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Transvaginal Doppler Ultrasonography and MRI for Prediction and Diagnosis of Adherent Placenta in High-Risk Group in the Second Half of Pregnancy

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ABSTRACT

Background: Placenta accreta is defined as abnormal trophoblast invasion of part or all of the placenta into the myometrium of the uterine wall. Abnormal placentation includes both abnormally adherent placenta (placenta accreta) and abnormally invasive placenta (AIP – including placenta increta and placenta percreta); the term PAS encompasses the whole spectrum of the disorder.

Objective: This study aimed to construct the basic criteria of both sonographic and MRI for the diagnosis of placenta accreta spectrum and figuring out the accuracy of those criteria parallel with the definition of the most peculiar features in clinical practice.

Patients and methods: This was a prospective cohort study conducted from September 2017 to May 2021 among women attending Sohag University Hospital which is considered to be the largest tertiary care maternity center in Sohag Governorate. The study included 300 pregnant females with mean age of 30.58 years old. They were suspected to have placenta accreta in the routine sonographic assessment. Moreover, the mean gestational age at which diagnosis was done was 33.46 ± 2.54 weeks.

Results: The sensitivities of US and MRI were 91.66% and 93.51% respectively and their Specificities were 95.83% and 96.35% respectively with statistically non-significant difference. Therefore, both ultrasonography and non-contrast MRI examinations had an equal diagnostic reliability for diagnosis of placenta accreta spectrum.

Conclusion: Both modalities have nearly the same diagnostic accuracy. Ultrasonography remains the most sensitive and commonly used imaging modality for the diagnosis of placenta accreta, because it is accurate, inexpensive, non-invasive and time-saving.

Keywords: Placenta accreta spectrum, Doppler ultrasonography, MRI.

INTRODUCTION

Placenta accreta spectrum (PAS), encompassing the terms placenta accreta, placenta increta, placenta percreta, morbidly adherent placenta, and invasive placentation, includes the full range of abnormal placental attachment to the uterus or other structures. There has been a dramatic rise in the incidence of PAS over recent years. This rise is most notably driven by increasing rates of cesarean delivery. The risk is highest in the presence of placenta previa and previous cesarean deliveries **(1).**

The use of Cesarean Section (C.S) has increased dramatically worldwide in the last decades **(1).** In Egypt, according to the latest data, more than half of all women give birth by CS without much difference between urban and rural areas .The incidence of placenta accreta in Egypt is rising due to rising rate of primary cesarean delivery. There are high rates of neonatal mortality and intraoperative complications, which can be explained by morbidly adherent placenta **(2).**

PAS is associated with a marked increase in maternal morbidity and mortality. The morbidity is primarily related to massive hemorrhage with associated organ damage, cesarean hysterectomy, and need for critical care resources **(3)**. Prenatal detection of PAS allows for mobilization of multidisciplinary care teams and surgical planning, which reduces maternal morbidity. Furthermore, the ability to correctly stratify the risk of PAS, including decreasing the risk with a "normal" ultrasound, reduces the possibility of iatrogenic complications associated with planned premature delivery, preoperative invasive procedures, and patient and provider anxiety **(4).**

The prenatal detection and risk stratification for PAS are primarily made by ultrasound. However, ultrasound is an operator-dependent imaging modality with substantial variability in image quality among providers. Furthermore, placental location and challenging imaging conditions, including elevated body mass index (BMI) or posterior placentation, may impede the sonographic detection of PAS markers. There has been limited consensus on the optimal approach to the ultrasound evaluation of patients at risk of PAS, such as the appropriate timing of screening, need for transvaginal ultrasound (TVUS) imaging, use of color and pulsed Doppler, angle of placental insonation, and equipment settings **(5).**

Magnetic Resonance Imaging (MRI) is being increasingly used both as a diagnostic adjunct and for pre-procedural planning. MRI and US are both non-invasive and non-ionizing imaging modalities and have unique technical and practical advantages with respect to imaging the placenta. Importantly, the advantages of one modality befittingly complement the drawbacks of the other **(6).**

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The main anatomic impact of placenta accreta spectrum is at the level of the deep uterine vasculature and, when unsuspected at the time of delivery, attempts to remove accrete placental tissue manually typically provoke rapid massive obstetric hemorrhage**.** The risk is particularly high in invasive cases because of the disruption of the main branches of uterine arteries and the possible invasion of the bladder wall and surrounding pelvic vessels **(6)**.

