

Role of MRI In Prediction of Success of Resective Technique of Lower Uterine Segment in Placenta Accreta Spectrum

Original
Article

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ABSTRACT

Objective: This study aimed to test the accuracy of prenatal MRI in prediction of degree of invasiveness of the disease and surgical management with determination of signs associated with hysterectomy in cases with placenta accreta spectrum.

Methods: This was a prospective interventional study on 30 patients diagnosed with PAS at Obstetrics and Gynecology Department in Mansoura university Hospitals, for one year period from January 2024 to January 2025. The study included all cases with at least one prior cesarean delivery and had placenta accreta spectrum based on prenatal imaging and confirmed intraoperative. All patients underwent standardized MRI protocols, with proposal of liability of uterine sparing technique when the main bulk of placenta anterior, no bladder wall interruption, no parametric invasion nor cervical invasion. All cases were assessed intraoperative according to FIGO classification system with uterine preservation in FIGO grades 1, 2 3a and cesarean hysterectomy for all higher grades. The MRI proposal was compared with intraoperative findings with determination of diagnostic accuracy of MRI in prediction of surgical technique.

Results: Our MRI proposal had correctly predicted surgical management in 27 out of 30 cases and overestimated the diagnosis in 3 cases. All 5 cases of cesarean hysterectomy were correctly diagnosed by MRI, while in the 25 cases of uterine preservation, the MRI diagnosis was correct in only 22 cases giving sensitivity, specificity, accuracy, PPV, and NPV of 88%, 100%, 90%, 100%, and 62% respectively in prediction of success of uterine sparing surgery. Individual MRI signs that were significantly higher in the hysterectomy group than uterine sparing group were bladder wall interruption ($P= 0.0069$) and cervical invasion ($P= 0.0011$). Parametric invasion was also higher in the hysterectomy group, but the difference did not reach a significant level ($P= 0.1188$).

Conclusion: MRI as adjunct to ultrasonography is a valuable tool that could be used in prenatal multidisciplinary team organization, and planning of surgery in cases with PAS. MRI signs like bladder wall interruption, cervical invasion, and parametric invasion were associated with more severe PAS.

Key Words: MRI, placenta accreta spectrum, resective technique.

Received: 23 September 2025, **Accepted:** 21 October 2025

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ISSN: 2090-7265, Vol. 15, 2025.

INTRODUCTION

Placenta accreta spectrum (PAS) is now considered one of the most challenging pregnancy complications for obstetricians. The main risk of the disease is related mainly to massive peripartum hemorrhage that can lead to multiple organ failure, disseminated intravascular coagulopathy (DIC), need for intensive care unit admission, organ damage especially those involving the urinary system, hysterectomy and even in some cases maternal mortality^[1].

The severity of the disease and hence potential for complications is determined mainly by depth of invasion of chorionic villi, the involved area (weather focal or total involvement), and presence or absence of placental extension into extrauterine tissues mainly the posterior bladder wall and parametrium^[2].

Determination of the severity of the disease could be done at time of surgery after laparotomy by applying the International Federation of Gynecology and Obstetrics (FIGO)^[3] grading system which classified PAS into the following three grades: 1) grade 1 (G1), which refers to only abnormally adherent placenta but not invasive disease; grade 2 (G2), which refers to abnormal placental invasion that had not invaded the uterine serosa; grade 3 (G3), which refers to abnormal placental invasion that had at least invaded uterine serosa only (G3a), posterior bladder wall (G3b), or other pelvic organs rather than the urinary bladder mainly the parametrium (G3c).

Despite this intraoperative diagnosis of disease severity, accurate prenatal diagnosis of PAS became of utmost importance as it allows multidisciplinary team planning

that in turn improves maternal outcome through better selection of surgical techniques manifested as reduced blood loss, transfusion burden and iatrogenic injuries^[4].

Ultrasound with the use of color flow doppler is considered the first and the main diagnostic tool used for prenatal diagnosis of PAS. Information gained by ultrasonography are very helpful in estimation of disease severity. Magnetic resonance imaging (MRI) is considered an important adjunct tool when the results of ultrasonography are inconclusive, in case of posterior or lateral placental extension, and in situations where the ultrasound examination seems difficult as in obese cases^[5,6].

