

# Combining Clinical Characteristics and Specific Magnetic Resonance Imaging Features to Predict Placenta Accreta

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**Objective:** The aim of this study was to explore the independent clinical and magnetic resonance imaging (MRI) performance risk factors for predicting placenta accreta.

**Methods:** From January 2012 to December 2015, we retrospectively reviewed the clinical characteristics and MRI features of 97 patients. Of these, 42 were confirmed to be placenta accreta by pathological results or cesarean delivery findings. We tried to identify the independent risk factors by multivariate logistic regression model for significant differences in variables determined by univariate analysis.

**Results:** The multivariate logistic regression model indicated that 2 or more instances of previous cesarean deliveries and/or abortions, placenta previa, and placenta-myometrial interface interruption were independent risk factors for placenta accreta. The odd ratios were 3.79 for patients who had 2 or more instances of previous cesarean deliveries and/or abortions, 0.04 for marginal/partial placenta previa, 0.024 for complete placenta previa, and 6.56 for placenta-myometrial interface interruption. The values of accuracy and positive prediction by combination of a single clinical risk factor and placenta-myometrial interface interruption and of positive prediction by a combination of all 3 risk factors for predicting placenta accreta were raised to 83.5%, 75%, and 92.9%, respectively. We obtained 3 different risk groups by different combinations of all 3 risk factors.

**Conclusions:** The study suggested that 2 or more instances of previous cesarean deliveries and/or abortion, placenta previa, and placenta-myometrial interface interruption were independent risk factors for placenta accreta. A combination of a single clinical risk factor and an MRI risk factor can improve the diagnosis of placenta accreta, and a combination of all 3 risk factors could help recognize patients with placenta accreta.

**Key Words:** placenta accreta, cesarean delivery, abortion, placenta previa, MRI

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After the initiation of the 2-child policy in China, and the beginning of the fertility era, clinical treatment schemes are particularly cautious in suspected patients with placenta accreta (PA). Placenta accreta is always a subject of clinical concern due to the high rate of morbidity and mortality.<sup>1,2</sup> Once PA has been accurately predicted at the antenatal screening, the first choice will be to plan a cesarean delivery instead of a traditional placental delivery, which can lead to maternal massive bleeding and even a hysterectomy.<sup>3,4</sup> Therefore, accurate antenatal diagnosis of PA is especially crucial. Currently, because of its low cost and high accuracy, ultrasonography is the first line of examination to detect PA.<sup>2,5,6</sup> However, ultrasound is probably insufficient for many suspected cases of posterior placenta or gastrointestinal pneumatosis.<sup>7,8</sup> In such cases, magnetic resonance imaging (MRI) results can supplement the clinical assessment as it can provide multidirectional imaging and excellent soft tissue contrast.<sup>6,9</sup> Thus far, there are abundant reported specific MRI features of PA. However, there is no consensus regarding the antenatal MRI diagnostic standard.<sup>10</sup> There are no relevant studies regarding the combination of MRI and clinical characteristics for predicting PA.

The placenta is a key structural link between the fetus and the mother, and any problems in the placenta can affect both the fetus and the mother. The placenta accreta includes the placenta adherence, placenta increta, and placenta percreta, depending on the depth of the chorionic villus invasion. In addition, deeper invasion will increase the risk for pregnant women. Therefore, obtaining an accurate prenatal diagnosis for PA and determining the type of PA are the great challenge for radiologists.

Thus far, the reported relevant clinical risk factors for PA include prior cesarean delivery, placenta previa, age at pregnancy, smoking, and history of uterine surgery.<sup>11,12</sup> In particular, prior cesarean delivery and placenta previa are universally accepted key risk factors.<sup>13,14</sup> The most useful MRI features for PA include dark intraplacental band on T2-weighted images (T2WIs), placental heterogeneity, abnormal intraplacental vascularity, and uterine bulging.<sup>10,12,15,16</sup> Other less significant MRI features include the placenta-myometrial interface, abnormal placental thickness, and myometrial thinness.<sup>4,17</sup>

Based on the above-mentioned MRI characteristics and clinical risk factors that can predict PA and due to lack of studies on their combined diagnosis of PA nowadays, we aimed to investigate the value of combining MRI characteristics and clinical risk factors to identify patients with PA in this study, so that they can receive timely and appropriate treatment.

