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Evaluation of the Diagnostic Accuracy of Prenatal MRI in Predicting Placenta Accreta Spectrum (PAS) and Clinical Outcomes in Cases with Placenta Previa

Plasenta Previa Olgularında Plasenta Akreta Spektrumunu (PAS) ve Klinik Sonuçları Tahmin Etmede Prenatal MRG'nin Tanısal Doğruluğunun Değerlendirilmesi

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Abstract

Introduction: The purpose of this study is to investigate the predictive value of magnetic resonance imaging (MRI) parameters in predicting placenta accreta spectrum (PAS) and clinical outcomes of patients with placenta previa.

Materials and Methods: A total of 56 prenatal placental MRI examinations acquired via 1.5 and 3 Tesla scanners were retrospectively examined by 2 radiologists in consensus. Presence of T2 dark band, thinning of myometrium, abnormal vascularization, uterine bulging, heterogeneous placenta, placental protrusion, placenta recess and percretism findings were evaluated. While pathology and clinical intrapartum findings constituted the reference standard for placenta accreta spectrum (PAS), intrapartum/peripartum bleeding over 1000 mL and emergency hysterectomy were regarded as poor clinical outcomes. The values of MRI findings in predicting both PAS and clinical outcomes were analyzed.

Results: Age, (platelet) PLT value and gestational age were similar in patients with both groups. Signs of percretism had the best diagnostic test performance in predicting clinical worsening, followed by intraplacental abnormal vascularization and placental recession (respectively 80.6%, 76.4%, 73.6%) . The most valuable finding in predicting PAS was percretism sign, placental recess, and myometrial thinning (respectively 85.0%, 81.3%, 79.4%).

Conclusion: Percretism and intraplacental abnormal vascularization are highly predictive of a possible poor clinical outcome.

Keywords: Placenta accreta spectrum; placenta previa; prenatal MRI; intrapartum bleeding; peripartum hysterectomy.

Özet

Amaç: Bu çalışmanın amacı, manyetik rezonans görüntüleme (MRG) parametrelerinin plasenta akreta spektrumunu (PAS) ve plasenta previalı hastaların klinik sonuçlarını öngörmedeki değerini araştırmaktır.

Gereç ve Yöntem: 1.5 ve 3 Tesla tarayıcı ile alınan toplam 56 prenatal plasenta MRG tetkiki 2 radyolog tarafından mutabakatla retrospektif olarak incelendi. T2 koyu bant varlığı, myometriumda incelme, anormal vaskülarizasyon, uterin bombeleşme, heterojen plasenta, plasenta protrüzyonu, plasenta reses ve perkretizm bulguları değerlendirildi. Plasenta akreta spektrumu (PAS) için patoloji ve klinik intrapartum bulgular referans standardı oluştururken, 1000 mL'nin üzerinde intrapartum/peripartum kanama ve acil histerektomi kötü klinik sonuçlar olarak kabul edildi. MRG bulgularının hem PAS'ı hem de klinik sonuçları öngörmedeki değerleri analiz edildi.

Bulgular: Klinik sonuçları iyi ve kötü olan hastalar arasında yaş, platelet (PLT) değeri ve gebelik süresi açısından anlamlı fark yoktu. Klinik kötüleşmeyi öngörmede perkretizm belirtileri en iyi tanısal test performansına sahipti, ardından intraplasental anormal vaskülarizasyon ve plasental gerileme geldi (sırasıyla respectively 80.6%, 76.4%, 73.6%). PAS'ı öngörmede en değerli bulgu perkretizm işareti, plasental reses ve miyometriyal incelme idi (sırasıyla 85.0%, 81.3%, 79.4%).

Sonuç: perkretizm ve intraplasental anormal vaskülarizasyon olası bir kötü klinik sonucun yüksek oranda göstergesidir.

Anahtar Kelimeler: Plasenta akreata spektrumu; plasenta previa; prenatal MRG; intrapartum kanama; peripartum histerektomi.