Planned cesarean hysterectomy is the recommended line of management for PAS by the American College of Obstetricians and Gynecologists (ACOG)^[7]. Although cesarean hysterectomy is a lifesaving procedure, it has many dangerous complications like injury to bladder, ureter, bowels, or neurovascular bundle. It is also associated with permeant loss of future fertility with many psychological issues^[8].

Because PAS is common in young pregnant women, many of whom desire to preserve the future fertility. Many uterine sparing methods have been widely used for this reason. One of the most common methods is to do resection of invaded lower uterine segment with attached placenta after uterine devascularization followed by uterine repair^[9].

However, fertility issues are not the only factors that determine the surgical plan, as the severity of the disease and its extent seem more important. More severe PAS with extrauterine disease invading the bladder, parametrium, or total uterine serosal invasion need cesarean hysterectomy, with uterine sparing procedures should be reversed for less invasive forms of the disease^[2].

No single diagnostic tool was studied in the prenatal planning of choice of surgical technique of PAS; hence, we aimed at this study to test the accuracy of prenatal MRI in prediction of degree of invasiveness of the disease and surgical management with determination of signs associated with hysterectomy in cases with placenta accreta spectrum.

PATIENTS AND METHODS

We carried out this prospective interventional study on 30 patients diagnosed with PAS at Obstetrics and Gynecology Department of Mansoura university Hospitals, for one year period from January 2024 to January 2025. Approval was obtained from Mansoura Faculty of Medicine - Institutional Research Board (MFM-IRB), under code ID: MS.22.04.1956.R1.R2.R3. Consent was collected from every patient before participating in the study. The Declaration of Helsinki,

the international Medical Association's guideline of ethics for studies involving humans, was followed in the conduct of this study.

This study included all cases with placenta accreta spectrum with at least one prior cesarean delivery who had MRI examination before elective surgery at our department. Cases with any of the following were excluded from the study: (1) Hemodynamic instability from severe bleeding. (2) Cases with low lying placenta and no prior cesarean delivery or no signs of accretion at time of surgery. (3) Cases with contraindication to MRI examination as metallic prosthetic valve. (4) Medical conditions complicating pregnancy.

Maternal demographic data, and clinical characteristics were collected and recorded. All cases had an initial evaluation with ultrasonographic examination with the use of color flow doppler. PAS was suspected when these signs were present; loss of clear zone, abnormal placental lacunae, myometrial thinning, bladder wall interruption, placental bulge, focal exophytic mass, uterovesical hypervascularity, and subplacental hypervascularity.

Selected cases were subjected to MRI examination. The MRI examinations were performed using a 1.5 Tesla system (Achieva, Philips Medical System, Netherlands).

Preparation and technique of MRI examination:

- Patients were positioned supine.
- The bladder was moderately full.
- Our protocol did not include the use of intravenous gadolinium contrast agent.

Sequences and imaging planes:

- Sagittal, coronal, and axial 2D T2W SSFSE (single-shot fast spin echo) sequences through the uterus to evaluate PAS disorders.
- Axial oblique T2Wsequence prescribed perpendicular to the placenta-myometrium interface.
- Slice thickness of at least 4mm or less was done.

During MRI examination the following parameters were evaluated^[10]:

T2-dark bands which are identified as one or more areas of hypointensity on T2-weighted images that with linear configuration and are often in contact with the maternal surface of the placenta.

Placental bulge which is defined as deviation of the uterine serosa from the expected plane that is caused by abnormal bulge of placental tissue toward the urinary bladder and the parametrium.

Loss of T2 hypointense interface which is defined as loss of a thin dark line that is present behind the placental bed.

Myometrial thinning which is defined as thinning of the myometrium over the placenta to less than 1mm or even no myometrium could be detected.

Bladder wall interruption which is defined as disruption or irregularity of the normally appearing hypointense bladder wall.

Focal exophytic mass which is defined as placental tissue that is seen protruding through the uterine wall and even extending beyond it, often seen anterior inside partially filled urinary bladder or laterally into the parametrium on one or both sides.

The MRI findings were interpreted by two radiologists with expertise in PAS.

According to MRI findings, we had a preliminary proposal of surgical plan that suggests:

Uterine sparing (resection) could be done when (Figure 1):

- main bulk of placenta anterior.
- no interruption of bladder wall.
- no focal exophytic mass into the bladder or parametrium.
- no cervical invasion.

