Section: Radiodiagnosis

Original Research Article

DIAGNOSTIC ACCURACY OF A COMPOSITE ANTENATAL MAGNETIC RESONANCE IMAGING SCORE IN DIAGNOSING PLACENTA ACCRETA SPECTRUM DISORDERS

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ABSTRACT

Background: Placenta accreta spectrum (PAS) of disorders is an important cause of post-partum hemorrhage and resultant maternal morbidity and mortality. Imaging by ultrasonography and magnetic resonance imaging (MRI) plays an indispensable role in antenatal diagnosis of PAS. However, diagnosis of PAS is reliant on recognition of multiple imaging signs each of which have a wide range of sensitivity and specificity. There is no single pathognomonic diagnostic feature. This results in interobserver variability. In our study, we aim to assess the accuracy of a combined clinico-radiological scoring system using prenatal Magnetic Resonance Imaging (MRI) attributes in predicting placenta accreta. **Materials and Methods:** This prospective study included 125 MRI examinations done for suspected placenta Accreta Spectrum by clinical or Ultrasonography features. Two clinical and eight imaging criteria were assessed. Each criterion was given 1 point and a total score was calculated for each patient. Patients were classified into low (0–3 points), moderate (4–6) or high probability (7–10) for placenta accreta based on the final score. The presence of any statistically significant difference in prevalence of PA among these groups was assessed. Intra-operative findings or histopathology was considered the gold standard. **Result :** MRI demonstrated high overall accuracy for diagnosing PAS (97.6%) with 100% sensitivity and 87.0% specificity (Kappa = 0.916, p=0.001) compared to HPR. The PASS showed excellent agreement in risk stratification between MRI and HPR (Kappa = 0.851, p=0.001) and a very strong positive correlation between the numerical scores (Spearman's rho = 0.932, p=0.001). ROC curve analysis for the PASS score yielded an Area Under the Curve (AUC) of 0.746 (95% CI: 0.660-0.820, p=0.001). An optimal cutoff score of >1 provided 100% sensitivity and 100% negative predictive value, with a specificity of 65.22%. **Conclusion:** Clinico – radiological scoring using prenatal Magnetic Resonance Imaging (MRI) attributes provides a simple, objective and accurate way to stratify patients into low, intermediate and high probability categories for Placenta accreta spectrum (PAS) of disorders. By integrating multiple clinico-radiological features, it overcomes the limitations of relying on individual imaging signs. Its high sensitivity and negative predictive value make it an excellent system for ruling out PAS, and its strong correlation with histopathology supports its use in clinical practice to guide peripartum management and improve maternal outcomes.

INTRODUCTION

Post-partum hemorrhage (PPH) is an important and avoidable cause of maternal morbidity and mortality. Placenta Accreta spectrum (PAS) of disorders remains a common cause of PPH. Placenta Accreta Spectrum Disorders (PAS) occur due to a defect in the decidua basalis which allows the invasion of chorionic villi into the myometrium. It is classified on the basis of depth of myometrial invasion into Placenta accreta, increta and percreta.[1] Making an accurate diagnosis of this condition has become all the more important due to the dramatic increase in

prevalence of PA worldwide over past two to three decades. This recent phenomenon has been primarily ascribed to increasing percentage of Caesarean section deliveries.[2]

Antenatal ultrasound and magnetic resonance imaging (MRI) have been utilised to make diagnosis of PA. Ultrasound remains the first-line imaging modality for screening and detection of adherent placenta. The various signs used on ultrasound to diagnose PA are placental lacunae, loss of hypoechoic retroplacental zone, abnormal bladder–uterus interface and abnormalities on colour, Doppler imaging such as hypervascularisation within the placenta and in the sub- placental zone. The sensitivity and specificity of these signs however varies widely between studies.[3] This is likely due to the dependence on various factors like operator experience and difference in equipment used to make the diagnosis.

