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The Application Value of Mri Different Scanning Sequences in The Diagnosis of Implanted Pernicious Placenta Previa

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1. Abstract

1.1. Objectives: Pernicious Placenta Previa (PPP) is more common due to rising rate of cesarean sections. PPP is one of the most severe complications of cesarean section, and it results in massive hemorrhage, travascular coagulopathy, deep venous thrombosis and sometimes maternal death.

1.2. Material and Methods: The clinical data and MRI imaging of 68 patients with PPP by ultrasound were analyzed retrospectively. All cases were divided into two groups, the implanted PPP group (n=40) and non-implanted PPP group(n=28), according to the operation or pathological findings.1.5T Single Shot Turbo Spin Echo (HASTE), True Fast Imaging with Steady-State Free Precession (True FISP) and Diffusion Weighted Imaging(DWI).

1.3. Results: Significant differences were identified for imaging quality among different MRI sequences and the best imaging quality was acquired on HASTE. The sensitivity, specificity and accuracy of placental heterogeneity, hypointense intraplacental bands, abnormal vessel, placental bulging, placenta recess and focal interruptions or thinning in the myometrial wall in the diagnosis of PPP were (95%, 78%, 72%, 72%, 65% and 67% respectively), (75%, 82%, 75%, 79%, 93% and 61% respectively) and (87%, 80%, 74%, 75%, 76% and 64% respectively).

1.4. Conclusion: Each sequence has its own advantages. The combination of placental heterogeneity, hypointense intraplacental bands and placenta recess was helpful to improve the diagnostic accuracy of implanted PPP.

2. Introduction

Pernicious Placenta Previa (PPP) is placental previa of pregnant woman with an history of cesarean section, and the placenta previa is attached to the front wall of the uterus, covering the lower part of the uterus and invading the myometrium of the uterus. PPP is divided into three grades including placenta accrete, placenta increta, placenta percreta, based on histopathology analysis of the depth of chorionic villi invasion [1]. Currently, PPP is more common due to rising rate of cesarean sections. PPP is one of the most severe complications of cesarean section, and it results in massive hemorrhage, travascular coagulopathy, deep venous thrombosis and sometimes maternal death. Currently, maternal mortality rate caused by PPP accounts for more than 27% of total maternal mortality rates [2,3]. Ultrasound (US) is the conventional approach for diagnosis of PPP. However, US does not show the posterior placenta clearly for diagnosis of placenta invasion due to attenuation of signals. In addition, it is vulnerable to interference by body size of pregnant women, gas and bone, and operators require high level of experience. MRI is proposed for diagnosis of placenta invasion disease and is associated with advantages like multi angle, multi- field of vision and excellent soft tissue resolution. MRI is performed when ultrasonographic findings are inconclusive or in cases of a posterior placenta [4]. The purpose of this study was to analyze the ability of Half Fourier Acquisition with Single Shot Turbo Spin Echo (HASTE), True Fast Imaging with Steady-State Free Precession (True FISP) and Diffusion Weighted Imaging (DWI) to display signs of pernicious placenta previa and diagnostivalue of MRI imaging findings. The findings of this study provides reference for selection of clinical surgical methods.

3. Materials and Methods

3.1. Patients Selection

Between November 2016 and October 2019, 68 consecutive patients (age range 24-44 years; mean age, 32±5 years; gestational age 21-37 weeks) suspected of having PPP and underwent prenatal US or MR imaging. These included 35 patients (one previous

cesarean section), 21 patients (two cesarean sections), 8 patients (three cesarean sections) and 4 patients (more than four cesarean sections) with PPP. According to clinical operation and pathological results, 68 patients with PPP were divided into implantation and non-implantation group. Exclusion criteria include those with severe claustrophobia and other MRI contraindication; non-implanted placenta previa; congenital uterine malformation; multifetation; combined history of gynecological diseases; metabolic diseases with potential effects on placental function. Both groups were performed MRI and the image quality meet diagnostic requirements.This study was approved by the Hospital Ethics Committee and informed consent was obtained from all patients.

3.2. MRI Technique

The MRI examinations were performed using a 1.5T MRI system (Aera, Siemens Medical Systems, Germany) with a phased-array body coil. All cases were examined in the supine position (Intolerant person takes left supine position). The MRI protocol included examination from the floor of the uterus to the symphysis pubis.

3.3. Image Analysis

Quality of MRI images was retrospectively analyzed by two independent and experienced radiologists (specializing in abdominal imaging) who were blinded to pathological and clinical information. Quality of images and structure of placental were graded using 5-level scores method [5, 14] The quality was assessed by two independent experienced radiologists and defined as excellent (≥3 points), or poor (<3 points).

