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# Placenta accreta scoring system (PASS)—assessment of a simplified clinico-radiological scoring system for antenatal diagnosis of placenta accreta

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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 plays an indispensable role in antenatal diagnosis of PAS. However, diagnosis of PAS on both ultrasonography and magnetic resonance imaging (MRI) 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 in predicting placenta accreta.

**Results:** This retrospective study included 60 MRI examinations done for suspected placenta accreta (PA). MRI findings were assessed by two radiologists in consensus. Clinical details of the patients were obtained from the hospital information system. Two clinical and six imaging criteria were assessed and a total score was calculated for each patient. Patients were stratified into three groups—low, moderate or high probability for placenta accreta based on the total score. The presence of any statistically significant difference in prevalence of PA among these groups was assessed. Intra-operative findings/histopathology were considered the gold standard. The prevalence of PA was 3% (1/33), 28.5% (2/7) and 90% (18/20) in the low-, moderate- and high-risk groups respectively. There was a statistically significant difference in the prevalence between the three groups (chi-square statistic = 41.54, $p$ value < 0.0001). A score of greater than or equal to 6 provided sensitivity, specificity and accuracy of 85.71, 94.87 and 92.5% respectively in diagnosing placenta accreta.

**Conclusion:** PASS provides a simple, objective and accurate way to stratify patients into low, intermediate and high probability categories for PA.

**Keywords:** Magnetic resonance imaging, Placenta accreta, Scoring, Diagnosis

## Background

Post-partum haemorrhage (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 (PA) is a condition characterised by incomplete or non-separation of the placenta from the uterine wall during labour due to abnormal placental adhesion to the myometrium. The term PAS also includes placenta increta and placenta percreta, which are characterised by invasion of the trophoblastic villi into the myometrium and into uterine serosa/adjacent organs respectively. In this article, the term placenta accreta is used to refer to this complete spectrum of abnormal placentation. PA is proposed to occur due to failure of normal decidualisation with resultant myometrial adherence/invasion by the trophoblastic villi [1]. Any attempt to manually remove an adherent placenta during labour can lead to life threatening bleeding. Antenatal recognition of an adherent

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placenta is thus of paramount importance in planning management of labour and preventing maternal morbidity and mortality. 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. A recent meta-analysis of prenatal ultrasound diagnosis of PA including 14 cohort studies of 3209 pregnancies found that ultrasound is highly sensitive and specific in making this diagnosis [3]. Another meta-analysis assessing the accuracy of ultrasound in detecting the depth of placental invasion found that sensitivity for correctly assessing the depth of invasion ranged from 80 to 90% with specificity of >95% [4]. 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 subplacental zone. The sensitivity and specificity of these signs however varies widely between studies [5]. 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 centres, 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 bulging, heterogeneous intraplacental signal intensity, T2 dark bands and focal myometrial interruption. Systematic reviews have found that the accuracy of MRI in diagnosing PA is comparable to that of ultrasound [6, 7]. Although many signs have been described on MRI in PA, there is no pathognomonic MRI feature. Many of the signs described on ultrasonography and MRI in PA can also be seen in the placenta of pregnant women without PA [8]. Interpretation thus often relies on a combination of signs which is subjective and often at the discretion of the physician interpreting the scan. To address this issue, we have attempted in this study to develop a scoring system based on clinical and MRI features and to assess its accuracy in predicting PA.

## Methods

This was a retrospective study which included pregnant women referred for MRI examination to the department of radiology in our institute with suspected placenta accreta based on ultrasound or with high risk for placenta accreta during a period of 4 years from May 2014 to April 2018. 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 either of the two 1.5T MRI scanners in our institute—Siemens MagnetomAvanto (Siemens Healthcare, Erlangen, Germany) or GE Signa HDxt (GE Medical systems, Milwaukee, WI, USA). 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.

Clinical data of these patients was sourced from the hospital medical records. These women were assessed using a scoring system. A score of 1 was awarded when each of the following features was present: (1) previous history of Caesarean section/uterine surgery, (2) more than 1 gravida, (3) placenta praevia, (4) loss of uterine–placental interface, (5) focal thinning of myometrium < 2mm, (6) heterogenous placenta with intraplacental vascular channels, (7) dark bands on t2-weighted images and (8) focal uterine bulge. Representative images are presented in Figs. 1, 2 and 3. Each criterion was awarded 1 point and the sum of points yielded the final score. Patients were classified into low (0–3 points), moderate (4–5) or high probability (6–8) for placenta accreta based on the final score. The MRI findings were interpreted by 2 radiologists in consensus. The MRI findings were correlated with findings at delivery and with histopathological findings whenever hysterectomy was performed. The sensitivity and specificity of each of the MRI findings in isolation was assessed. Prevalence of PA was calculated in the low, moderate and high probability categories. Presence of any statistically significant difference between the three groups was assessed using the chi-square test.