Women with placenta accreta spectrum are also more likely to deliver early, and most cases of placenta increta and percreta require complex surgical management that often involves different surgical specialists, interventional radiologists, intensivists anesthesiologists, hematologists, and neonatologists. Prenatal diagnosis has been shown to decrease maternal morbidity and has become crucial in improving the management of placenta accreta spectrum **(7).**

Aim of the present study was to construct the basic criteria of both sonographic and MRI for the diagnosis of placenta accreta spectrum and figuring out the accuracy of those criteria parallel with the definition of the most peculiar features in clinical practice.

PATIENTS AND METHODS

This prospective cohort study was conducted from September 2017 to May 2021 among women attending Sohag University Hospital, which is considered to be the largest tertiary care maternity center in Sohag governorate. The study included 300 pregnant females with age ranged from 20 to 40 and a mean of 30.58 years old. They were suspected to have placenta accreta in the routine sonographic assessment. Moreover, the mean gestational age at which diagnosis was done was 33.46 ± 2.54 weeks.

All patients included in the study were given an information sheet that stated the benefits of the study and all risks of PA as well as the suitable time of hospital admission and mode of delivery. If full delivery data were not available, the patient was excluded, as were patients who delivered outside the hospital.

Ethical consent:

The current study is a prospective cohort clinical trial that was approved by Faculty of Medicine **Research and Ethical Committee, Sohag University. All the included cases gave an informed consent before participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.**

Inclusion criteria:

Our study included the pregnant women with the followings: Increased risk factors of placenta accreta such as history of previous cesarean deliveries, placenta previa diagnosed by ultrasonography in the second half of pregnancy, and full availability of delivery information.

Exclusion criteria: Primigravida, gestational age less than 20 weeks, all contraindication of MRI study, and pregnant women refused to be included in the study or not available for follow up.

All patients were subjected to:

1- Complete history taking.
2- Complete general and local examination.
3- Routine lab investigations.
4- Transabdominal ultrasound after 20 weeks of gestation with special attention to placental site to determine patients who will be included in the study during the transabdominal scan. The placenta was imaged with a bladder volume sufficient to clearly visualize the serosa–bladder interface, which helped to visualize better the newly formed vessels in the vesico-placental interface.
5- Transvaginal Doppler ultrasonography to scan the placenta in a systematic fashion in normal pregnancy, the lower margin of the placenta is seen at least 2 cm from the margin of the internal cervical os. The 4 types of placenta previa are: (i) Low lying placenta (the lower placental margin is within 2 cm of the internal cervical os); (ii) Marginal previa (the lower placental margin extends to the margin of the internal cervical os); (iii) Complete previa (the placenta completely covers the internal cervical os); and (iv) Central previa (the midportion of the placenta not the margin completely covers the internal cervical os).
7- MRI to detect placental site and degree of placental invasion.
8- Final diagnosis of placenta accreta was defined by clinical criteria at the time of delivery and by pathologic findings in cases managed by hysterectomy.

Our study population included 300 pregnant women who had been investigated by both ultrasound and prenatal MRI. Both ultrasonography and MRI were done for the patients at risk of placenta accreta. For the purpose of the study, ultrasound images and MRI were blindly assessed by 2 raters. They scored features previously described in the literature as useful for predicting placental invasion to assess their diagnostic accuracy in diagnosis of placenta accreta.

The mean time interval between ultrasound and MRI was 3.3 ± 11.8 days in cases of severe PAS and 2.6 ± 24.3 days in cases without severe PAS. The ultrasound and MRI findings were compared with the final diagnosis made at delivery and the pathologic examination of the specimens for cases which had undergone hysterectomy.

Statistical Analysis

Pearson chi-square test and Fisher exact test were used to compare the frequency of the clinical and

radiologic variables between patients with and without severe PAS. The accuracy, sensitivity, specificity, PPV, and NPV of the US and MRI findings for determining severe PAS were calculated. A p value ≤ 0.05 was considered statistically significant.. The imaging features found to be statistically significant on univariable analyses were used for multivariable binary logistic regression analyses to determine imaging findings on US and MRI that were independently associated with severe PAS.