1. Abnormal placental vascularity: Tortuous, enlarged flow voids＞5 mm in diameter or increased number of flow voids [6].
2. Placenta recess: A placental deformity owing to contraction of the placental surface and uterine outer rim, with a wedge-shaped contour and decreased thickness; and accompanying a T2 dark band [8].
3. Hypointense intraplacental bands: Appears as nodular or linear areas of low signal intensity on T2-weighted images [8, 10].
4. Placental bulging: A focal outward contour bulge or disruption of the normal pear shape of the uterus with the lower uterine segment
5. being wider than the uterine floor fundus [10].
6. Interruptions or thinning in the myometrial wall: Focal thinning and indistinctness of the myometrium and loss of thin dark uteroplacental interface on True FISP [11].
7. Placental heterogeneity: On T2WI placental signals show patch-like low-signal foci scattered in distribution [13].

3.4. Statistical Analysis

Data were collected and analyzed using SPSS (Statistical Package for the Social Science, version 23, IBM, NY). P＜0.05 was considered statistically significant. Quantitative data was presented as mean ± SD deviation and by percentage (%). Chi-square test or Fisher's exact test were used to compare patients with pernicious placenta previa by analyzing the image quality evaluation, ability to show imaging findings and diagnostic value of MRI imaging findings acquired through the three approaches. kappa values were considered insignificant when ＜0.2, low for a range between 0.21 and 0.4, and moderate for a range between 0.41–0.6. Values ＞0.6 were considered to be good agreement and ＞0.8 represented excellent agreement. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of the different MRI findings among PPP patients were analyzed and compared with the pathological results.

4. Results

A total of 59 cases analyzed using Half Fourier Acquisition with Single Shot Turbo Spin Echo (HASTE) approach were graded as good (86. 7%) whereas 9 cases were poor (13. 2%). Analysis using True Fast Imaging with Steady-State Free Precession (True FISP) showed that 46 cases were good (67. 6%) whereas 22 cases were poor (32. 4%). Diffusion Weighted Imaging (DWI) showed that 26 cases were good (38. 2%) whereas 42 cases were poor (61. 7%). Image quality of HASTE sequence was significantly better compared with image quality obtained using True FISP ($\chi 2$ =9.238, p =0.002) and DWI sequence ($\chi 2$ =30.288, p＜0.001) (Table 1).

A total of 40 (58.8%) of patients were pathologically diagnosed with implanted pernicious placenta previa, whereas 28 (41.1%) patients were diagnosed with non-implanted pernicious placenta previa. Interobserver variability between the two observers were consistent for the six MRI imaging findings of placental heterogeneity, hypointense intraplacental bands, abnormal vessel in the placenta, placental bulging, placenta recess and interruptions or thinning in the myometrial wall. Kappa values for these parameters were 0.850, 0.633, 0.680, 0.718, 0.916, 0.906, respectively.

HASTE, True FISP and DWI sequences showed significant differences in placental heterogeneity, hypointense intraplacental bands, abnormal vessel in the placenta and interruptions or thinning in the myometrial wall (p<0.05). However, the three approaches showed no significant differences in uterine bulging and placenta recess (p>0.05) (Table 2). HASTE sequence showed excellent presentation of placental signals and abnormal vessel (Figure 1). The True FISP sequence showed interruptions or thinning in the myometrial wall (Figure 2). DWI sequence showed the best quality in displaying placental morphology (Figure 3). Sensitivity, specificity, positive and negative predictive values and accuracy of the six MRI imaging findings are shown in (Table 3). The highest diagnostic sensitivity of placental heterogeneity was 95% whereas placenta recess showed the highest diagnostic specificity at 93%. The highest diagnostic accuracy for placental implantation was 92.1% after combining placental heterogeneity, hypointense intraplacental bands and placenta recess (Figure 4).