## Results

A total of 60 MRI examinations in 60 pregnant women were included in the study. Mean age of the patients at time of the MRI study was 29.38 years with a standard deviation of 4.46 years. Fifty-two women (86.6%) were multiparous. Fifty-one women (85%) had history of previous Caesarean section. Forty women (66.6%) had placenta praevia. Placenta accreta was seen in 21 women of these 60 women (35%) based on surgical/

**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** | **T1 dual echo Axial** | **GRE sagittal** | **DWI axial** |
| TE (ms) | 91 | 1.6 | 4.7 | 23 | 101 |
| TR (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 | 256 × 256 | 256 × 100 | 256 | 192 × 75 | 192 × 100 |
| 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

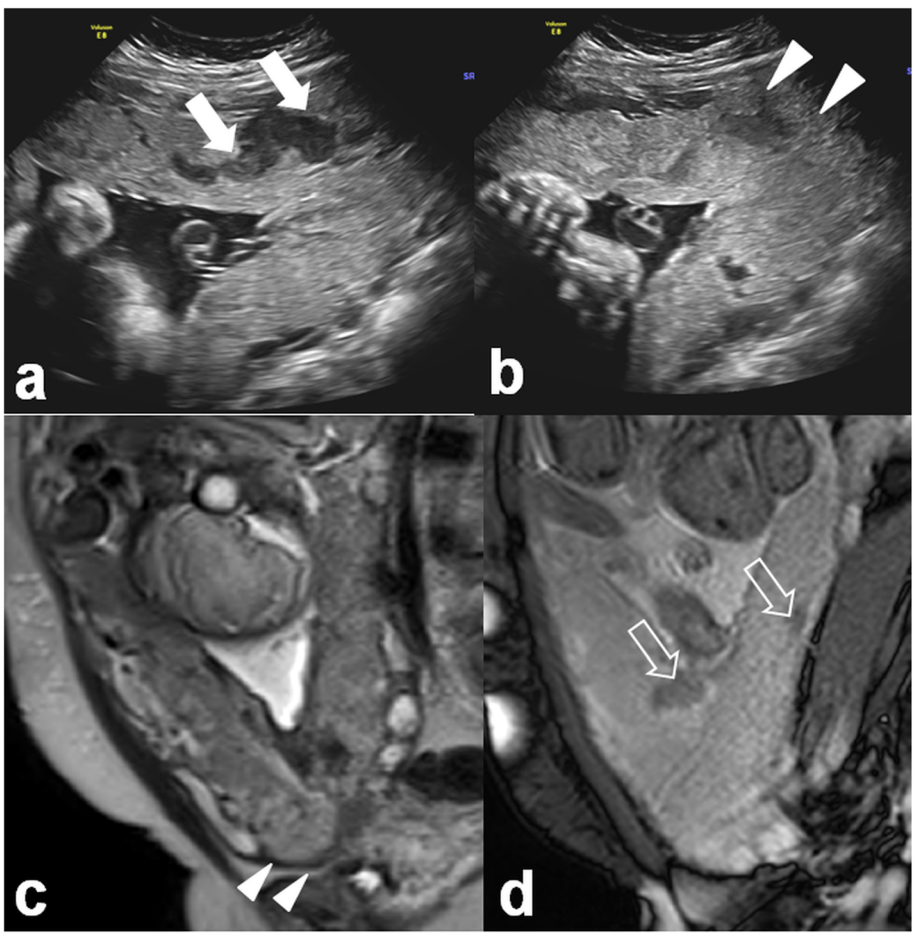


**Fig. 1** A 36-year-old woman (gravida −3) with history of previous Caesarean section. Sonography images (**a**, **b**) of the placenta show intraplacental venous lakes (arrows) and loss of uteroplacental interface (arrowheads). Sagittal T2 HASTE (**a**) and SSFP (**b**) images show placenta previa with loss of interface and focal bulge (arrowheads), heterogenous placenta and dark bands (open arrows). Elective Caesarean section confirmed placenta accreta and obstetric hysterectomy was performed