Introduction

Placenta accreta spectrum (PAS) is used to describe the clinical condition that occurs as a result of uterine invasion by trophoblasts in excess of the required amount (1). It is named differently according to the amount of invasion of the placenta to the myometrium. For example, the superficial invasion of the myometrium of the placenta: placenta accreta, invasion up to the outer wall of the myometrium: placenta increta, overcoming of the uterine serosa or infiltration of the surrounding organs: placenta percreta (2). There are two major risk factors for PAS reported

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to date. The first of these is a previous cesarean section and the second is placenta previa (2). An invasive placenta is a fairly strong risk for premature birth and fatal bleeding. Placental implantation abnormality is a risk that can lead to may lead to risky consequences for the mother and child in the later stages of pregnancy. Placenta previa vasa previa carries a risk for premature rupture of membranes. These risks include rupture and bleeding (3). Approximately 45-65% of mandatory hysterectomies during delivery are performed due to PAS. The International Federation of Gynecology and Obstetrics (FIGO) has developed a guideline to improve the diagnosis and management of PAS in order to reduce maternal mortality and the risk of child or maternal sequelae (4-6). Although ultrasound (US) is still the first test used for prenatal evaluation, the use of magnetic resonance imaging (MRI) has increased (5). Compared to US, MRI has the advantage of providing high soft tissue contrast resolution and topographic imaging of parauterine tissues and organs (6). Therefore, its topographic and morphological contribution is of value as a supplement material in cases where US findings are disputable or when specific information on parauterine tissues is needed (7). Moreover, several studies described various MR-predictive "signs" of placental invasion. There is increasing research investigating the role of MRI in predicting the clinical outcome of treatment and bleeding with invasive placenta previa (1,2,8). This study aims to investigate the predictive value of prenatal MRI in predicting clinical outcomes and the diagnostic accuracy of the criteria evaluated for the diagnosis of PAS in cases with placenta previa.

Materials and Methods

Patient Selection and Study Design: During this study, the guidelines of the Declaration of Helsinki were fully complied with. Informed consent was abandoned due to the retrospective nature of the study. Eighty-one patients with placenta previa with suspicion of PAS due to clinical status and/or US results operated on in our hospital between January 2018–September 2022 were evaluated retrospectively. The patients were placed into 2 groups according to their clinical outcomes. The poor outcome group consisted of pregnant women who had massive intrapartum/peripartum bleeding (>1000 mL) and/or who underwent emergency hysterectomy (non-conservative treatment). The good outcome group was made up of pregnant women who had minor peripartum bleeding (≤1000 mL) or who underwent conservative treatment (uterotonic treatment, balloon tamponade, and uterine artery embolization). A total of 26 patients who did not have prenatal MRI examination records in our hospital system, whose examination was not optimal due to peristalsis or motion artifacts were excluded from the study. 56 patients who were considered eligible for evaluation were included in the study. The diagnosis of PAS was made by pathology reports and/or clinical intrapartum findings.

MRI Acquisition: Imaging was performed using a 1.5 and 3-Tesla scanner (Ingenuity; Philips) with a body-parallel array coil (SENSE Torso/cardiac coil, USA). All patients were instructed to empty their bladders roughly 20 min. before examination; subsequently, each patient drank 500 mL of water. A coronal pelvic scan was performed, followed by axial, sagittal, and coronal placental scans according to the fetal position. The details of the sequences and parameters used are presented in Table 1.

Table 1: Perinatal placental MRI sequence parameters.

	T2-weighted Sagittal	T2-weighted Coronal	T2-weighted Axial	T2-BTFE Sagittal	T2-BTFE Axial
TR/TE (ms)	3.1/100	2.9/100	5.1/100	3/2	3/2
Slice thickness (mm)	5	5	5	6	6
Flip angle	90	90	90	90	90
Reconstruction matrix	256	256	384	384	256
Field of view (mm)	480 x 480	480 x 480	480 x 480	400 x 400	400x400
No. of sections	39	40	52	46	62

MRI Evaluation: The MRI criteria included in the PAS evaluation were as follows.