## METHODS

### Patients

This retrospective study was approved by the Institutional Ethics Committee of Xinhua Hospital, and informed consent for

the study was waived. From January 2012 to December 2015, 122 patients at our institution with suspected PA by ultrasound examination underwent prenatal MRI. Of these, 25 patients were excluded from participation: 10 patients had previous uterine surgery, and 15 cases had fetal abnormalities. Thus, only 97 patients were recruited in this study. Data of 97 patients and their clinical-radiologic data were used for the analysis.

**Clinical Characteristic Analysis**

The possible risk factors for PA were evaluated by consulting the clinical records of patients enrolled in this study. The following clinical characteristics were evaluated: age at delivery, vaginal bleeding, placenta previa, and number of previous cesarean deliveries and/or abortions leading to injury to the endometrium.

**Imaging Protocol**

All patients underwent pelvic MRIs in a 1.5-T system (GE Medical System, Milwaukee, Wisconsin) using torso coil, and the axial, coronal, and sagittal planes were included. Fast imaging using steady-state acquisition and fast inversion recovery motion insensitive were used. Their parameters were as follows: flip angle of 60° and 55°; echo time/repetition time of 1.6–1.8/3.6–3.9 ms and 2.0–5.3 ms/7.7–10.7 ms, respectively; thickness of 4 to 5 mm; slice interval of 0 to 2 mm; 224 × 224 matrix; and a field of view of 360 to 420 mm.

**Image Analysis**

An MRI radiologic database was used for image analysis. Two board-certified obstetric radiologists (with 7 and 8 years of experience) who were blinded to the histopathological findings and the clinical data analyzed the MRI features of patients in consensus. Disputes between the radiologists were resolved by consultation with a third radiologist with 12 years of experience in obstetrics. A total of 5 MRI features of PA were assessed as presence or absence, including dark intraplacental band on T2WI, abnormal placenta thickness, placenta-myometrial interface, myometrium thinness, and uterine bulging. Considering deviation due to subjective judgment and limits on scanning technology, placental heterogeneity with dark intraplacental band on T2WI and abnormal intraplacental vascularity were not included in the analysis.

**Statistical Analysis**

Statistical analysis was performed with SPSS 19.0 (IBM, New York, New York), and a *P* value less than 0.05 indicated a statistically significant difference. The Cohen *k* value was used to evaluate interobserver agreement in the interpretation of the magnetic resonance images. The interobserver agreement was defined as no agreement (<0.00), slight agreement (0.00–0.20), fair agreement (0.21–0.40), moderate agreement (0.41–0.60), substantial agreement (0.61–0.80), and almost perfect agreement (0.81–1.00).<sup>18</sup> Univariate association of clinico-radiological variables with patients was assessed. A multivariate logistic regression model was performed to identify independent risk factors for variables with *P* < 0.05 in the univariate analysis. Afterward, the univariate analysis carried out using the  $\chi^2$  test and the multivariate logistic regression model carried out using an entry method were used to identify the predictive value of the clinico-radiological variables for PA. The accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of 2 or more instances of previous cesarean deliveries and/or abortion, placenta previa, placenta-myometrial interface interruption, and the combination of 2 risk factors as well as all 3 risk factors were all calculated.

**RESULTS**

**Patients**

Data of all the patients were confirmed by findings after cesarean delivery or by consulting pathological reports. Of 97 patients, 42 (43.3%) were confirmed to be PA, of these, 27 pregnant women were verified as having placenta adherence, 13 with placenta increta, and the other 2 with placenta percreta. Table 1 shows the clinical characteristics, specific MRI features, and their associations among patients with suspected PA. The median age of the patients was 32 years (range, 23–44 years).