RESULTS

This study was conducted to evaluate how the prenatal diagnosis of PAS using the most widely available diagnostic tools can be established. During the study period a total of 36.00% (108/300) of patients were finally diagnosed as having severe PAS (72 with FIGO grade 2 PAS, 36 with FIGO grade 3 PAS) and 64.00% (192/300) as not having severe PAS (108 without PAS, 84 with FIGO grade 1 PAS).

The clinical characteristics of patients with and without severe PAS are compared in Table (1). Patients with severe PAS compared to patients without severe PAS, had a lower mean gestational age at delivery (32.9 ± 4.6 vs 35.0 ± 3.7 weeks; p = .02), a higher number of prior cesarean section (more than two prior cesarean sections in 73.14% vs 18.75%; p = .0) a higher frequency of hysterectomy (38.88% vs 1.56%; p < .001), a lower frequency of vaginal bleeding during pregnancy (54.81% vs 38.02%; p = .01), and greater estimated blood loss (median of 1500 vs 1000 mL; p = .02). The two groups showed no significant difference in terms of patient age, gestational age at US or MRI, history of multiparity, previous miscarriage, or previous uterine surgery (all p > .05).

Table (1): Comparison between patients with and without severe placenta accreta spectrum (PAS) disorder

Characteristic	Patients With Severe PAS (n = 108)	Patients Without Severe PAS (n = 192)	p
Age (yr)	33.2 ± 5.5	33.4 ± 6.0	0.89
GA at US (wk)	28.0 ± 4.1	29.0 ± 4.4	0.37
GA at MRI (wk)	28.3 ± 4.3	28.7 ± 4.5	0.92
Interval between US and MRI (d)	3.3 ± 11.8	2.6 ± 24.3	0.46
GA at delivery (wk)	32.9 ± 4.6	35.0 ± 3.7	0.02
Parity			
0	0 (0)	0 (0)	
1	5.55 (6)	69.27 (133)	0.13
2	21.29 (23)	21.35 (41)	
> 2	73.14 (79)	18.75 (18)	
Previous miscarriage	21.29 (23)	24.47 (47)	0.16
No. of previous cesarean sections			
0	0 (0)	0 (0)	
1	5.55 (6)	69.27 (133)	0.03
2	21.29 (23)	21.35 (41)	
> 2	73.14 (79)	18.75 (18)	
Previous uterine surgery	6.48 (7)	5.72 (11)	0.09
Vaginal bleeding in pregnancy	54.81 (56)	38.02 (73)	0.01
Hysterectomy	38.88 (42)	1.56 (3)	< 0.001
Estimated blood lossa (mL)	1500 (925–2925)	1000 (800–1400)	< 0.001
FIGO grade of PAS	NA	56.25 (108)	0.02
No PAS			
1	NA	43.75 (84)	
2	66.66 (72)	NA	
3a	24.07 (26)	NA	NA
3b	0.92 (6)	NA	
3c	0.37 (4)	NA	

Association of US findings and Severe PAS:

On US, patients with severe PAS, compared to patients without severe PAS, exhibited higher frequencies (all p ≤ .001) of placental bulge sign (92.6% vs 35.4%), loss of clear zone (91.7% vs 41.1%), myometrial thinning (83.3% vs 35.4%), abnormal lacunae (83.3% vs 58.9%), uterovesical hypervascularity (84.3% vs 29.2%), bridging vessels (88.9% vs 26.6%), feeding lacunar vessels (75.0% vs 35.4%) and placental bulge at the site of the bulge (61.1% vs 23.4%) (Table 2).