1. Intraplacental T2 dark bands: ≥2-cm lines in the placenta that formed bands with low signal intensity.

2. Uterine bulging: Disruption of the shape of the uterus; caudal section that appeared wider.
3. Placental recess: Deformity of the placenta caused by contraction of the surface of the placenta and outer edge of the uterus; forms a wedge-shaped contour and occurs alongside the T2 dark bands.
4. Percretism signs: Signs of invasion of parauterine organs.
5. Intraplacental abnormal vascularization: Enlarged and sedimented vascular packages in the placenta that appeared as signal voids on T2w images with a diameter of >6 mm.
6. Myometrial thinning: Thinning of the myometrium and a hypointense focal defect at the uteroplacental interface or the dimming of the myometrial border in the T2w images.
7. Heterogeneous intraplacental sign: Thinning of the myometrium accompanied by a focal defect at the hypointense uteroplacental interface or blurring of the myometrial border on T2w images.
8. Placental protrusion sign: A placenta that enlarged and extended to the internal uterine os (1).

The study was conducted retrospectively, and the evaluation was undertaken based on the consensus of 2 radiologists who examined images obtained from the Picture Archiving and Communication System (PACS) of our hospital. In case of disagreement, a third radiologist (with 35 years of experience in abdominal-imaging MRI) decided on the final result.

Ethical Consent: This study was conducted in full accordance with the guidelines of the Declaration of Helsinki. Ethics committee and Turkish Ministry of Health approvals were obtained for the study (2022/2248). Requirement for informed consent from the patients was waived due to the retrospective nature of the study.

Statistical Analysis: Statistical analysis of the data was performed with SPSS 25.0. Categorical measurements were summarized numerically and as percentages, while continuous measurements were summarized as means and standard deviations (or median and minimum-maximum where necessary). Classified units were compared with the chi-square test. Chi-square and Fisher's exact tests were used to analyze the classified subunits. The Shapiro-Wilk test was used to analyze the distribution of the parameters in the study. The Mann-Whitney U test was used to examine the values that did not show normal distribution in pairs. The sensitivity and specificity values of PAS, intrapartum/peripartum bleeding, hysterectomy, prenatal MRI signs of the patients included in the study grouped according to good clinical outcome and poor clinical outcome were calculated.

Results

A total of 36 of the patients included in the study had poor clinical outcomes, while 20 had good clinical outcomes.

Table 2: Numerical distribution of clinical outcomes, laboratory results, and MRI parameters of patients

Group	Quantity (n)	Percentage (%)
Good clinical outcome	20	35.7
Poor clinical outcome	36	64.3
PAS	40	71.4
Intrapartum peripartum bleeding		
Lower than 1000 cc	31	55.4
Over 1000 cc	25	44.6
Hysterectomy	30	53.6
Intraplacental T2 dark bands		
<2	12	21.4
≥2	44	78.6
Myometrial thinning	40	71.4
Intraplacental abnormal vascularization	33	58.9
Uterine bulging	20	35.7
Heterogenous intraplacental sign	34	60.7
Placental protrusion sign	28	50
Placental recess	31	55.4
Percretism signs	36	64.3
	Avr ± Ss	Med (min-max)
Age	33.1 ± 5.7	33 (20–43)
Preoperative PLT	198.3 ± 69.0	180.5 (112–381)
Week of pregnancy at time of operation	33.9 ± 1.4	34 (30–36)

Twenty-five of the patients with poor clinical outcomes hemorrhaged more than 1000 cc of blood. The MRI evaluation of 40 patients out of 56 showed PAS (Table 2). There were no significant differences between patients with good and poor clinical outcomes in terms of age, platelet (PLT) value, and pregnancy period ($p > 0.005$) (Table 3). Myometrial thinning, intraplacental abnormal vascularization, uterine bulging, placental recess, and percretism sign rates were significantly higher in patients with poor clinical outcomes compared to those with good clinical outcomes ($p = 0.001$; $p < 0.001$; $p = 0.003$; $p = 0.001$; $p < 0.001$, respectively), (Table 3).