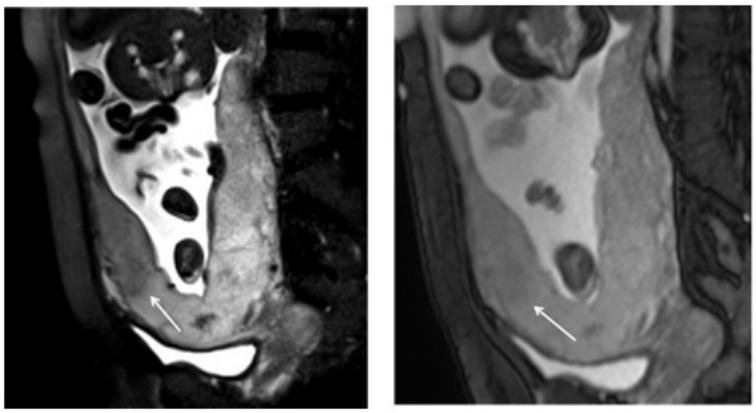
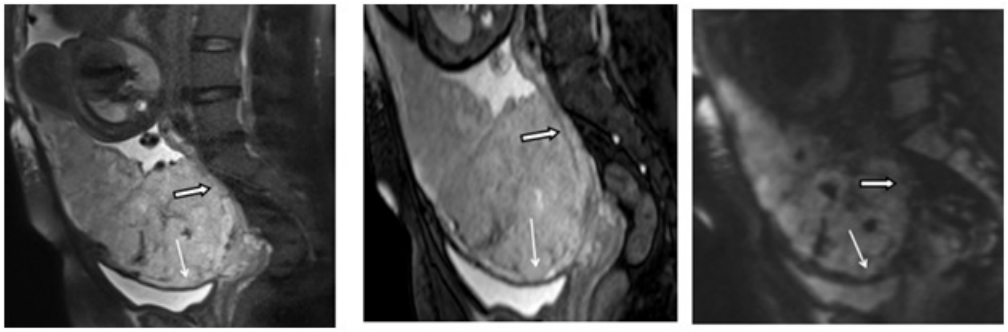
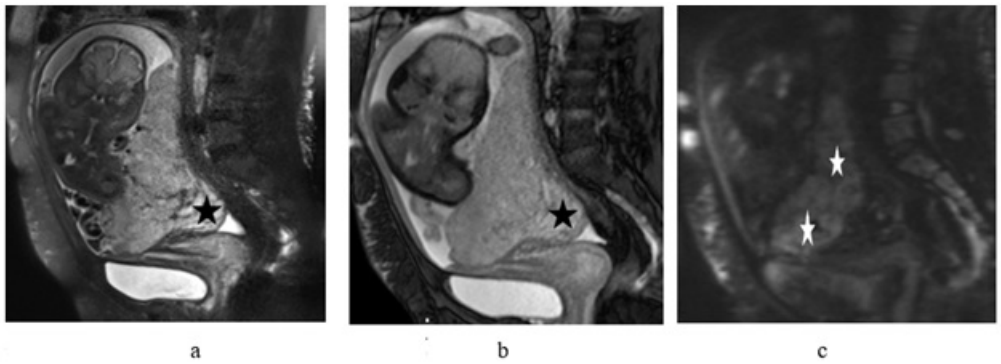


Figure 1: Implanted pernicious placenta previa in a 37-year-old woman at 36＋3 weeks' gestation. Sagittal T2-HASTE (a) demonstated placental heterogeneity (arrow) was better than that of True FISP (b) image (arrow)



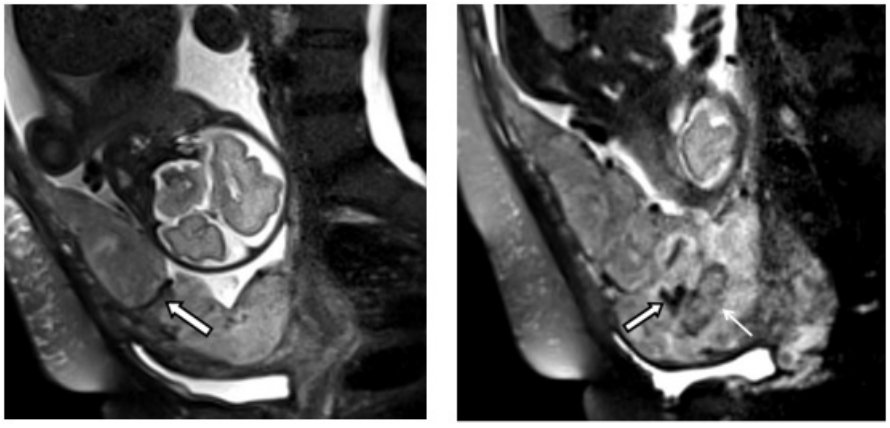
a **b** **c**

Figure 2: Implanted pernicious placenta previa in a 30-year-old woman at 36＋2 weeks' gestation. Sagittal True FISP (b) displayed normal uterine myometrium (thick arrow) and thinning/interrupting uterine myometrium (thin arrow) was better than HASTE (a) and DWI (c) images



a b c

Figure 3: Implanted pernicious placenta previa in a 39-year-old woman at 32＋6 weeks' gestation. Sagittal HASTE (a) and True FISP (b) indicated that the complete placenta previa was mostly located in the posterior wall of the uterus. The bulge of the inferior wall of the uterus (asterisk) was difficult to distinguish from the placenta. Sagittal DWI (c) image showed the best quality in displaying placental morphology(asterisk)