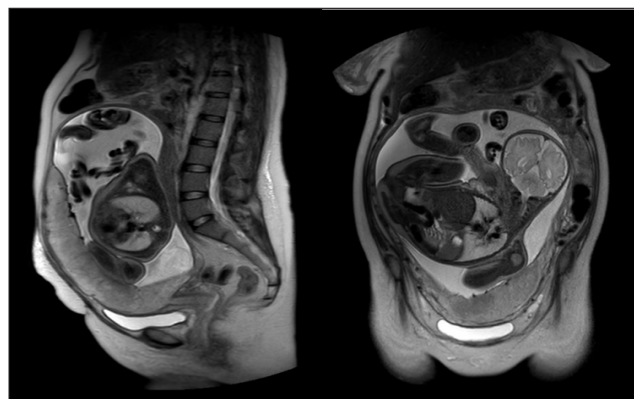


Fig. 1: Sagittal and coronal T2-weighted MRI images of a case that had uterine sparing surgery with main bulk of placenta anterior and no bladder wall interruption, no parametric nor cervical invasion.

Planned cesarean hysterectomy (Figure 2) with no attempt at placental separation when there is thinning of the myometrium with focal interruption or complete myometrial loss plus at least one of the following:

- Bladder wall interruption.
- Focal exophytic mass into the bladder or parametrium.

- Cervical invasion.

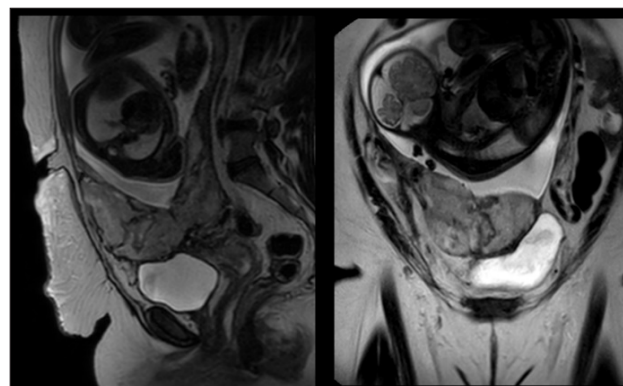


Fig. 2: Sagittal and coronal T2-weighted MRI images of a case that had cesarean hysterectomy showing placenta central in the pelvis, tenting of bladder, and parametric invasion.

Surgical intervention:

Blood products such as packed RBCs, fresh frozen plasma and platelets were prepared. The surgery was done by two consultants with expertise in PAS and complex pelvic surgery. After laparotomy, the fetus was delivered through upper uterine incision that avoids the placenta, after which the cord was clamped with no attempt at placental removal. Safe retro peritoneal dissection and creation of bladder flab was done for classification of the disease according to FIGO classification system. *According to surgical technique, the study cases were divided into two groups:*

- Cesarean hysterectomy group (for FIGO grade G3b, G3c, and G3a total disease).
- Uterine sparing (resection) group (for lesser FIGO grades).

The amount of blood loss, surgical complications such as bladder, ureteric or bowel injury were documented. The amount transfusion of blood products, and use of massive transfusion protocol also was documented. The duration of hospital stay, ICU admission, post operative complications such as infection, relaparotomy and readmission were documented.

We had compared data obtained from MRI examination with intraoperative findings. Our MRI proposal was compared with FIGO classification system and surgical management to determine MRI accuracy in prenatal prediction of surgical plan.

Statistical analysis:

Statistical analysis was conducted using SPSS v22.0. Descriptive statistics included mean $\pm$ SD or median (range) for quantitative data and frequency (%) for qualitative data. Inferential tests included Chi-square, Fisher's exact, Monte Carlo, *t*-test, and Mann-Whitney *U* as appropriate. Diagnostic performance was assessed using sensitivity, specificity, PPV, NPV, and accuracy. Agreement between

methods was evaluated with the kappa coefficient. A p -value <0.05 was considered statistically significant.

RESULTS

Table (1) shows demographic data and clinical history in the cases of the study, with the mean age was 32.27 ± 5.85 . Also, the mean BMI was 28.96 ± 2.6 . The number of prior caesarean deliveries ranged from 2 to 6. The mean gestational age at time of delivery was 35.27 ± 4.88 weeks.