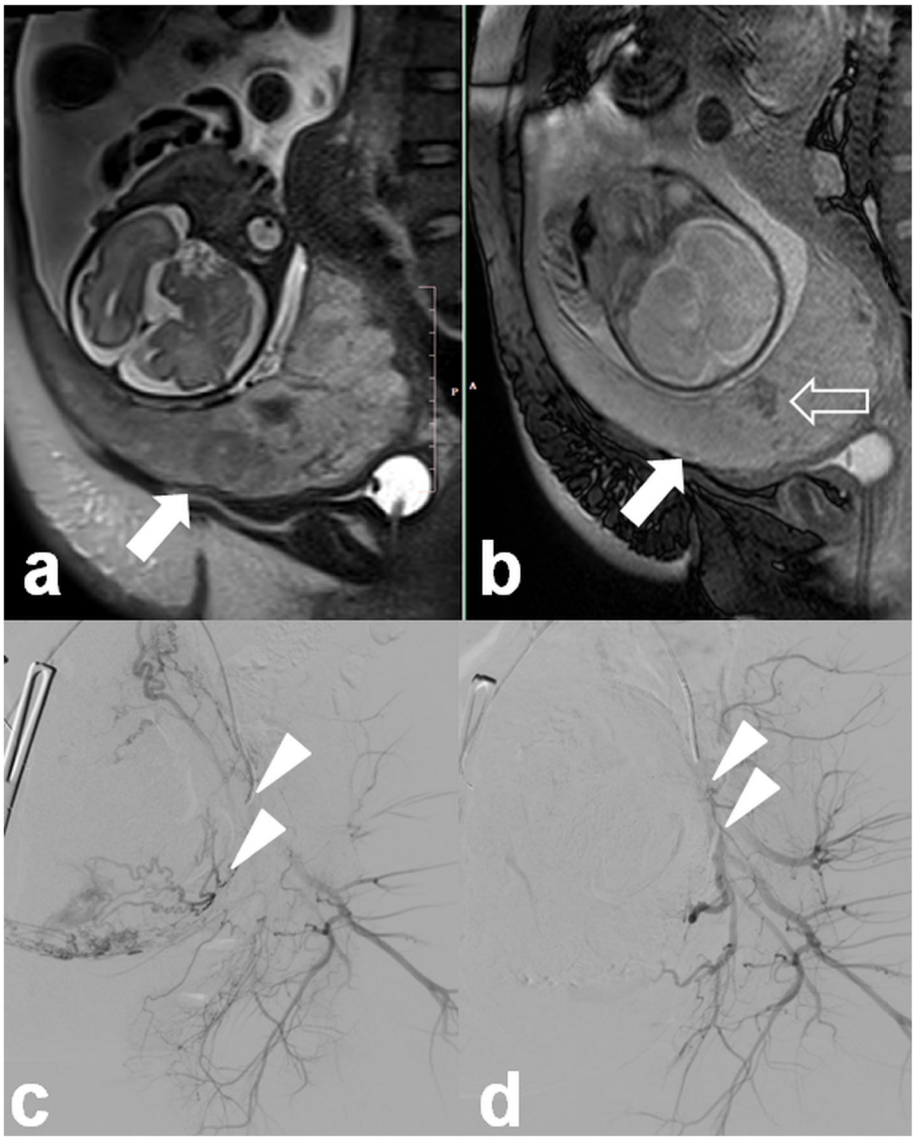


**Fig. 2** A 26-year-old woman (gravida −3) with history of previous Caesarean section. Sagittal T2 HASTE (**a**) and SSFP (**b**) MR images show placenta previa with loss of uteroplacental interface (arrows) and dark bands (open arrows). Since placenta accreta was present during elective Caesarean section, uterine artery embolization was performed. Digital subtraction images of left uterine artery pre-embolization (**c**) and post-embolization (**d**) (arrowheads)

histopathological findings. There were 33 women in the low probability category (score 0–3 points) and among these women placenta accreta was seen in 1 woman. There were 7 women in the moderate probability category (score 4–5 points) and placenta accreta was seen in 2 women. There were 20 women in the high probability category (score 6–8 points) and placenta accreta was seen in 18 women. Thus, there was a prevalence of PA of 3%, 28.5% and 90% in the three groups respectively. There was a statistically significant difference in the prevalence between the three groups—chi-square statistic was 41.54 with $p$ value < 0.0001. The sensitivity and specificity of each MRI finding in isolation is represented in Table 2. A score of greater than or equal to 6 provided sensitivity, specificity and accuracy of 85.71, 94.87 and 92.5% respectively. Cut-off score of greater than or equal to 7 increased specificity to 97% but reduced sensitivity to 72.73%.

