34 (89.47)	94 (78.33)	10 (47.62)	
Placental bulge				0.105
Yes	4 (10.53)	26 (21.67)	7 (33.33)	
No	34 (89.47)	94 (78.33)	14 (66.67)	
Abnormal vascularization of the placental bed				0.199
Yes	8 (21.05)	20 (16.67)	7 (33.33)	
No	30 (78.95)	100 (83.33)	14 (66.67)	
Myometrial thinning/interruption				0.417
Yes	9 (23.68)	30 (25.00)	8 (38.10)	
No	29 (76.32)	90 (75.00)	13 (61.90)	
Bladder wall interruption ('tenting' of the bladder wall)				0.01
Yes	0	1 (0.83)	2 (9.52)	
No	38 (100.00)	119 (99.17)	19 (90.48)	

Data are presented as n (%). MRI, magnetic resonance imaging; PAS, placenta accreta spectrum; T2W, T2-weighted.

hypervascularity, 'bladder vessel' sign, and 'parametrial vessel' sign), myometrial interruption, and bladder wall interruption ('tenting' of the bladder wall) have been proposed as indicators of PAS disorders (14-16). However, previous studies have not accounted for placental location when interpreting the MRI signs. Our study found that placental bulge varied according to placental location and was less common in posterior placentas. Typically, the pregnant uterus assumes an inverted pear shape; an abnormal placental bulge is characterized by the widening of the lower uterine segment, resulting in an hourglass configuration of the uterus (14). This abnormality occurs when chorionic villi invade deep into or through the myometrium, leading to a loss of structural integrity in the surrounding myometrium (26). Jha *et al.* demonstrated that the placenta bulge signified myometrial invasion and was observed in placenta increta and placenta percreta. When other indicators of invasive placenta were accompanied placenta bulge, it was 100% indicative of myometrial invasion (27). Maurea *et al.* showed that placental bulge was an independent MRI predictor of PAS (20). Our study observed that the placental bulge was not commonly found