Table 3: Statistical analysis of the distribution of laboratory data and MRI parameters of the 2 groups included in the study.

	Good clinical outcome (n = 20)	**Poor clinical outcome (n = 36)**	**p1**
	n (%)	**N (%)**	
PAS	13 (65)	27 (75)	0.427
Intrapartum/peripartum bleeding			
Lower than 1000 cc	20 (100)	11 (30.6)	<0.001**
Over 1000 cc	-	25 (69.4)	
Hysterectomy	-	30 (83.3)	<0.001**
Intraplacental T2 dark bands			
<2	5 (25)	7 (19.4)	0.627
≥2	15 (75)	29 (80.6)	
Myometrial thinning	9 (45)	31 (86.1)	0.001**
Intraplacental abnormal vascularization	5 (25)	28 (77.8)	<0.001**
Uterine bulging	2 (10)	18 (50)	0.003**
Heterogenous intraplacental sign	10 (50)	24 (66.7)	0.221
Placental protrusion sign	7 (35)	21 (58.3)	0.094
Placental recess	5 (25)	26 (72.2)	0.001**
Percretism signs	5 (25)	31 (86.1)	<0.001**
	Good clinical outcome (n = 20) Avr ± Ss	Poor clinical outcome (n = 36) Avr ± Ss	p2
Age	32.8 ± 4.9	33.4 ± 6.2	0.687
Preoperative PLT	197.4 ± 82.8	198.8 ± 61.4	0.516
Week of pregnancy at time of operation	33.8 ± 1.6	33.9 ± 1.3	0.758

Table 4. Sensitivity, specificity, and ROC analysis of the ability of prenatal MRI findings in predicting poor clinical outcomes.

	Myometrial thinning	**Intraplacental abnormal vascularization**	**Intraplacental dark band**	**Uterine bulging**	**Placental recess**	**Percretism signs**
AUC 95%-Cl (%)	0.706 (0.569-0.820)	0.764 (0.631-0.867)	0.655 (0.458-0.725)	0.700 (0.563-0.815)	0.736 (0.601-0.845)	0.806 (0.678-0.899)
Cut-off	>0	>0	>0	>0	>0	>0
Sensitivity 95%-Cl (%)	86.11 (70.5-95.3)	77.78 (60.8-89.9)	69 (48.9-71.4)	50 (32.9-67.1)	72.22 (54.8-85.8)	86.11 (70.5-95.3)
Specificity 95%-Cl (%)	55 (31.5-76.9)	75 (50.9-91.3)	76.25 (39.8-70.1)	90 (68.3-98.8)	75 (50.9-91.3)	75 (50.9-91.3)
PPV 95%-Cl (%)	68.8 (47.1-84.5)	84.8 (72-92.4)	71.1 (66.5-81.1)	90 (69.9-97.2)	83.9 (70.3-91.9)	86.1 (74.2-93.1)
NPV 95%-Cl (%)	77.5 (67.6-85.1)	65.2 (49.2-78.4)	48.4 (31.5-62.3)	50 (41.1-58.9)	60 (45.5-72.9)	75 (56.1-87.5)
P	0.003**	<0.001**	0.008	0.002**	0.002**	<0.001**