Table (2): Comparison of ultrasound findings between patients with and without severe placenta accreta spectrum (PAS) disorder

US	With severe PAS		Without Severe PAS		X^2	p	Sig.
	n	%	n	%			
Pl. bulge	100	92.6	68	35.4	91.7	<0.001	HS
Pl. bulge, bridging v.	66	61.1	45	23.4	42.1	<0.001	HS
Loss of clear zone	99	91.7	79	41.1	73.1	<0.001	HS
Myom. thinning	90	83.3	68	35.4	63.7	<0.001	HS
Ab. lacunae	90	83.3	113	58.9	18.9	<0.001	HS
Blad. wall interrup.	33	30.6	34	17.7	6.6	0.0103	S
Subpl. Hypervasc.	72	66.7	101	52.6	5.6	0.0179	S
Uteroves. Hypervas.	91	84.3	56	29.2	43.3	<0.001	HS
Bridging v.	96	88.9	51	26.6	54.1	<0.001	HS
Feeding lacunar v.	81	75.0	68	35.4	43.3	<0.001	HS

Among the nine features assessed on US, accuracy was highest for bridging vessels sign (79 %), followed by uterovesical hypervascularity (75.7%) and placental bulge sign (74.7%). However, the accuracy of bridging vessels sign was significantly higher than only one of the other eight features on the basis of 95% CIs (Table 3).

Placental bulge sign exhibited the highest sensitivity of 92.6% and specificity of 64.6% for severe PAS. Myometrial thinning and feeding lacunar vessels had specificities identical to that of placental bulge sign (64.6%) but lower sensitivities (83.3 and 75% respectively). The incorporation of coexisting bridging vessels at the site of placental bulge resulted in a lower overall accuracy (71.0%) compared to use of either of these signs alone. Patients with and without severe PAS were not significantly different in terms of frequency of bladder wall interruption or subplacental hypervascularity ($p > .05$) (Table 3).

Four US findings, placental bulge sign, loss of clear zone, bridging vessels and myometrial thinning were included in the multivariable logistic regression analysis for predicting severe PAS. Of these, only placental bulge sign was independently associated with severe PAS (odds ratio [OR], 8.94; 95% CI, 1.37–58.48; $p = .02$) (Table 3).

Among patients with placental bulge sign, neither the length nor the depth of bulge was significantly different between patients with and without severe PAS (all $p > .05$).

Table (3): Diagnostic performance of ultrasound findings in diagnosis of placenta accreta spectrum (PAS) disorders.

	Accuracy		Sensitivity		Specificity		PPV		NPV	
US										
Pl. bulge	74.7	224/300	92.6	100/108	64.6	124/192	59.5	100/168	93.9	124/132
95% CI	69.35% to 79.49%		85.93% to 96.75%		57.37% to 71.34%		54.67% to 64.20%		88.75% to 96.82%	
Pl. bulge, bridging v.	71.0	213/300	61.1	66/108	76.6	147/192	59.5	66/111	77.8	147/189
95% CI	65.51% to 76.07%		51.25% to 70.34%		69.92% to 82.36%		52.16% to 66.37%		73.18% to 81.78%	
Loss of clear zone	70.7	212/300	91.7	99/108	58.9	113/192	55.6	99/178	92.6	113/122
95% CI	65.16% to 75.76%		84.77% to 96.12%		51.54% to 65.89%		51.18% to 59.97%		86.92% to 95.96%	
Myom. thinning	71.3	214/300	83.3	90/108	64.6	124/192	57.0	90/158	87.3	124/142
95% CI	65.86% to 76.38%		74.94% to 89.81%		57.37% to 71.34%		51.79% to 61.99%		81.69% to 91.41%	
Ab. lacunae	56.3	169/300	83.3	90/108	41.1	79/192	44.3	90/203	81.4	79/97
95% CI	50.52% to 62.03%		74.94% to 89.81%		34.11% to 48.46%		40.79% to 47.94%		73.59% to 87.36%	
Blad. wall interrup.	63.7	191/300	30.6	33/108	82.3	158/192	49.3	33/67	67.8	158/233
95% CI	57.94% to 69.12%		22.05% to 40.16%		76.14% to 87.41%		39.01% to 59.56%		64.65% to 70.81%	
Subpl. Hypervasc.	54.3	163/300	66.7	72/108	47.4	91/192	41.6	72/173	71.7	91/127
95% CI	48.51% to 60.07%		56.95% to 75.45%		40.16% to 54.71%		37.11% to 46.28%		65.06% to 77.43%	
Uteroves. Hypervas.	75.7	227/300	84.3	91/108	70.8	136/192	61.9	91/147	88.9	136/153
95% CI	70.40% to 80.41%		76.00% to 90.55%		63.86% to 77.16%		56.23% to 67.27%		83.67% to 92.59%	
Bridging v.	79.0	237/300	88.9	96/108	73.4	141/192	65.3	96/147	92.2	141/153
95% CI	73.95% to 83.47%		81.40% to 94.13%		66.60% to 79.54%		59.58% to 70.62%		87.25% to 95.28%	
Feeding lacunar v.	68.3	205/300	75.0	81/108	64.6	124/192	54.4	81/149	82.1	124/151
95% CI	62.74% to 73.56%		65.75% to 82.83%		57.37% to 71.34%		48.88% to 59.74%		76.52% to 86.62%	