MRI has been increasingly used in recent times to make the diagnosis of PA. It is commonly used as a problem- solving tool in individual cases having equivocal findings on ultrasound. In some centers, MRI is done routinely in all patients with suspected PA. MRI is especially useful when the placenta is posterior and in suspected placenta percreta. The various signs described on MRI in PA are focal uterine bulge, heterogeneous intraplacental signal intensity, T2 dark bands and focal myometrial interruption.[4] Although many signs have been described on MRI in PA, there is no pathognomonic MRI feature. Interpretation thus often relies on a combination of signs which is subjective and often at the discretion of the physician interpreting the scan.[5] To address this issue, this study intends to develop a scoring system based on clinical and MRI features and to assess its accuracy in predicting PAS disorders. There is evidence that MRI has very low accuracy when it is performed before the 24th of gestation. The accuracy is also low when it is performed after the 35th of gestation because of the accentuated myometrial thinning and the natural placental heterogeneity, limiting the use of these two MRI features. Therefore, the gestational age to perform MRI for diagnosing PAS is taken between 24 and 35 weeks.[6]

MATERIALS AND METHODS

This was a cross sectional study which included pregnant women referred for MRI examination to the Department of Radiodiagnosis in our institute with suspected placenta accrete based on ultrasound or with high risk for placenta accrete from department of Obstetrics and Gynaecology. Patients who were lost to follow-up after the MRI and those unable to undergo MRI examination due to other contraindications like claustrophobia were excluded from the study. MRI was performed in 1.5T Siemens Magnetom Avanto MRI scanner.

Patients were examined in supine position with a body imaging phased array surface coil placed on the anterior abdominal wall. The main sequences used to evaluate the patients were T2 HASTE and fat saturated TRUFI in axial, coronal and sagittal planes planned according to the axis of the uterus. Supplementary sequences done were T1 dual echo gradient sequence, diffusion-weighted imaging and T2 gradient echo in axial or sagittal plane. The details of the protocol are given in [Table 1]. Average scan time was around 30 min.

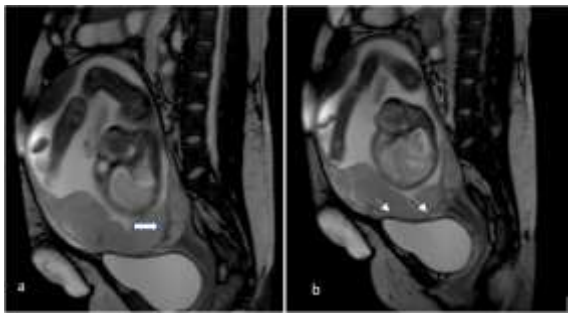

Figure 1: A 25 year old woman (Gravida 2) with previous history of Caesarean section. MRI T2WI HASTE sagittal images show (a) placenta previa with intraplacental dark band (b) thinning of myometrium with loss of placenta- myometrium interface and bladder wall interruption.

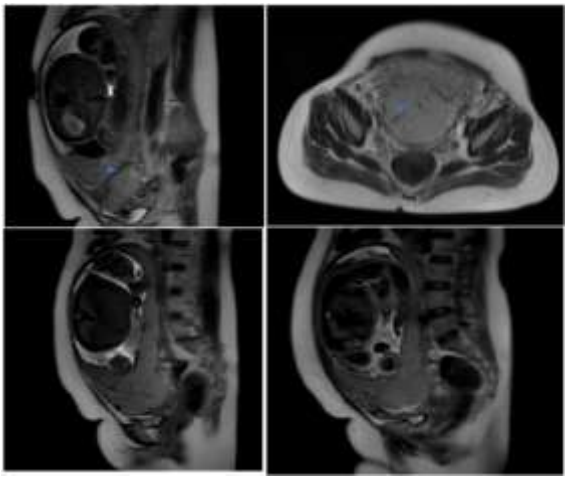

Figure 2: A 32 year old woman (Gravida 2) with previous history of Caesarean section. MRI T2WI HASTE sagittal and axial images show complete placenta previa (a) and (b) intraplacental dark bands (c) and (d) thinning of myometrium with loss of placenta- myometrium interface and retroplacental vascularity.