## Discussion

Studies have shown that PA spectrum disorders may remain undiagnosed during pregnancy in up to half of all patients [9, 10]. Maternal morbidity and mortality are reduced when PA is diagnosed antepartum and women with this condition deliver in hospitals equipped to handle the operative and perioperative challenges faced

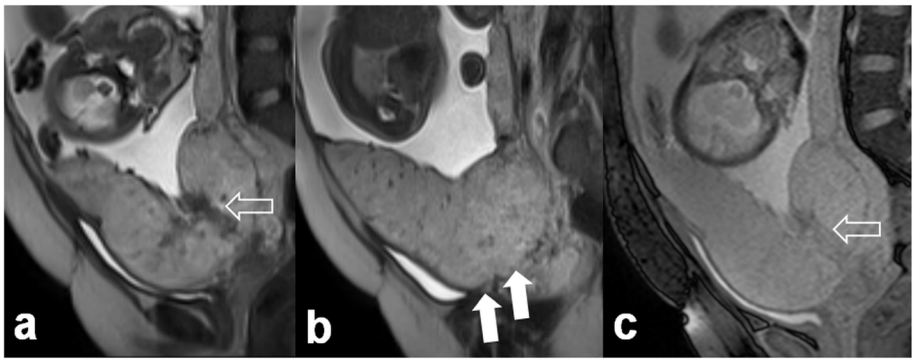


**Fig. 3** A 23-year-old woman (gravida −2) with history of previous Caesarean section. The sagittal T2 HASTE (**a**, **b**) and SSFP (**c**) MR images show placenta previa with dark bands (open arrows) and loss of uteroplacental interface (arrows). Since placenta accreta was present during elective Caesarean section, uterine artery embolization was performed and she was placed on follow-up

during management of these patients [11]. 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 [11]. To reduce the subjective nature of interpretation, scoring systems have been developed to predict the risk of PA in individual patients.

Tovbin et al. [12] 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.

Uena et al. [13] used a MRI-based scoring system to predict invasive placenta previa in which five MRI features were individually scored on a 5-point scale and the cumulative score was calculated as the sum of the scores. They found good interobserver agreement and found that the accuracy and area under the curve for the total score was significantly higher or at least equivalent to individual MRI features.

Tanimura et al. [14] 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.

**Table 2** Sensitivity and specificity of individual MRI findings in diagnosing placenta accreta

| Finding | Sensitivity | Specificity | Accuracy |
|---|---|---|---|
| Myometrial thinning | 95.24 | 87.18 | 90 |
| Loss of interface | 95.24 | 87.18 | 90 |
| Focal uterine bulge | 52.38 | 94.87 | 80 |
| T2 hypointense bands | 85.71 | 82.05 | 83.33 |
| Heterogeneous signal | 66.67 | 76.92 | 73.33 |

Knight et al. [15] 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.

In the studies by Tovbin et al., Uena et al. and Tanimura et al., each finding was assigned one of multiple possible scores and the total score was calculated as the sum of scores for each finding. Having multiple possible scoring options for each criterion adds an element of subjectivity and calculating the final score also becomes somewhat cumbersome in a routine clinical scenario. In contrast, our study assigned a score of 0 or 1 based on presence or absence of a particular imaging finding. In our study, a score of 6/8 or greater provided the greatest diagnostic accuracy which was comparable to previous such studies.

There were some limitations in our study. It was retrospective in nature. Validation of this scoring and stratification system by a prospective study would be required to assess its efficacy in clinical practice. We did not assess the interobserver variability in assigning the score as it was done by two readers in consensus and not independently. We did not correlate the MRI findings with ultrasonography. We did not evaluate the depth of invasive placentation—the score was not correlated with presence of accreta, increta or percreta.

## 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 PA.

**Abbreviations**
MRI: Magnetic resonance imaging; PA: Placenta accreta; PAS: Placenta accreta spectrum; PASS: Placenta accreta scoring system

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**Authors' contributions**
PJ and HM collected the patient data. HM, RR and AC analysed and interpreted the patient data. HM prepared the manuscript. RR and AC edited the manuscript. All authors read and approved the final manuscript.

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**Availability of data and materials**
The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

**Ethics approval and consent to participate**
This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Sri Ramachandra University with IEC number CSP-MED/16/JUN/29/66. Written informed consent was obtained from all patients participating in this study.

**Consent for publication**
Not applicable. No patient identifying information is included in the manuscript material.

**Competing interests**
The authors declare no competing interests.

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## Publisher's Note