Prenatal MRI findings of study cases were demonstrated in Table (2), with myometrial thinning, placental bulge, loss of retroplacental hypointense line and dark T2 bands were the most frequently encountered signs and were present in 100%, 90%, 76.7%, and 70.0% of cases respectively. On the other hand, less common signs were bladder wall interruption (23.3%), cervical invasion (10%), and parametric invasion (13.3%). Our MRI proposal revealed that 22 Of cases could undergo uterine sparing surgery, and 8 cases need hysterectomy.

Perioperative data of study cases were demonstrated in Table (3), with the mean blood loss (ml) was 1910 ± 469.3 . Mean transfused packed RBCs was 3.13 ± 1.5 . About 10% of cases had bladder injuries. 25 cases had uterine preservation surgery through resection technique, and hysterectomy was done in 5 cases.

Table (4) revealed the agreement between preoperative MRI proposal and surgical technique, where the MRI proposal correctly correlated with the surgical management in 27 cases and overestimated the diagnosis in 3 cases. All 5 cases that underwent hysterectomy were correctly diagnosed by MRI, while in the remaining 25 cases that had uterine preservation surgery, the MRI had correctly diagnosed only 22 cases, with estimated sensitivity, specificity, diagnostic accuracy, positive and negative predictive values were 88, 100, 90, 100, and 62 respectively.

Table 1: Demographic data and clinical history in the cases of the study:

Variables	Study cases N= 30	
	Mean $\pm$ SD	Median (Range)
Age (Years)	32.27 ± 5.85	32(21–42)
BMI (Kg/m ²)	28.96 ± 2.6	29.57(22.7–32.4)
Gravidity	4.6 ± 1.6	4.5(3–8)
Parity	3.03 ± 1.2	3(2–7)
Previous CS	2.8 ± 1.06	2.5(2–6)
Gestational age at delivery (Weeks)	35.27 ± 4.88	37(21–39)
	Number	Percent
Prior miscarriage	12	40
Previous hysteroscopy	3	10
Previous uterine metroplasty	1	3.3

Table 2: MRI findings in the cases of the study:

Variables	Study cases N= 30	
	Number	Percent
Myometrium thickness		
Thin	25	83.3
Complete absent myometrium over the placenta	5	16.7
Retroplacental hypointense line		
Intact	7	23.3
Interrupted	23	76.7
dark T2 bands		
Absent	9	30.0
Present	21	70.0
Placental bulge		
No bulge	3	10
Placental bulge	27	90
Bladder tentening		
Absent	16	53.3
Present	14	46.7
Bladder wall interruption		
No interruption	23	76.6
Interruption	7	23.3
cervical invasion	3	10
parametric or lateral invasion	4	13.3
Proposed surgical plan by MRI		
Uterine sparing (resective) group	22	73.3
Planned cesarean hysterectomy group	8	26.7

Table 3: Peri-operative data in the cases of the study:

Variables	Study cases N= 30	
	Number	Percentage
Bladder injury	3	10
Ureteric injury	0	0
Internal iliac Ligation	2	6.67
Operation technique		
Uterine sparing (resective technique) group	25	83.3
Cesarean hysterectomy group	5	16.67
Postoperative ICU admission	1	3.3
Relaparotomy	0	0
Wound infection	0	0
	Mean $\pm$ SD	Median (Range)
Blood loss (ml)	1910 ± 469.3	1800(1000–3000)
Transfused RBCs units	3.13 ± 1.5	3(0–6)
Operative time (Minutes)	107.17 ± 30.87	112(60–190)
Pre-operative Hgb level	11.19 ± 1.2	11(9.5–16)
Operative time (Min)	115.17 ± 41.2	120(60 – 240)
Postoperative Hgb level	9.47 ± 2.1	9.8(0–11.8)
Postoperative hospital stay	8.67 ± 4.07	7.5(1–18)

Table 4: Agreement between preoperative MRI proposal and surgical technique:

	Surgical technique				Agreement analysis
	Cesarean hysterectomy (<i>n</i> = 5)		Uterine sparing (<i>n</i> = 25)		
	No	%	No	%	
MRI proposal					
Planned cesarean hysterectomy (<i>N</i> = 8)	5 (TN)	100	3 (FN)	12	κ = 0.71
Uterine sparing (<i>N</i> = 22)	0 (FP)	0	22 (TP)	88	P = 0.25
Sensitivity			88%		
Specificity			100%		
Accuracy			90%		
<i>PPV</i>			100%		
<i>NPV</i>			62%		

κ : Kappa agreement coefficient; *: Statistically significant ($p < 0.05$).