**Risk Factors Analysis of Clinico-radiological Variables for PA**

Table 1 presents the results of the univariate analysis for the correlation between the clinico-radiological parameters and PA. Significant differences were observed in vaginal bleeding, number of previous cesarean deliveries and/or abortions, placental previa, dark intraplacental bands on T2WI, abnormal placental thickness, placental-myometrial interface, myometrial thinness, and uterine bulging. On multivariate logistic analysis, number

**TABLE 1.** Clinical Characteristics and MRI Features of Patients With Suspicious PA as well as the Associations

Parameter	Patients Without PA	Patients With PA	<i>P</i>
Number	55	42	
Age			0.935
Less than 35	41 (74.5%)	31 (73.8%)	
35 or older	14 (25.5%)	11 (26.2%)	
No. previous cesarean deliveries and/or abortions			0.006
≤1	31 (56.4%)	12 (28.6%)	
≥2	24 (43.6%)	30 (71.4%)	
Vaginal bleeding			0.028
No	32 (58.2%)	15 (35.7%)	
Yes	23 (41.8%)	27 (64.3%)	
Placenta location			0.000
Normal	10 (18.2%)	1 (2.4%)	
Marginal/partial placenta previa	32 (58.2%)	9 (21.4%)	
Complete placenta previa	13 (23.6%)	32 (76.2%)	
Dark intraplacental band on T2WI			0.001
No	45 (81.8%)	21 (50%)	
Yes	10 (18.2%)	21 (50%)	
Placenta thickness			0.011
Normal	39 (70.9%)	19 (45.2%)	
Abnormal	16 (29.1%)	23 (54.8%)	
Placenta-myometrial interface			0.000
Continuity	44 (80%)	12 (28.6%)	
Interruption	11 (20%)	30 (71.4%)	
Myometrium thinness			0.000
No	48 (87.3%)	19 (45.2%)	
Yes	7 (12.7%)	23 (54.8%)	
Uterine bulging			0.007
No	49 (92.7%)	14 (38.1%)	
Yes	6 (7.35%)	28 (61.9%)	

*P* < 0.05 indicates a statistically significant difference.

**TABLE 2.** Multivariate Logistic Regression Analysis of Risk Factors for Patients With PA

Variables	Multivariate Analysis	
	OR (95% CI)	P
No. previous cesarean deliveries and/or abortions		
≤1	1	
≥2	3.79 (1.10–13.09)	0.035
Vaginal bleeding		
No	1	
Yes	1.77 (0.52–6.00)	0.359
Placenta location		
Normal	1	
Marginal/partial placenta previa	0.04 (0.00–0.68)	0.026
Complete placenta previa	0.24 (0.07–0.83)	0.024
Dark intraplacental band on T2WIs		
No	1	
Yes	1.89 (0.426–8.43)	0.402
Placenta thickness		
Normal	1	
Abnormal	0.97 (0.24–3.91)	0.969
Placenta-myometrial interface		
Continuity	1	
Interruption	6.56 (1.18–36.45)	0.032
Myometrial thinness		
No	1	
Yes	3.06 (0.72–12.95)	0.129
Uterine bulging		
No	1	
Yes	3.21 (0.73–14.21)	0.124

*P* < 0.05 indicates a statistically significant difference.

of previous cesarean deliveries and/or abortion, placenta previa, and placental-myometrial interface variables remained statistically significant (Table 2).

The multivariate logistic regression model showed that 2 or more instances of previous cesarean deliveries and/or abortions [*P* = 0.035; odd ratio (OR), 3.79; 95% confidence interval (CI), 1.10–13.09], marginal/partial placenta previa (*P* = 0.026; OR, 0.04; 95% CI, 0.00–0.68), complete placenta previa (*P* = 0.024; OR, 0.24; 95% CI, 0.07–0.83), and placental-myometrial interface interruption (*P* = 0.032; OR, 6.56; 95% CI, 1.18–36.45) remained statistically significant.