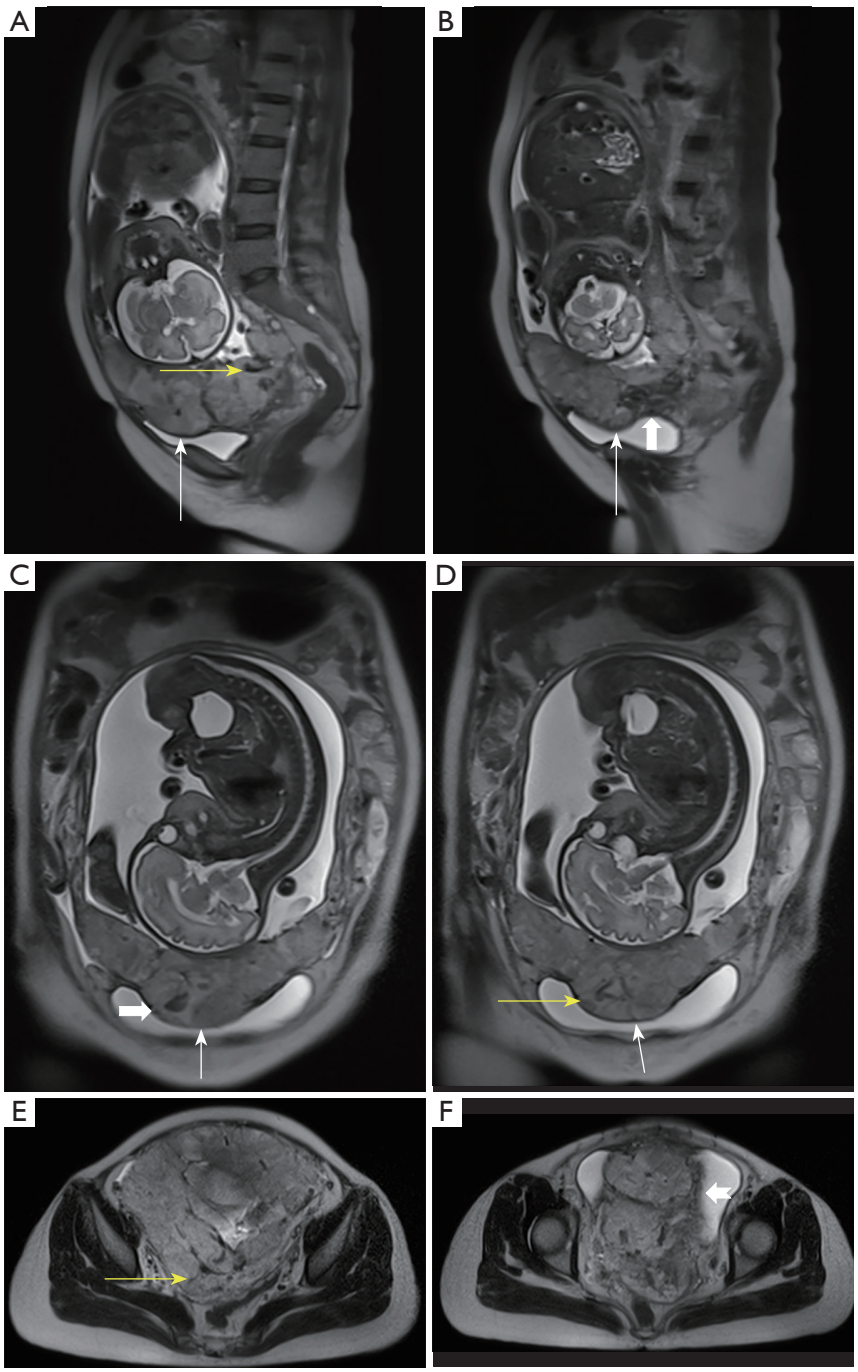

Figure 3 A 37-year-old woman who had previously undergone two cesarean sections presented with complete placenta previa and concerns regarding placenta accreta spectrum disorder. The patient was at 30 weeks of gestation with placenta increta. The placenta extends to cover the anterior and the posterior walls of the uterus. (A,B) In sagittal, (C,D) coronal, and (E,F) axial half-Fourier acquisition single-shot turbo spin echo images, the presence of placental bulge is evident, characterized by widening of the lower uterine segment (white arrows). Additionally, T2-dark bands (white, thick arrows), abnormal intraplacental vascularity (yellow arrows), and myometrial interruption (arrowhead) were observed.