Table (5) showed comparison between MRI findings in the uterine sparing group and cesarean hysterectomy group. Two MRI signs were significantly more frequent in the hysterectomy group than in the uterine sparing group, the first is bladder wall interruption 80% in the hysterectomy group versus only 12% in uterine sparing group ($P = 0.0069$). The second is cervical invasion, 60% in hysterectomy group versus 0% in uterine sparing group ($P = 0.0011$). Parametric invasion was higher in the hysterectomy group than uterine sparing group, 40% versus 8% but the difference was not statistically significant. Other MRI signs did not differ between the two groups.

Table (6) shows comparison of perioperative data between the cesarean hysterectomy group and uterine sparing group, and there was no significant difference between the two groups regarding the blood loss and transfused RBCs. The operating time was significantly longer in the cesarean hysterectomy group ($p = 0.0017$). Also, the rate of bladder injury was higher in the cesarean hysterectomy group but did not reach a significant level ($P = 0.064$). The length of postoperative hospital stay was significantly longer in the cesarean hysterectomy group ($p = 0.023$). The only case that was readmitted due to vesicovaginal fistula was in the caesarean hysterectomy group.

Table 5: comparison between MRI findings in the uterine sparing group and cesarean hysterectomy group:

	Cesarean hysterectomy (n= 5)		Uterine sparing (resection technique) (n= 25)		Test of significance
	Number	Percent	Number	Percent	
Myometrium thickness					
Thin	0	0	25	100	MC= 18.8809 $P = 0.00$
Absent (Complete loss of myometrium over lower segment)	5	100	0	0	
Retroplacental hypointense line					
Intact	0	0	7	28	$\chi^2 = 0.5963$ $P = 0.44$
Interrupted	5	100	18	72	
dark T2 bands					
Absent	1	20	8	32	FET $P = 1$
Present	4	80	17	68	
Placental bulge					
No bulge	1	20	2	8	MC= 0.6851 $P = 0.71$
Focal bulge	3	60	19	76	
Multiple bulge	1	20	4	16	
Bladder tentening					
Present	5	100	9	36	$\chi^2 = 4.5268$ $P = 0.0334$
Absent	0	0	16	16	
Bladder wall interruption					
Interruption	4	80	3	12	$\chi^2 = 7.3043$ $P = 0.0069$
No interruption	1	20	22	88	

	Cesarean hysterectomy (n= 5)		Uterine sparing (resection technique) (n= 25)		Test of significance
	Number	Percent	Number	Percent	
Cervical invasion	3	60	0	0	$\chi^2= 10.6667$ $P= 0.0011$
Parametric invasion					
Yes	2	40	2	8	FET $P= 0.1188$
No	3	60	23	92	

Table 6: Comparison between perioperative data in the uterine sparing group and cesarean hysterectomy group:

Variables	Cesarean hysterectomy (n= 5)	Uterine sparing (resection technique) (n= 25)	Test of significance
Blood loss (ml)	2160±512.84	1860 ±454.61	$t= -1.216$ $P= 0.275$
Transfused RBCs units	4.6(1–6)	2.84(0 – 6)	$z= 17.5$ $P= 0.0113$
Operative time (Minutes)	188±30.33	100.6±23.95	$t= -6.0756$ $P= 0.0017$
Massive transfusion	5(100%)	7 (28%)	FET $P= 0.0056^*$
Internal iliac Ligation	0(0%)	2 (8%)	FET $P= 1$
Bladder injury	2(40%)	1 (4%)	FET $P= 0.064$
Postoperative haemoglobin (gm/dl) (gm/dl) (gm/dl)	9.06±0.96	9.56 ± 2.26	$t= 0.7939$ $P= 0.4399$
Postoperative blood transfusion	3(60%)	7 (28%)	$\chi^2= 0.75$ $P= 0.3865$
Postoperative hospital stay (days)	12±3.54	8±3.89	$z= 21.5$ $P= 0.023$
Readmission	1(20%)	0(0%)	$P= 0.1667$

t: Independent samples *t*-test; *z*: Mann-Whitney *u*-test; χ^2 : Chi-square test; FET: Fischer's exact test.