Table 3 presents the accuracy, sensitivity, specificity, PPV, and NPV of 2 or more instances of previous cesarean deliveries

and/or abortion, placenta previa, placenta-myometrial interface interruption, and the combination of 2 risk factors as well as all 3 risk factors together for predicting PA (Figs. 1, 2).

### DISCUSSION

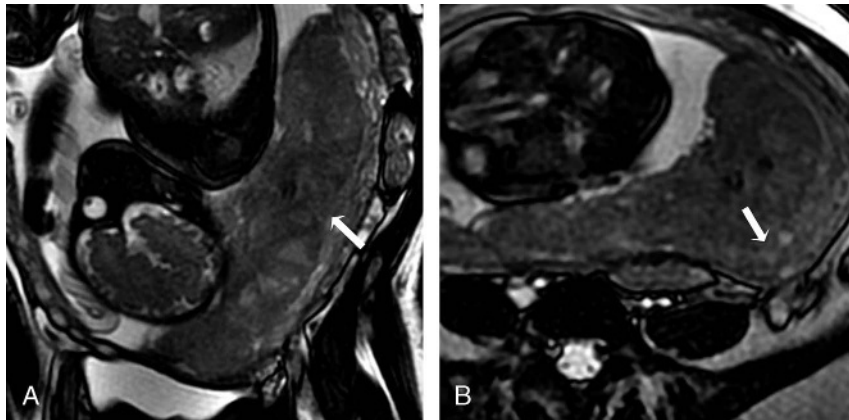
Our study showed that 2 or more instances of previous cesarean deliveries and/or abortions, placenta previa, and placental-myometrial interface interruption were independent risk factors for PA. The accuracy and PPV of predicting PA were raised to 83.5% and 75%, respectively, by the combination of a single clinical risk factor and MRI risk factor. The PPV of predicting PA would reach up to 92.9% by combining all 3 risk factors, which was higher than those reported in other articles.<sup>16,19</sup> Therefore, using the combination of these 3 independent risk factors can antenatally predict cases of PA and further guide treatment.

Among these MRI features for predicting PA, multiple logistic regression analysis revealed that the placental-myometrial interface interruption was the most useful one and an independent risk factor. Why would the placental-myometrial interface interruption stand out from all these MRI features? Perhaps, we can analyze it from the following 2 points. First, the pathology of PA is that chorionic villi adhere to and invade the myometrium, and even penetrate it. Thus, in theory, the placental-myometrial interface in patients with PA is indeed discontinuous. Second, MRI having a super soft resolution can distinguish the placenta from the myometrium based on signal intensity.<sup>8</sup> The normal placenta has a homogeneously moderate signal on T2WI and may become heterogeneous in late pregnancy. However, the signal intensity of the myometrium is slightly higher than that of the placenta on T2WI.<sup>20</sup> Thus, the placental-myometrial interface can be observed on T2WI. This feature, described as a thin or absent retroplacental myometrial zone in sonography, was deemed to be a useful diagnostic sign of PA.<sup>21</sup> However, there is no consensus among experts regarding it. Alamo et al<sup>15</sup> reported that it was the second most predictive MRI feature and, furthermore, highly depended on the reader's experience. To avoid this problem, we chose senior board-certified obstetric radiologists and also conducted the test on interobserver consistency. Other scholars consider it less helpful, as the discontinuous placental-myometrial interface can also appear in a normal placenta with progression of gestation.<sup>22</sup> In order to avoid false positives, we will not define the placental-myometrial interface interruption as positive until we could observe it in all 3 planes, including the axial, sagittal, and coronal planes. Therefore, placental-myometrial interface interruption obtained in our study can serve as a diagnostic indicator.