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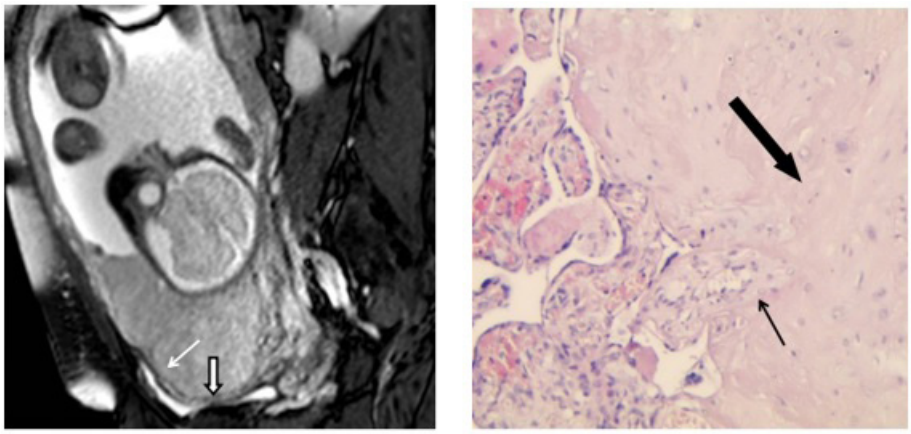

c d

Figure 4: Implanted pernicious placenta previa in a 37-year-old woman at 34＋1 weeks' gestation. Sagittal T2-HASTE (a) showed contraction of the placental surface (thick arrow) accompanied by a T2 dark bands. Sagittal T2-HASTE (b) showed abnormal intraplacental dark bands (thin arrow) and abnormal dilated intraplacental vascularity (thick arrow). Sagittal True FISP (c) showed focal uterine bulging of lower uterine segment with uterine deformation (thick arrows). There was loss of thin dark subplacental-myometrium zone (thin arrow). Photomicrograph (d)showed that the late-stage placental villi (thin arrows) invading the uterine myometrium (thick arrows) (magnification, ×100; haematoxylin-eosin stain)

Table 1: MRI imaging parameters

Sequence	HASTE	True FISP	DWI	T1WI
TR/TE(ms)	1000/93	3.86/1.63	5000/97	286/4.81
Thickness/gap(mm)	2-Apr	Apr-00	2-May	2-Apr
FOV(mm)	420	400	380	400
Bandwidth(Hz/Px)	710	558	1236	410
NEX	1	1	2	1
Flip angle	150°	76°	-	-
Scan duration(s)	30	24	110	60.04

Table 2: The ability of HASTE, True FISP and DWI sequence to display MRI imaging findings of placenta increta

Sequence	Placental heterogeneity	Hypointense intraplacental bands	Abnormal vessel	Placental bulging	Placenta recess	Interruptions or thinning in the myometrial wall
HASTE	58(10)	30(38)	46(22)	31(37)	16(52)	47(21)
True FISP	45(23)	23(45)	31(37)	33(35)	14(54)	56(12)
DWI	48(20)	38(30)	33(35)	38(30)	22(46)	19(49)
$\chi 2$	7.086	6.705	7.852	1.529	2.684	45.555
p	0.029	0.035	0.02	0.465	0.261	＜0.001

Table 3: Sensitivity, specificity, positive and negative predictive values, accuracy and p value of six MRI imaging findings

MR imaging findings	Sensitivity	Specificity	PPV	NPV	Accuracy	$\chi 2$	P value
＜1mm	67% (27/40)	61% (17/28)	71% (27/38)	56% (17/30)	64% (44/68)	4. 008	0.045
≥1mm and ＜2mm	20% (8/40)	64% (18/28)	44% (8/18)	36% (18/50)	38% (26/68)	1. 233	0.027
≥2mm	13% (5/40)	75% (21/28)	42% (5/12)	38% (21/56)	38% (26/68)	1. 709	0.191
Placental heterogeneity	95% (38/40)	75% (21/28)	84% (38/45)	91% (21/23)	87% (59/68)	36.056	＜0.001
Hypointense intraplacental bands	78% (31/40)	82% (23/28)	86% (31/36)	72% (23/32)	80% (54/68)	23.518	＜0.001
Abnormal vessel in the placenta	72% (29/40)	75% (21/28)	81% (29/36)	66% (21/32)	74% (50/68)	14.916	＜0.001
placental bulging	72% (29/40)	79% (22/28)	83% (29/35)	76% (22/29)	75% (51/68)	25.115	＜0.001
Placenta recess	65% (26/40)	93% (26/28)	93% (26/28)	65% (26/40)	76% (52/68)	22.763	＜0.001