DISCUSSION

Our MRI proposal had correctly predicted surgical management in 27 out of 30 cases and overestimated the diagnosis in 3 cases. All 5 cases of cesarean hysterectomy were correctly diagnosed by MRI, while in the 25 cases of uterine preservation, the MRI diagnosis was correct in only 22 cases giving sensitivity, specificity, accuracy, PPV, and NPV of 88%, 100%, 90%, 100%, and 62% respectively in prediction of success of uterine sparing surgery. Individual MRI signs that were associated with more severe PAS and hence hysterectomy included bladder wall interruption, cervical invasion, and parametric invasion.

A recent systematic review and meta-analysis that had evaluated the diagnostic accuracy of MRI in diagnosing PAS and found that the overall sensitivity of MRI was 86.7%, and the specificity was 86%. The estimated odds ratio was 28.693, the negative likelihood ratio was 0.178, and the positive likelihood ratio was 4.316^[11].

Dark intraplacental bands could be detected on T2W and are characterized by irregular margins with their maximum diameter ranging between 6 and 20mm. The

association between increased volume of dark T2 bands and depth of placental invasion was also reported^[12].

According to the results of a meta-analysis^[13], the sensitivity of these dark T2 bands for the diagnosis of placenta accreta, increta, and percreta was 89.7, 89.7, and 82.6% respectively; but the specificity was not high with corresponding values of only 49.5, 63.4, and 58.5%.

In our study, dark T2 bands were present in 21 out of 30 cases (70%), with 80% of most severe PAS (placenta percreta) had these bands compared to 68% of less severe PAS ($P= 1$), which means that this sign is highly sensitive for the diagnosis of PAS, but should be combined with other signs for determination of degree of invasiveness of the disease. On the other hand, placenta percreta could not be excluded when this sign is absent in presence of other MRI signs suggesting highly invasive PAS.

In a meta-analysis^[13], focal myometrial interruption had a sensitivity of 63.6%, 67.9%, and 78.6% for diagnosis of placenta accreta, increta, and percreta respectively. The

corresponding values of specificity were 72.2%, 77.5%, and 70.2%. myometrial thinning was present in all our 30 cases, with nearly complete myometrial loss present in more severe cases. Again, this sign is sensitive for diagnosis of PAS especially when most of the myometrium is lost but should be combined with other signs for confirmation of invasiveness of the disease.

The sensitivity and specificity of bladder wall interruption for diagnosis of PAS was 38.4%, 98.5% respectively in a meta-analysis^[11]. In our study, this sign was present in only 7 out of 30 cases (23.3%), with 80% of cases diagnosed with severe PAS had this sign versus only 12 % of non percreta cases ($P= 0.0069$).

The presence of abnormal placental bulge had a sensitivity and specificity for diagnosis of placenta increta and percreta of 76.7 and 62.5%, respectively^[13]. Another meta-analysis revealed the sensitivity and specificity of this sign for diagnosis of PAS was 51.8%, 91.6% respectively^[11]. The specificity of this sign could be increased when it is associated with focal myometrial interruption. In our study, this sign was commonly encountered as it was detected in nearly 90% of the cases, with no significant difference between most severe PAS and milder forms of the disease.

The presence of parametric invasion was present only in 4 out of 30 cases (13.3%) in our study, and although it was more common in hysterectomy group than the uterine sparing group, the difference did not reach a significant level. Parametric invasion is considered according to FIGO classification the most severe form of PAS (G3c). 2 cases in our study diagnosed by prenatal MRI to have parametric invasion underwent uterine preservation surgery, and this could be explained by finding the lateral placental invasion involving the upper but not the lower parametrium. According to one study, upper parametric involvement at time of surgery was associated with much better outcome than lower parametric invasion^[14].

The point of strength is that it is to our knowledge this study is the first one that had evaluated use of prenatal MRI to tailor the surgical plan and select cases amenable for uterine preservation surgery and those who will need radical surgery. The second point is that our MRI proposal was targeted at prediction of cases in whom the disease is confined to uterus and differentiate from those with extrauterine disease which is the main point in determining success of uterine sparing surgery.

LIMITATION

The limitation of our study is the small sample size, and this is due to many cases admitted to our department with diagnosis of PAS based on ultrasonography and no sufficient time to perform MRI examination before

surgery. The second limitation is that the MRI examination did not differentiate between cases with upper and lower parametric invasion that made results inconclusive.

CONCLUSION

The conclusion of our study is that MRI used as adjunct to ultrasonography is a valuable tool that could be used in prenatal multidisciplinary team organization, and planning of surgery with determination of cases suitable for uterine preservation surgery.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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