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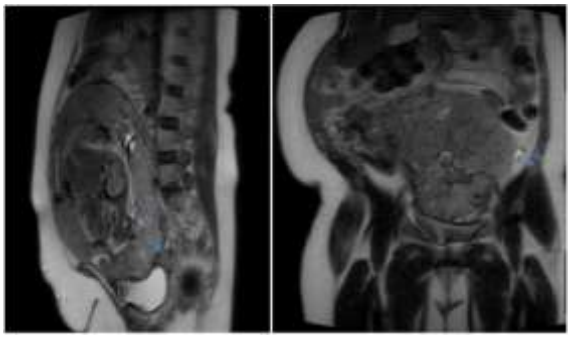

Figure 3: A 28 year old woman (Gravida 2) with previous history of Caesarean section. MRI T2WI HASTE sagittal and coronal images show placenta previa with (a) thinning of myometrium with loss of placenta- myometrium interface and (b) intraplacental dark bands.

Table 1: MRI protocol for assessment of patient with suspected placenta accreta spectrum disease

Parameters	Sequence		Add-on sequences		
	T2 HASTE Axial, coronal, sagittal	TRUFI FS Axial, coronal, sagittal	T1dual echo Axial	GRE sagittal	DWI axial
TE(ms)	91	1.6	4.7	23	101
TE(ms)	1350	3.9	70	1290	7000
Slice thickness(mm)	4	0.4	4.5	5	0.6
Interslice gap	0.4	4	0.45	0.5	6
FOV	270	380	280	280	320
Matrix	256x256	256x100	256	192x75	192x100
Flip angle		60	70	30	

DWI- Diffusion weighted imaging, FOV – field of view, FS- fat suppressed, GRE-gradient recall echo, HASTE-half Fourier-acquired turbo spin echo, TE- time to echo, TR- repetition time, TRUFI –true fast imaging with steady state precession.

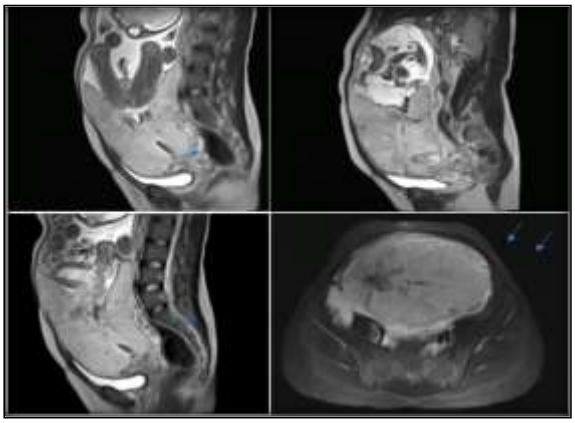

Figure 4: 21 year old woman (Gravida 2) with previous history of Caesarean section. MRI T2WI HASTE sagittal and axial images show complete placenta previa with placenta accreta (a) intraplacental dark bands (b)heterogenous placenta with intraplacental vascularity (c) retroplacental vascularity (d) thinning of myometrium with loss of placenta- myometrium interface

A score of 1 was awarded when each of the following clinical and MRI features was present: (1) Previous history of Caesarean section/uterine surgery (2) Placenta praevia, (3) Intraplacental dark bands on T2WI (4) heterogeneous placenta (5) focal uterine bulge (6) loss of placenta-myometrial interface (7) focal thinning of myometrium (8) abnormal intraplacental vascularity (9) Bladder wall interruption (10) penetrating placenta.

The MRI findings were correlated with intraoperative findings and with histopathological findings whenever hysterectomy was performed. Representative images are presented in [Figure 1-4]. The sensitivity and specificity of each of the MRI findings in isolation was assessed. Patients are classified into low (0–3 points), moderate (4–6) or high probability (7–10) for placenta accreta based on the final score. Presence of any statistically significant difference between the three groups was assessed using the chi-square test.

RESULTS

A total of 125 MRI examinations in 125 antenatal women were included in the study. Mean age of the patient antenatal women included in the study was 28.3 years with a standard deviation of 2.7 years, indicating a relatively young reproductive population. The majority of the participants (85.6%) were gravida 2, with the remaining 14.4% being gravida 3. The average gestational age at which the assessment was performed was 29.3 weeks (SD: 2.5), reflecting the third-trimester timeframe during which placental imaging is generally most informative. With respect to placental location, 81.6% of women had complete placenta previa, 16% had marginal placenta previa, and only a small minority (2.4%) had placentation involving the upper and mid uterine segments. This distribution is consistent with existing

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literature, where complete placenta previa is a major risk factor for PAS disorders.