*p < 0.05; **p < 0.001; ROC curve test

No significant differences between groups with good and poor clinical outcome in terms of T2 dark bands, heterogeneous intraplacental sign, and placental protrusion sign were observed. Diagnostic test performances in detecting poor clinical results in prenatal MRI examination are presented in Table 4. Accordingly, it was observed that the AUC values of myometrial thinning, intraplacental abnormal vascularization, uterine bulging, placental recess, and percretism sign were 70.6%; 76.4%; 70.0%; 73.6%; 80.6%, respectively ($p = 0.003$; $p < 0.001$; $p = 0.002$; $p = 0.002$; $p < 0.001$, respectively). It was found that percretism signs had the best diagnostic test performance, followed by intraplacental abnormal vascularization and placental recess (Table 4). The diagnostic test performances of myometrial thinning, intraplacental abnormal vascularization, uterine bulging, placental recess and percretism signs values according to PAS are shown in Table 5. Accordingly, the areas below the cut off (threshold value) determined in percretism sign, myometrial thinning and placental recess values were while observed that respectively 85.0%, 79.4%, 81.3% (Table 5) (Fig.1).

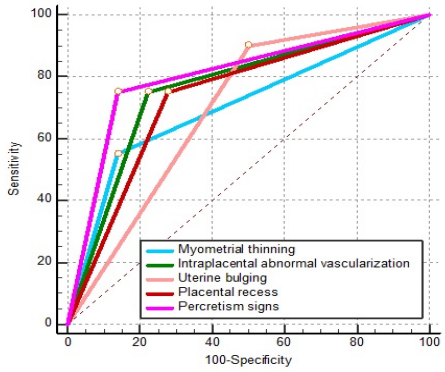

Figure 1. Multivariant ROC curve analysis showing the ability of prenatal MRI findings to predict poor clinical outcomes.

Table 5: Sensitivity, specificity, and ROC analysis of the ability of prenatal MRI findings in predicting PAS.

	Myometrial thinning	Intraplacental abnormal vascularization	Intraplacental dark band	Uterine bulging	Placental recess	Percretism signs
AUC 95%-Cl (%)	0.794 (0.656-0.810)	0.606 (0.567-0.734)	0.616 (0.557-0.713)	0.531 (0.393-0.666)	0.813 (0.5760.836)	0.850 (0.6600.889)
Cut-off	>0	>0	>0	>0	>0	>0
Sensitivity (%) 95%-Cl (%)	82.5 (67.2-92.7)	65 (48.3-79.4)	69 (47.5-77.5)	37.5 (22.7-54.2)	67.5 (50.9-0.826)	88 (53.5-93.4)
Specificity 95%-Cl (%)	76.25 (29.9-80.2)	56.25 (29.9-80.2)	66.25 (39.8-77.2)	68.75 (41.3-89.0)	75 (47.6-92.7)	80 (24.7-75.3)
PPV 95%-Cl (%)	82.5 (72.7-89.3)	78.8 (67.1-87.1)	78.8 (66.5-84.4)	75 (56.7-87.3)	87.1 (73.8-94.2)	77.8 (67.3-85.6)
NPV 95%-Cl (%)	56.2 (36.6-74.1)	39.1 (26.0-54.1)	42.4 (29.5-52.1)	30.6 (22.6-39.8)	48 (35.2-61)	40 (25.2-56.9)
p	0.006**	0.154	0.148	0.661	0.002**	0.001**

* p<0.05, **p<0.001, Roc curve test

Discussion

The value of MRI in the diagnosis of PAS has recently received increasing attention. The incidence of PAS disorders, especially abnormal placental invasion (varying between 1/2510 and 1/533 of births), and the significant prevalence of PAS even among women experiencing their first pregnancy is of great concern to obstetrics and gynecology professionals (9,10). Treatment strategies for PAS vary. For example, the type of invasion of the PAS spectrum is the most important factor in this selection. Another criterion is whether there is active bleeding in the mother or fetus, depending on whether the treatment requires urgency (11). Patient-based treatment strategies range from conservative strategies (uterotonic drug, balloon tamponade, and arterial embolization) to hysterectomy (12-14). In addition, although the presence of an invasive placenta is a major risk factor for mortal bleeding, not all patients with an invasive placenta will have bleeding requiring intervention during or after surgery (15). Abnormal vascularity, T2 dark bands, uterine distension, heterogeneous placenta, placental recess sign and myometrial thinning are

the most commonly used parameters for placental invasion and most frequently mentioned in radiology reports (16) (Fig. 2).