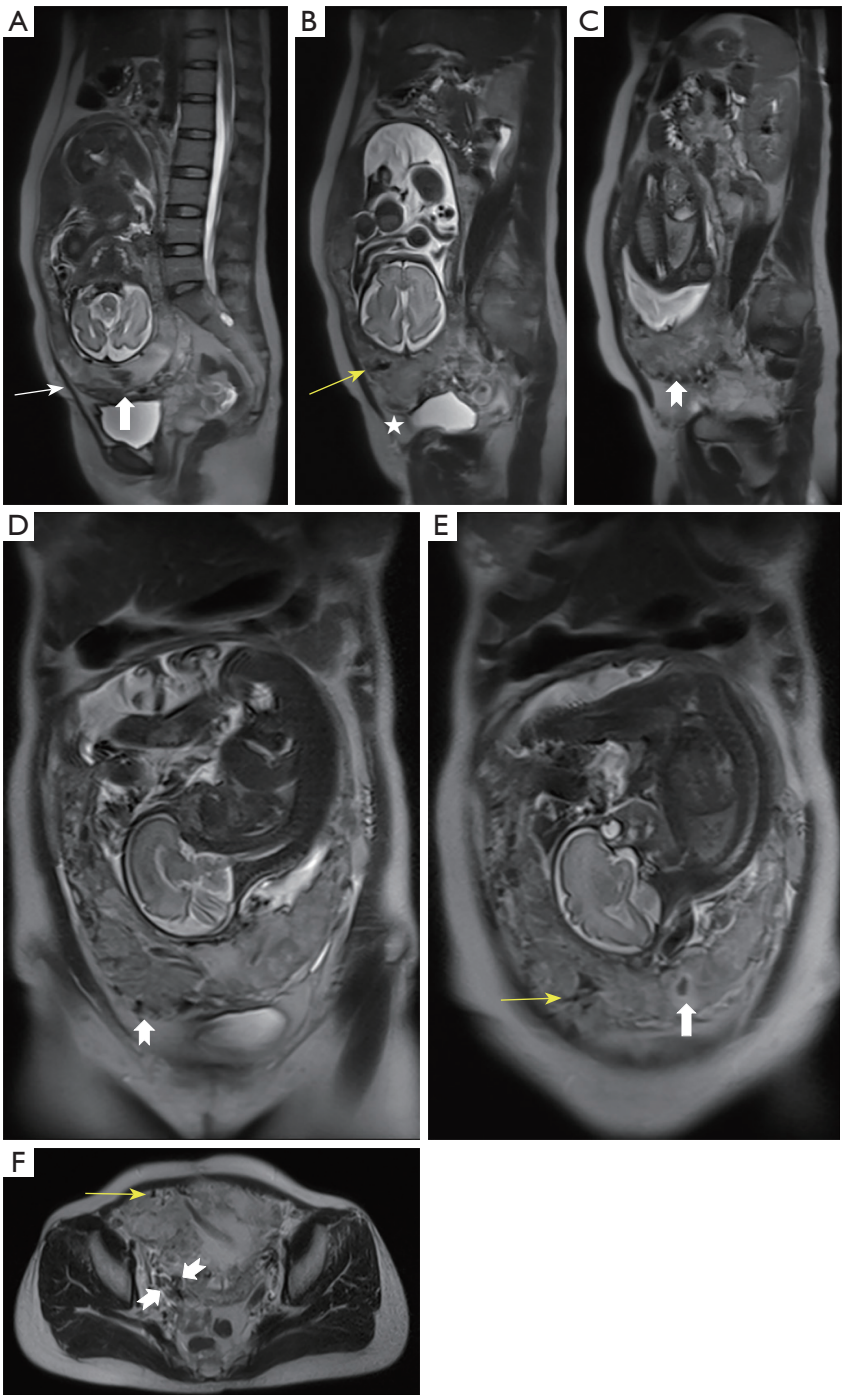

Figure 4 A 32-year-old woman who had undergone one prior cesarean section presented with complete placenta previa and concerns regarding placenta accreta spectrum disorder. The patient was at 30 weeks of gestation with placenta percreta. The placenta extends to cover the anterior and the posterior walls of the uterus. (A-C) In sagittal, (D,E) coronal, and (F) axial half-Fourier acquisition single-shot turbo spin echo images, the presence of placental bulge is evident, characterized by widening of the lower uterine segment (white arrow). Additionally, T2-dark bands (white, thick arrows), focal exophytic mass (star), abnormal intraplacental vascularity (yellow arrows), abnormal vascularization of the placental bed, and parametrial vessel sign (arrowheads) were observed.

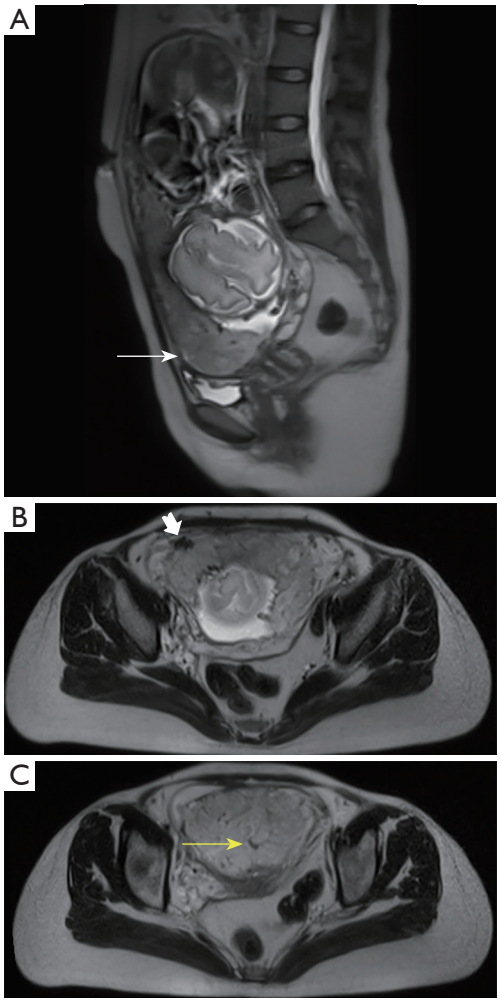

Figure 5 A 35-year-old woman who had undergone 1 prior cesarean section presented with complete placenta previa and concerns regarding placenta accreta spectrum disorder. The patient was at 29 weeks of gestation with placenta increta. The placenta extends to cover the anterior wall of the uterus. (A) In sagittal and (B,C) axial half-Fourier acquisition single-shot turbo spin echo images, the presence of placental bulge is evident, characterized by widening of the lower uterine segment (white arrow). Additionally, abnormal intraplacental vascularity (yellow arrow) and abnormal vascularization of the placental bed (arrowhead) were observed.