The diagnostic utility of various MRI imaging markers was evaluated in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy (Table 2). The presence of intraplacental bands demonstrated high diagnostic accuracy with both sensitivity and specificity around 96%, and a PPV of 99.0%, indicating that this sign was highly reliable in diagnosing PAS. Loss of the placenta-myometrial interface and myometrial thinning, though commonly present (88% and 92.8% on MRI, respectively), had somewhat reduced specificity (73.7% and 69.2%, respectively), despite high sensitivity. Abnormal intraplacental vascularity had perfect specificity and PPV (100%), though its sensitivity was slightly lower at 92.6%. Both bladder wall interruption and penetrating placenta, though rare (each seen in only 5.6% and 1.6% cases, respectively), showed 100% accuracy, indicating that their presence is strongly indicative of severe PAS involvement.

When MRI diagnosis was compared as a whole to the gold standard of histopathological examination (HPR), its performance was outstanding. Out of the 125 cases, MRI correctly identified all 102 HPR-confirmed accreta cases (100% sensitivity), with only three false positives. The specificity of MRI was 87%, with a positive predictive value of 97.1% and a negative predictive value of 100%.The positive likelihood ratio (+LR) of 7.7 signifies that a positive MRI finding substantially increases the probability of PAS, while the negative likelihood ratio (-LR) of 0.0 confirms that a negative MRI effectively rules out the condition.

Table 2: Diagnostic Performance of MRI Signs in Predicting Placenta Accreta

Parameter	Sensitivity	Specificity	PPV	NPV	Accuracy
Intraplacental T2WI dark bands	96	95.8	99	85.2	96
Placental heterogenity	96	94	96	94	95.2
Placenta/uterine bulge	100	98.9	97.2	100	99.2
Loss of placenta- myometrial interface	99.1	73.7	95.5	93.3	95.2
Myometrial thinning	100	69.2	96.6	100	96.8
Abnormal intraplacental vascularity	92.6	100	100	88	95.2
Bladder wall interruption	100	100	100	100	100
Penetrating placenta	100	100	100	100	100

The distribution of PASS classes as assessed by MRI and validated by HPR indicates a strong correlation. MRI classified 13 patients (10.4%) as low-risk, 54 (43.2%) as moderate-risk, and 58 (46.4%) as high-risk. Corresponding HPR classifications identified 15 (12%) as low-risk, 47 (37.6%) as moderate-risk, and 63 (50.4%) as high-risk. This similar distribution further supports the diagnostic reliability of the PASS system in grading PAS severity antenatally. The consistency in the categorization underscores the potential for using PASS as a reliable antenatal tool.

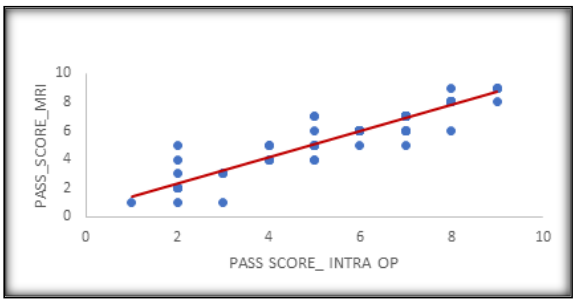

Chart 1: Scatter plot showing correlation between INTRA OP and MRI assessment for PASS score

[Figure 1] provides a detailed match between PASS scores assigned via MRI and the corresponding histopathological (HPR) findings. Of the 13 MRI-classified low-risk cases, all were confirmed low-risk on HPR. Among the moderate-risk MRI cases, 45 were confirmed as moderate by HPR, 2 were low, and 7 were upgraded to high-risk by HPR. In the high-risk category, 56 of the 58 MRI-identified cases were corroborated by HPR, with 2 found to be moderate.

The kappa value of 0.851 (p=0.001) indicates excellent agreement between MRI and HPR for risk stratification using PASS scores.