Association of MRI Findings and Severe PAS

On MRI, patients with severe PAS, compared to patients without severe PAS, exhibited higher frequencies (all $p \leq .001$) of placental bulge (94.4% vs 23.4%), heterogeneous placenta (75.0% vs 52.6%), dark intraplacental bands (86.1% vs 41.1%), loss of retroplacental dark zone (92.6 % vs 35.4%), myometrial thinning (93.5% vs 52.6%), focal exophytic mass (41.7% vs 0%), and abnormal vascularization of the placental bed (63.9% vs 35.4%) (Table 4).

Among the eight features assessed on MRI, accuracy was highest for placental bulge sign (83%), followed by loss of retroplacental dark zone (74.7%), dark intraplacental bands (68.7%) and myometrial thinning (64% accuracy). However, the accuracy of placental bulge sign was significantly higher than only two of the other seven features on the basis of 95% CIs (Table 5).

Placental bulge sign exhibited a sensitivity of 94.4% and specificity of 76.6%. Focal exophytic mass and bladder wall interruption both had 100% specificity but low sensitivity (41.7% and 0%, respectively). The incorporation of coexisting findings with placental bulge sign did not result in higher accuracy compared to the placental bulge sign alone except when combined with subjacent dark intraplacental bands (85.3%) (Table 5).

Four MRI findings (placental bulge, dark intraplacental bands, loss of retroplacental dark zone, and myometrial thinning) were included in the multivariable logistic regression analysis to predict severe PAS. Of these, only placental bulge sign was independently associated with severe PAS (OR, 45.67; 95% CI, 3.59–581.19; $p = .003$) (Table 7). Among patients with placental bulge sign, neither the length nor the depth of bulge was significantly different between patients with and without severe PAS (all $p > .05$) as shown in table (6).

Table (4): Comparison of MRI findings between patients with and without severe placenta accreta spectrum (PAS) disorder

MRI	With severe PAS		Without severe PAS		X^2	P	Sig.
	n	%	n	%			
Pl. bulge	102	94.4	45	23.4	139.5	<0.001	HS
Pl. bulge, subjacent dark intrapl. bands	87	80.6	23	12.0	140.0	<0.001	HS
Pl. bulge along bladd. interface	51	47.2	0	0.0	109.2	<0.001	HS
Pl. bulge with abn. v. pl. bed at site of bulge	66	61.1	23	12.0	80.0	<0.001	HS
Heterog. placenta	81	75.0	101	52.6	14.5	<0.001	HS
Dark intrapl. bands	93	86.1	79	41.1	57.1	<0.001	HS
Loss of retropl. dark zone	100	92.6	68	35.4	91.7	<0.001	HS
Myomet. thinning	101	93.5	101	52.6	52.6	<0.001	HS
Bladd. wall interrup.	0	0.0	0	0.0			
Focal exophytic mass	45	41.7	0	0.0	94.1	<0.001	HS
Ab. Vas. of placental bed	69	63.9	68	35.4	22.6	<0.001	HS

Table (5): Diagnostic performance of MRI findings in diagnosis of placenta accreta spectrum (PAS) disorders.