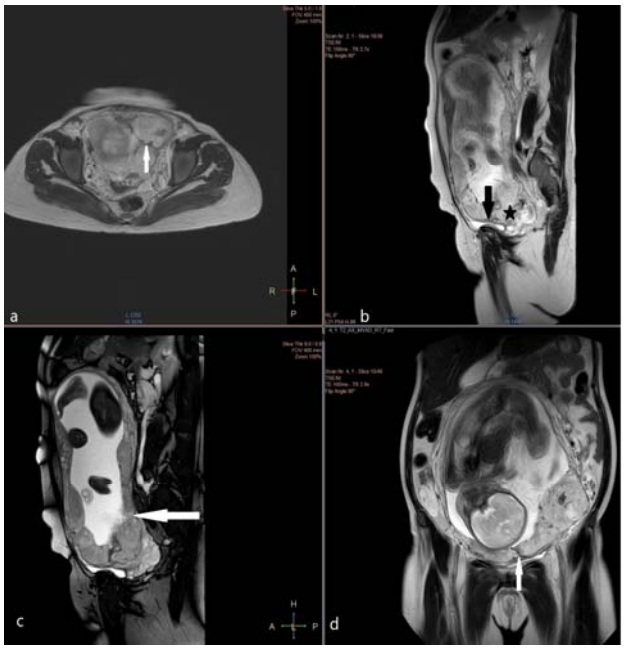

Figure 2. Axial T2-weighted (**a**) showing; Intraplacental dark band (white arrow) with the major diameter longer than 2 cm. Sagittal T2-weighted (b) showing: Percretism signs: direct invasion (dark arrow) of bladder, Placental protrusion sign: the placenta extends and projects (dark asterix) into the internal uterine os. Sagittal T2-BTFE image showing: (c) and coronal T2-weighted (d) images showing: Placental recess: the contraction of the placental surface accompanying a dark band (white arrow).

Previous studies have proven the value of MRI in the antenatal diagnosis of an invasive placenta; however, there is insufficient data on whether MRI is sufficient or which of these parameters is valuable to predict the clinical outcome of patients with suspected PAS (17,18). Our results suggest that the diagnostic performance of MRI findings may be sufficient to predict conservative and emergency management. The association of intrapartum/peripartum hemorrhages with the presence of invasive placenta is quite high. It has been proven in our study that intrapartum/peripartum hemorrhages are highly correlated with the presence of invasive placenta (Fig.3). However, management of obstetrics, infectious diseases, coagulation defects, uterine atony, uterine rupture, remnant placental tissue and other uterine bleeding such as uterine inversion are just a few of the factors that may affect the patient's clinic during pregnancy. Our results, are compatible with the literature, show that there is perfect alignment between MRI and intraoperative/histological findings in terms of PAS diagnosis, depth of placenta invasion, extrauterine spread of the placenta, or parametrial tissues. The finding of intraplacental abnormal vascularization was observed as the second most valuable finding in predicting poor clinical outcome. Placental recess was determined as the second most important variable in PAS definition. Consistent with the literature, the presence of T2 dark bands makes the diagnosis of PAS, but it has low value in defining the spectrum and predicting clinical outcome (19,20). Postpartum pathology studies have shown that T2 dark bands likely represent fibrin deposition. It also represents occlusions or bleeding areas caused by fibrin deposition. There are studies reporting that the size of these bands is related to the size of placental invasion (21). In addition, abnormal blood vessels, that is, increased intraplacental vascularity and hypervascularity in the uterine serosa or in the fatty tissue between the uterus and the bladder or in the parauterine fatty tissue, are observed as abnormal vascularization on prenatal MRI. It is usual for this abnormal vascularization to suggest only the risk of heavy bleeding. Therefore, it was not surprising that abnormal vascular structures were the second most valuable MRI finding in predicting poor clinic in our study (22,23).