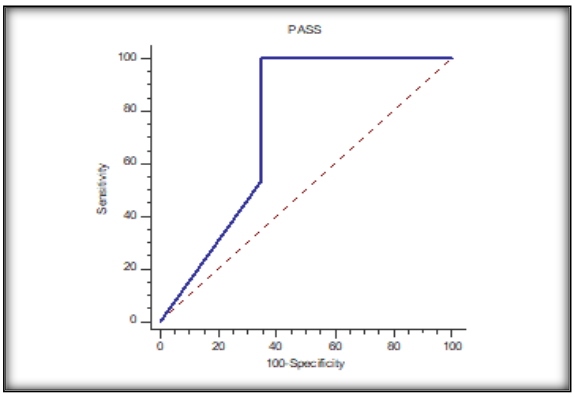

Chart 2: ROC Curve Analysis of PASS Score for Predicting Placenta Accreta

The receiver operating characteristic (ROC) curve analysis yielded an area under the curve (AUC) of 0.746, with a standard error of 0.0747 and a 95% confidence interval ranging from 0.660 to 0.820. The z statistic was 3.294 (p=0.001), confirming statistical significance. The optimal cutoff score determined via Youden's Index was >1, which provided a sensitivity of 100% and a specificity of 65.22%. The associated positive predictive value was 92.7%, and the negative predictive value was 100%, with a positive likelihood ratio of 2.87 and a negative likelihood ratio of 0. These values suggest that while the PASS score is highly sensitive and capable of ruling out PAS when negative, its moderate specificity necessitates careful interpretation to avoid false positives.

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DISCUSSION

The incidence of PAD during pregnancy has been increasing mainly owing to the increased rates of cesarean sections. History of prior cesarean sections and placenta previa is the most significant and frequent risk factor described in many series.[7] As PAD can be life threatening, cesarean hysterectomy is required in many cases that in turn has its own complications like ureteral and bladder injury when performed in an emergency setting. Severe PAD can result in massive hemorrhage during placental separation, retention of placenta and might even require pre-emptive uterine artery embolization. Hence, prior knowledge and accurate diagnosis of this condition allow treatment planning, there by minimizing maternal morbidity and mortality.

Ultrasonography and MRI have been used in the preoperative diagnosis, with several studies showing MRI to be a sensitive tool when performed between 24 and 30 weeks of gestation.[8] Diagnosis of PA in current clinical scenario rests upon detection of some so-called typical signs on imaging, be it either ultrasonography or MRI. Although many signs have been described in literature, no particular sign can be said to be pathognomonic for this condition. Interpretation of the scan remains subjective with dependence on the experience of the physician interpreting the scan.[9] To reduce the subjective nature of interpretation, scoring systems have been developed to predict the risk of PA in individual patients. Tovbin et al,[10] developed a scoring system based on ultrasonography findings. Based on the score, they stratified patients in low, medium and high probability groups. They reported sensitivity and specificity of 69.6% and 98.7% in predicting PA with classifying a patient into the high probability group. Knight et al. used a combined ultrasonography and MRI score to diagnose PA. They reported a sensitivity of 56% and specificity of 92% for identifying invasive placentation combining ultrasound and MRI findings.[11] Tanimura et al,[12] developed a scoring system to predict adherent placenta in patients with placenta previa based on past history of Caesarean section, ultrasonography and MRI findings. A score of 8 or more out of maximum of 24 had a sensitivity of 91.3% and specificity of 98%. However, this study included only those women with placenta previa.

In our study, a score of 0 or 1 was assigned based on presence or absence of a particular imaging finding. The excellent agreement between MRI-based scoring system and HPR-based classification (Kappa=0.851) and the near-perfect correlation between the numerical scores from both methods (Spearman's rho=0.932) directly validate the system. The PASS (Placenta Accreta Scoring System) is a powerful tool, capable of not only making a binary diagnosis (accreta vs no accreta) with high confidence but also of categorizing patients into low, moderate, and high-risk groups, which is critical for tailoring peripartum management.

Study Limitations: Validation of this scoring and stratification system would be required to assess its efficacy in clinical practice. We did not correlate the MRI findings with ultrasonography.

CONCLUSION

MRI is an important tool in assessing placenta accreta spectrum of disorders, and PASS provides an accurate and objective way to stratify patients into low, intermediate and high -risk categories for Placenta Accreta Spectrum.

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