	Accuracy		Sensitivity		Specificity		PPV		NPV	
MRI										
Pl. bulge	83.0	249/300	94.4	102/108	76.6	147/192	69.4	102/147	96.1	147/153
95% CI	78.26% to 87.07%		88.30% to 97.93%		69.92% to 82.36%		63.61% to 74.61%		91.81% to 98.17%	
Pl. bulge, subjacent dark intrapl. bands	85.3	256/300	80.6	87/108	88.0	169/192	79.1	87/110	88.9	169/190
95% CI	80.82% to 89.14%		71.83% to 87.54%		82.57% to 92.25%		71.83% to 84.88%		84.53% to 92.22%	
Pl. bulge along bladd. interface	81.0	243/300	47.2	51/108	100.0	192/192	100.0	51/51	77.1	192/249
95% CI	76.10% to 85.28%		37.54% to 57.06%		98.10% to 100.00%				73.81% to 80.10%	
Pl. bulge with abn. v. pl.bed at site of bulge	78.3	235/300	61.1	66/108	88.0	169/192	74.2	66/89	80.1	169/211
95% CI	73.24% to 82.86%		51.25% to 70.34%		82.57% to 92.25%		65.53% to 81.25%		75.95% to 83.68%	
Heterog. placenta	57.3	172/300	75.0	81/108	47.4	91/192	44.5	81/182	77.1	91/118
95% CI	51.52% to 63.00%		65.75% to 82.83%		40.16% to 54.71%		40.29% to 48.81%		70.18% to 82.84%	
Dark intrapl. bands	68.7	206/300	86.1	93/108	58.9	113/192	54.1	93/172	88.3	113/128
95% CI	63.09% to 73.87%		78.13% to 92.01%		51.54% to 65.89%		49.44% to 58.63%		82.27% to 92.44%	
Loss of retropl. dark zone	74.7	224/300	92.6	100/108	64.6	124/192	59.5	100/168	93.9	124/132
95% CI	69.35% to 79.49%		85.93% to 96.75%		57.37% to 71.34%		54.67% to 64.20%		88.75% to 96.82%	
Myomet. thinning	64.0	192/300	93.5	101/108	47.4	91/192	50.0	101/202	92.9	91/98
95% CI	58.28% to 69.44%		87.10% to 97.35%		40.16% to 54.71%		46.43% to 53.57%		86.21% to 96.43%	
Bladd. wall interrup.	64.0	192/300	0.0	0/108	100.0	192/192			64.0	192/300
95% CI	58.28% to 69.44%		0.00% to 3.36%		98.10% to 100.00%				64.00% to 64.00%	
Focal exophytic mass	79.0	237/300	41.7	45/108	100.0	192/192	100.0	45/45	75.3	192/255
95% CI	73.95% to 83.47%		32.25% to 51.55%		98.10% to 100.00%				72.21% to 78.14%	
Ab. Vas. of placental bed	64.3	193/300	63.9	69/108	64.6	124/192	50.4	69/137	76.1	124/163
95% CI	58.63% to 69.75%		54.08% to 72.91%		57.37% to 71.34%		44.44% to 56.28%		70.78% to 80.67%	

Comparison of US and MRI for Severe PAS:

Placental bulge on MRI, compared with US, exhibited higher accuracy (83% vs 74.7%), sensitivity (94.4% vs 92.6%), and specificity (76.6% vs 64.6%) for severe PAS, though none of these differences were significant on the basis of 95% CIs (Table 3). Placental bulge also exhibited a higher OR for severe PAS on MRI than on US in the multivariable analysis (55.5 vs 22.7), though these differences also were not significant on the basis of 95% CIs (Table 7).

Myometrial thinning on MRI, compared to US, exhibited a lower accuracy (64% vs 71.3%), higher sensitivity (93.5% vs 83.3%), and a lower specificity (47.4% vs 64.6%) for severe PAS, though none of these differences were significant on the basis of 95% CIs (Table 5). Myometrial thinning also exhibited a higher OR for severe PAS on MRI than on US in the multivariable analysis (13 vs 9.11), though these differences also were not significant on the basis of 95% Cis (Table 7).

Loss of retroplacental dark zone on MRI, compared to US, exhibited higher accuracy (74.7% vs 70.7%), sensitivity (92.6% vs 91.7%), and specificity (64.6% vs 58.9%) for severe PAS, though none of these differences were significant on the basis of 95% CIs (Table 9). Placental bulge also exhibited a higher OR for severe PAS on MRI than on US in the multivariable analysis (22.7 vs 15.7), though these differences also were not significant on the basis of 95% Cis (Table 7).