in posterior placentas. We hypothesize that when the placenta is located in the posterior uterine wall, it may be compressed more easily by the maternal spine or sacrum, resulting in the infrequency of placental bulge in such cases. Conversely, when the placenta is positioned in the anterior uterine wall, the placental bulge is more easily recognizable without compression. Therefore, when interpreting MRI images, we should not expect to observe placental bulge as frequently in posterior placentas as in anterior placenta or anterior/posterior placenta. Notably, some authors have emphasized the diagnostic significance of placental bulge in severe PAS but without specifying the placental location (27-29). As placental bulge primarily manifests in anterior or anterior/posterior placentas, there is a need to reassess its diagnostic performance considering different placental locations. Despite our study revealing a 26.82% incidence of PAS with posterior location, MRI studies remain deficient in diagnosing posterior PAS.

Our study revealed that T2 dark bands, focal exophytic mass, and placental heterogeneity were more frequently observed in cases of placenta percreta. T2 dark bands are the most common and sensitive MRI signs in PAS (30,31), believed to stem from areas of repetitive hemorrhage or infarcts (32). Lim *et al.* demonstrated variations in the volumes of T2 dark bands among patients with accreta, increta, and percreta (30). Although the presence of T2 dark bands can be noted in all PAS subtypes, our study found them more prevalent in placenta percreta, warranting further investigation to confirm the correlation between the volume or size of T2 dark bands and the severity of PAS. Focal exophytic mass, defined as placental tissue breaking through the uterine serosa and extending beyond it, emerged as highly specific for placenta percreta (33). Our results further support the strong associations between focal exophytic mass and placenta percreta. Placental heterogeneity, resulting from T2 dark bands and abnormal intraplacental vascularity, was also more common in placenta percreta, according to the findings of our study.

In our study, abnormal intraplacental vascularity was more prevalent in patients with placenta increta and placenta percreta. Bourgioti *et al.* confirmed that abnormal intraplacental vasculature extended from the cord or chorionic and/or subchorionic placental surface deep into the placenta, and even one such vessel suggested PAS (34). Furthermore, 3 mm or greater intraplacental fetal vessels were associated with placenta percreta (34). Consistent with Bourgioti *et al.*'s findings, we detected abnormal intraplacental vascularity in more women with placenta increta and placenta percreta.

The retrospective nature of our study limited the quality of our measures, potentially influenced by the limited sample size of documentation available over a 5-year study period at a single institution. Further prospective studies will be helpful to substantiate the findings in practice.