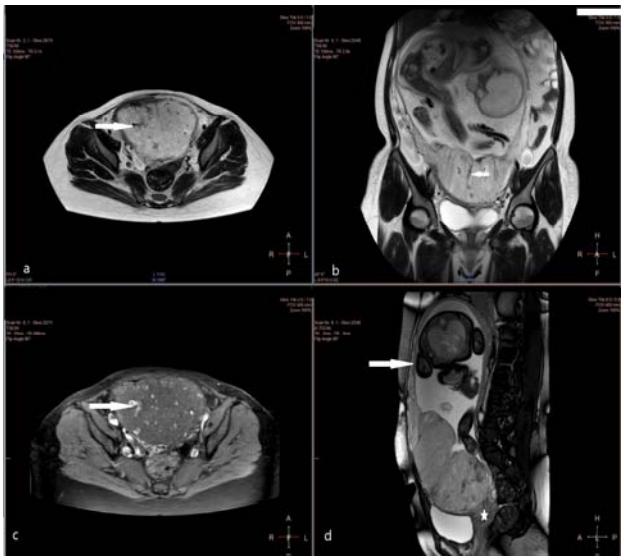

Figure 3. Axial T2-weighted (a) showing ; Intraplacental dark band (white arrow) with the major diameter longer than 2 cm. Coronal T2-weighted (b) and axial T1-weighted images (c) showing Intraplacental abnormal vascularity: enlarged and tortuous vessels (white arrow) with a diameter>6 mm (white arrow). Sagittal T2-BTFE image(d) showing; Myometrial thinning : focal defect of the hypointense uteroplacental interface with myometrial thinning or indistinctness of myometrial delineation(whire arrow), Uterine bulging: loss of normal "pear shape" of the uterus, with the wider appearance of the body than the caudal segments(white asterix).

It is usual for these abnormal vascular structures to correspond to increased newly formed vessels or enlarged anastomoses from the placenta to the uterus or adjacent structures, causing unexpected and fatal bleeding, usually in late pregnancy (23-26). MRI scoring system that can be used in routine practice; It can help identify patients at high risk of complications (26-29). The results of this study also showed ; when MRI findings are combined to predict conservative and non-conservative management, the diagnostic performance of MRI increased. Another result of the study was that the finding of percretism was very valuable in both predicting PAS and predicting poor clinic. The fact that aggressive invasion of the placenta is accompanied by fibrin structures and vascular structures, and that it is easier to detect as percretism with prenatal MRI may be another reason that increases the value of this finding.

Study limitations: This study had some critical limitations. The fact that the data were obtained from a study group at high risk for PAS disorders indicates that the generalizability of the findings is limited and is the first and most important limitation of this study. The second limitation is that the management of patients with suspected PAS disorders differs between clinics, and the surgeon's experience, the patient's desire to maintain fertility, the presence of a multidisciplinary team, and hemodynamic stability have a large impact on the surgical outcome. In addition, the retrospective nature of this study, the hereditary pathologies of patients that may have caused possible bleeding other than the PLT value not being identified-and the interobserver variability of the MRI parameters included in the study not being evaluated are additional limitations.

Conclusion

Identifying various MRI risk factors preoperatively allows practitioners to predict the course of labor in high-risk pregnant patients with PAS, resulting in better overall maternal care. Percretism and intraplacental abnormal vascularization are highly predictive of a possible poor clinical outcome and should be looked for during MRI and specified in prenatal MRI reports.

Ethical Approval: This study was approved by the University of Health Sciences Ethics Committee (date/approval number: 2022/2248) and it was done according tothe declaration of Helsinki.

Conflict of Interest: The authors declare that they have no conflict of interest for this study.

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Author Contributions: Conception, Data Collection and Literature Rewiev: HA, BG, NI,ZAT Design, Materials, Supervision and Analysis: HA, NI, BG, ZAT
MT Writer: HA, ZAT, NI , Critical Rewiev: HA, BG, NI, ZAT

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