Table (6): Multivariable logistic regression analysis of imaging features on ultrasound for predicting severe placenta accreta spectrum disorder

US findings	OR	95p CI		P	Sig.
		Min.	Max.		
Placental bulge	22.7	10.464	49.651	0	HS
Loss of clear zone	15.7	7.5035	32.992	0	HS
Myometrial thinning	9.11	5.0736	16.385	0	HS
Bridging vessels.	22.1	11.202	43.667	0	HS

Table (7): Multivariable logistic regression analysis of imaging features on MRI for predicting severe placenta accreta spectrum disorder.

MRI findings	OR	95 p CI		P	Sig
		Min.	Max.		
Placental bulge	55.5	22.839	135.02	0	HS
Dark intraplacental bands	8.86	4.7875	16.427	0	HS
Loss of retroplacental Dark zone	22.7	10.464	49.651	0	HS
Myometrial thinning	13	5.7442	29.420	0	HS

DISCUSSION

This study was conducted to evaluate how the prenatal diagnosis of PAS using the most widely available diagnostic tools can be established. Overall, in our study, US correctly suggested the diagnosis of severe PAS in 99/108 cases (91.66%) and the diagnosis of non-severe PAS in 184/192 cases (95.83%). On the other hand US underestimated 9 cases of severe PAS and overestimated 8 cases as severe PAS. MRI correctly suggested the diagnosis severe PAS in 101/108 cases (93.51%) and the diagnosis of non-severe PAS in 185/192 cases (96.35%), on the other hand MRI underestimated 7 cases severe PAS and overestimated also 7cases as severe PAS.

The sensitivities of US and MRI were 91.66% and 93.51% respectively and their specificities were (95.83% and 96.35%) respectively with non-significant difference, therefore both ultrasonography and non-contrast MRI examinations have an equal diagnostic reliability for diagnosis of placenta accreta spectrum. **D'Antonio *et al.*** [8, 9] reported a sensitivity of 90.7% for ultrasound and 94.4% for MRI, and a specificity of 96.9% for ultrasound and 84% for MRI. **Meng *et al.*** [10] showed that ultrasound sensitivity was 83%, and its specificity was 95%, compared to 82% and 88%, respectively for MRI. These meta-analyses showed good accuracy of ultrasound and MRI in the diagnosis of placental invasion. They comprised several studies and a large number of patients, but also included studies that were clinically and methodologically varied, and in which ultrasound and MRI were not applied to the same population. This may represent an unavoidable source of bias. The results are only applicable to women with placenta previa and a history of a cesarean delivery or uterine surgery. These 3 meta-analyses reported that ultrasound and MRI are equally accurate in diagnosing the presence of invasive placentation. We found no statistical difference in sensitivity between MRI and ultrasound or in the percentage of correct diagnoses. **Warshak and coauthors** [11] evaluated the role of ultrasonography and MR with gadolinium because they thought that it improved the specificity of the technique as it delineates the outer placental surface proximal to the myometrium more clearly, and showed that the sensitivity and specificity of ultrasonography diagnosis were lower than those diagnosed with MRI with 77%-95% and 88%-100%, respectively.

In a case of posterior placenta, many others reported the better diagnostic outcome of MRI over ultrasound in detecting placenta accrete [12, 13, 14]. Nevertheless, in our results, we did not find a distinction between these two modalities in this case.

In our study, the placental bulge sign exhibited a sensitivity of 92.6%, specificity of 64.6%, PPV of 59.5% and accuracy of 74.7% for severe PAS on US and was one of the most distinguished signs for diagnosis of placenta accreta spectrum. This agrees with the findings of **Thiravit and co-workers** [15] who found that on US, the finding with the highest accuracy for severe PAS was placental bulge (85.5%), which had a sensitivity of 91.7% and specificity of 76.9%. On MRI, the finding with highest accuracy was also placental bulge (90.3%), which had a sensitivity of 94.4% and specificity of 84.6%. In the multivariable regression analysis, placental bulge was an independent predictor of severe PAS on US (odds ratio [OR], 8.94; p = .02) and MRI (OR, 45.67; p = .003). Interobserver agreement analysis showed a kappa value for placental bulge of 0.48 for MRI and 0.40 for US. Given wide 95% CIs, differences among features for a given modality and differences between modalities were not statistically significant. Their findings suggest a strong performance of placental bulge in diagnosing severe PAS on both US and MRI, with a potentially stronger performance on MRI. Nonetheless, interobserver agreement remains suboptimal for both modalities [15].