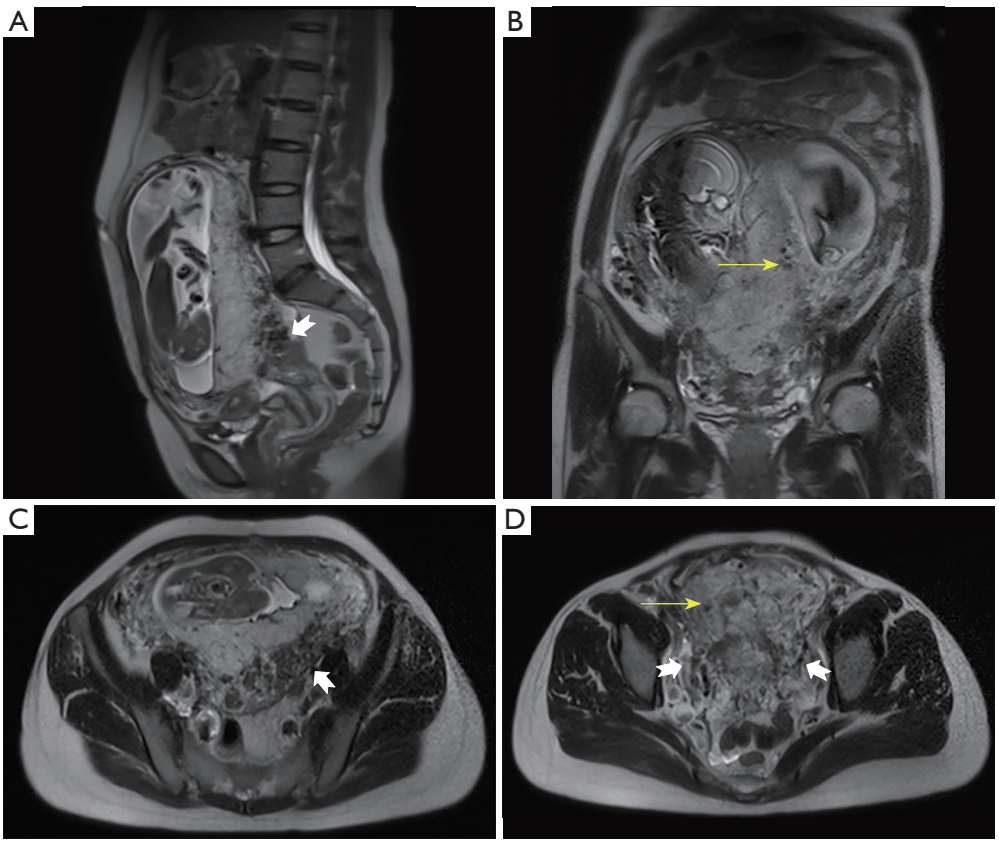

Figure 6 A 34-year-old woman who had undergone 1 prior cesarean section presented with complete placenta previa and concerns regarding placenta accreta spectrum disorder. The patient was at 24 weeks of gestation with placenta increta. The placenta extends to cover the posterior wall of the uterus. (A) Sagittal, (B) coronal, and (C,D) axial half-Fourier acquisition single-shot turbo spin echo images, abnormal intraplacental vascularity (yellow arrows). Additionally, abnormal vascularization of the placental bed and a parametrial vessel sign (arrowheads) were observed.

Table 5 Intraclass correlation coefficient for assessment of interobserver agreement for MRI features

Features	Kappa	95% CI
Dark intraplacental bands on T2W images	0.70	0.553–0.798
Placental heterogeneity	0.440	0.267–0.586
Abnormal intraplacental vascularity	0.741	0.615–0.844
Focal exophytic mass	0.529	0.372–0.657
Placental bulge	0.578	0.432–0.695
Abnormal vascularization of the placental bed	0.580	0.351–0.725
Myometrial thinning/interruption	0.449	0.180–0.629
Bladder wall interruption ('tenting' of the bladder wall)	0.797	0.750–0.839

MRI, magnetic resonance imaging; T2W, T2-weighted; CI, confidence interval.

The discrepancy of placental bulge in different placental locations requires further confirmation through studies with larger sample sizes and enrollment of patients from different centers. Additionally, our patients were referred for MRI due to suspected PAS from US, leading to a high incidence of PAS, including posterior PAS. We also acknowledge that this referral bias increased the incidence of positive cases, and at the same time limited the generalizability of our results as the results were based from a study population already at high possibility for PAS. Finally, we did not evaluate the diagnostic performance of each MRI sign in diagnosing PAS or in the differentiation of placenta percreta.

Conclusions

Our study identified increased maternal age, placenta previa, and prior CS as risk factors for PAS. Placental location varied among patients with and without PAS disorders and patients with different PAS subtypes. Placental bulge was more frequently observed in the anterior placenta and anterior/posterior placentas compared to posterior placentas, with the discrimination of this sign heavily reliant on placental location. However, studies investigating the actual diagnostic performance of this sign, considering the variation in placental location, are still lacking. Additionally, T2 dark bands, placental heterogeneity, abnormal intraplacental vascularity, and focal exophytic mass exhibited differences among various PAS subtypes. We anticipate future studies that prospectively follow a cohort of patients with different placental locations and explore the differentiation of PAS subtypes based on placental location, thus help further define risks for PAS subtypes and improve patient counseling.

Acknowledgments

Funding: This research was supported by Sichuan Medical Association (No. S23054) and Health Commission of Chengdu (No. 2024009).

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-24-443/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-24-443/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. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study obtained approval from the Institutional Review Board of Sichuan Provincial People's Hospital (No. 2021288) and written informed consent was provided by all participants.

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Cite this article as: Lu T, Li H, Wang L, Li M, Wang Y. Impact of placental location matter in placenta accreta spectrum disorders. Quant Imaging Med Surg 2024;14(12):9086-9100. doi: 10.21037/qims-24-443