The dark intraplacental band on T2WI has been demonstrated to be the most useful MRI feature by many other researches.<sup>10,12,15,22</sup> However, it was not found to be an independent risk factor by multivariate logistic regression analysis. The dark intraplacental band on T2WI usually represents placental infarction under the

**TABLE 3.** Predictive Performance of Various Risk Factors for Patients With PA

Risk Factors	Accuracies, %	Sensitivities, %	Specificities, %	PPV, %	NPV, %
Two or more instances of previous cesarean deliveries and/or abortions	62.9	71.4	56.4	56.6	72.1
Placenta previa	56.7	97.6	18.2	47.7	90.9
Combination of the 2 clinical risk factors	60.8	35.7	80.0	57.7	62.0
Placenta-myometrial interface interruption	76.3	71.4	80.0	73.2	78.6
Combination of a single clinical risk factor and placenta-myometrial interface interruption	83.5	92.9	76.4	75.0	93.3
Combination of all 3 risk factors	69.1	31.0	98.2	92.9	65.1



**FIGURE 1.** A pregnant 29-year-old woman with complete placenta previa. Coronal and axial T2WI (A, B) of a uterus at 38 weeks of gestation showed obvious placental-myometrial interface interruption in the left posterior uterine wall (white arrow). The patient was found to have PA by cesarean operation findings.

pathological state. Nevertheless, the dark band on T2WI would appear in the normal placenta, which represents fibrin deposition, with ongoing maturity of placenta. Thus, the specificity of this feature is not high enough. In our study, the dark intraplacental band on T2WI had statistical significance by univariate analysis, as did other features in this study. However, previous researches did not use multivariate logistic regression analysis, which may explain why our research result is different from those reported in other studies.

Uterine bulging is another useful MRI feature, but it was not found to be an independent risk factor in our study. Many studies have proven that this feature is more common in placenta percreta than in PA or increta.<sup>19</sup> However, there were only 2 cases with placenta percreta in our study, which might be regarded as the reason.

As many reports described, our research also showed that 2 or more instances of previous cesarean deliveries and/or abortions and placenta previa were independent clinical risk factors of PA.<sup>11,13,23,24</sup> According to the report of Silver et al,<sup>25</sup> 40% of women with both placenta previa and 2 instances of previous cesarean deliveries would progress to PA. In this study, the accuracy and PPV of predicting PA were about 60% and 58%, respectively, by the combination of 2 clinical risk factors. Obviously, these predictive results cannot meet the clinical demand. Hence, we add the independent MRI risk feature to improve the predictive value. The accuracy and PPV of predicting PA could be improved to

83.5% and 75%, respectively, by the combination of a single clinical risk factor and placenta-myometrial interface interruption, much higher than the single risk factor's prediction as well as the combination of 2 clinical risk factors' prediction. In addition, the PPV of predicting PA could reach up to 92.9% by combining all 3 risk factors.

According to Table 3, we found that the PPV of predicting PA would increase as the independent risk factors were combined. Therefore, we applied the combination of these risk factors to stratify the risk of patients into 3 groups. First, the moderate-risk population refers to patients with 2 clinical risk factors. Second, the high-risk population refers to patients with single clinical risk factor and MRI risk factor. Third, the very high-risk population refers to patients with all 3 risk factors.

This study has several limitations. First was our limited sample size, as the results of a multivariate logistic regression with a larger sample size may be more accurate. Second, although we tried our best, complete matching between the radiological-pathological features and the condition of the placenta was difficult to achieve.

In conclusion, our study revealed that 2 or more instances of previous cesarean deliveries and/or abortions, placenta previa, and placenta-myometrial interface interruption were independent risk factors for PA. The accuracy of predicting PA could reach to 83.5% by combining a single clinical risk factor and an MRI risk



**FIGURE 2.** A pregnant 30-year-old patient with 1 cesarean delivery and 1 abortion as well as complete placenta previa. Axial, sagittal, and coronal T2WI (A, B, C) of the uterus at 30 weeks of gestation showed prominent placental-myometrial interface interruption in the anteroinferior (black arrow) and bottom-posterior (white arrow) uterine wall. The patient was found to have placenta increta by cesarean operation findings.

factor, and the PPV of predicting PA could reach up to 92.9% by combining all 3 risk factors. We can prospectively predict patients with PA according to 3 different risk groups.

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