Many studies reported that the highest positive predictive values in MRI examination are achieved in the presence of constructed association of dark intraplacental bands together with evident myometrial thinning and uterine bulging [13, 16 17]. **Lim *et al.*** [12] also showed that the volumes of dark intraplacental bands on T2-weighted images were significantly different in the patients with abnormal placentation and without placenta accreta (p = 0.047), and that band volumes were differed significantly between patients with accreta, increta, and percreta (p, 0.0005).

In our study, the most sensitive criteria for diagnosis of placental invasion were the placental bulge sign (94.4%), evident myometrial thinning (93.5%), loss of retroplacental dark zone (92.6%) and to lesser extent dark intraplacental bands on T2 weighted images (86.1%). The highest positive predictive values in MRI examination are achieved in the presence of the placental bulge along bladder interface (100%) followed by placental bulge with subjacent dark intraplacental bands. On the other hand, the most specific features were a placental bulge along bladder interface, focal exophytic mass, neovascularization and bladder wall interruption each has a (100%) specificity. A range of other findings for both modalities exhibited lower accuracy (although most differences were non-significant). In addition, on both modalities, the placental bulge sign was independently associated with severe PAS [15]. Past studies have also found the placental bulge to be a useful sign on MRI for detection of PAS, with reported sensitivity of 34–88% and specificity of 92–100% [18, 19, 20]. In comparison, fewer studies have reported the performance of the placental bulge sign on US. In a systematic review of prenatal US for grading of PAS that included 53 series and 31 case reports, the placental bulge sign was reported in only three patients [6]. The results highlight the attention warranted for the placental bulge sign on both US and MRI when performing prenatal imaging of women with suspected PAS. The placental bulge may be particularly associated with severe PAS given its presumed origin from deeper villous invasion in PAS [21].

Previous studies suggested the superiority of MRI to US in the diagnosis of PAS [22, 23, 24]. But, did not directly compare the performance of the bulge sign between the two modalities. Although the differences were not statistically significant, our study suggested greater performance of the bulge sign on MRI than on US. MRI provides more complete anatomic detail and high soft-tissue contrast, helping to overcome several limitations of US including operator dependence, imaging difficulty in obese patients or in patients with a posteriorly located placenta, restricted FOV, lack of a coronal view, and lack of visualization of parametrial invasion [18, 22, 23]. MRI also provides more detailed information for treatment planning [25]. The combined use of MRI and US signs has also been recommended to optimize the diagnosis of PAS [22]. In directly comparing the role of the placental bulge sign between the two modalities, we observed more false-positive and false-negative cases on US than on MRI. Interpreting radiologists need to be aware of the potential pitfalls that may contribute to such instances, including technical aspects of the examination (e.g. an empty bladder contributing to a false-negative on US) [26]. Past studies have found that most of the US and MRI findings had fair or moderate interobserver agreement [18, 27, 28]. The limited interreader agreement reflects the often ambiguous nature of assessing imaging features for PAS, which requires experience and can be difficult in complex cases. Our study suggested that the placental bulge sign may be slightly more reproducible on MRI than on US, though this difference is not significant. Continued efforts are needed to simplify and standardize these evaluations.

Our study had the strengths that it was prospective, each patient was examined systematically by US and MRI. Furthermore, investigating the same group of patients for both techniques with subsequent evaluation of the results and comparison of their accuracy gave the present study its integrity and reliability. Also, the sensitivity and specificity of MRI were evaluated without using contrast media, that is matching with most of the higher centers world-wide.

CONCLUSION

Both modalities have nearly the same diagnostic accuracy. Ultrasonography remains the most sensitive and commonly used imaging modality for the diagnosis of placenta accreta, because it is accurate, inexpensive, non-invasive and time-saving. MRI acts as a perfect complement method to ultrasonography in case of the presence of few inconclusive ultrasound findings. Findings in addition to the placental bulge sign that were highly sensitive for severe PAS in our study included briding vessels, loss of clear zone, myometrial thinning, and abnormal lacunae on US and dark intraplacental bands, loss of retroplacental dark zone, and myometrial thinning on MRI.

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