5. Discussions

Studies report that previous cesarean section and placenta previa are the highest risk factors for placenta increta. Prevalence of PPP is currently high due to increasing rate of multiple cesarean sections [12, 13, 15]. The risk of placenta increta is approximately 24% for women with placenta previa and one previous cesarean delivery and 67% for women with placenta previa and three or more previous cesarean deliveries [14]. In our study, 19 (19/31) cases of PPP had a history of cesarean section, 12 (12/25) PPP patients had a history of two previous cesarean sections, 7 (7/12) patients with PPP had a history of three or more cesarean sections. Placenta increta causes massive peri-partum bleeding when the placenta separates from the mother which is associated with high incidence of maternal deaths. In the present study, 2 cases underwent total hysterectomy or subtotal hysterectomy due to excessive bleeding. Therefore, it is important to accurately diagnose PPP for proper management and reduction potential complications.

MRI is being adopted as a method for diagnosis of PPP due to advantages such as fast imaging, parallel acquisition, phased array coil and DWI. HASTE sequence is characterized by advantages such as short echo time and high sensitivity to water-bearing tissues. Therefore, HASTE approach is effective for exploring placental anatomical structure and intraplacental signal indication [16, 17]. In this study, the image quality of HASTE sequence was better compared with that of True FISP and DWI sequence. In addition, the display ability of placental signals and abnormal blood vessels in placenta was better compared with the quality of True FISP sequence, with good image quality accounting for 86.7%. Images collected by True FISP sequence showed chemical displacement effect and hook effect and showed uterine contours and distinction with surrounding tissue. The position and range of the interruption of the uterine myometrium were observed directly due to high signal to noise ratio and high contrast. However, bleeding in the placenta, dilated blood vessel signal and the normal placental tissue showed high signal, therefore, it was easy to miss the diagnosis [18, 19]. DWI sequence is based on brownian motion of water molecules for imaging, therefore it shows different signal characteristics changes according to different forms of water molecules. When there is an infarction or bleeding in the placenta, limited movement of water molecules is characterized by reduced signal and good contrast with high-signal amniotic fluid and bladder. In this study, DWI showed better changes of placental signal, low signal band and placental morphology, which is consistent with findings from a previous study [20, 22].

On T2WI, the normal placenta shows a slightly higher signal. For placenta increta, when placenta is attached to the scar of myometrium resulting in local decidua tissue coloboma, bleeding and necrosis is caused by invasion of the muscular layer of placental villi [1]. The placental base extent to the entire chorion, therefore, the division of the myometrium is unclear. This causes the placenta to attach to the blood vessel and dilate, arranging in clusters or forming a blood pool which accounts for many different MRI imaging findings such as placental heterogeneity, abnormal vessel, interruptions or thinning in the myometrial wall and uterine bulging [23]. Hypointense intraplacental bands are seen on MRI due to aging of placental septum and fibrin deposition [21]. Placenta recess is a placental deformity caused by contraction of the placental surface and uterine outer rim resulting in a wedge shaped contour with decreased thickness accompanied by a T2 dark band [6]. Sensitivity, specificity and accuracy of different signs for diagnosis of PPP are different from findings reported in previous reports. [8] report that placenta recess is 100% specific to diagnosis of PPP, and diagnostic accuracy of PPP for abnormal vessel was 86%. Diagnostic specificity of placenta recess in our study was 93% and the diagnostic accuracy of abnormal vessel was 74%. Noda [24] reports that sensitivity of hypointense intraplacental bands and uterine bulging to PPP in the placenta was 71%, whereas specificity and accuracy of placental heterogeneity were 52% and 64%, respectively. In this study, sensitivity of hypointense intraplacental bands and uterine bulging to PPP were 78% and 72%, respectively. On the other hand, specificity and accuracy of placental heterogeneity were 75% and 87% which are higher compared with values reported previously. A previous study reports that accuracy of thinning in the myometrial wall is 41. 4% in diagnosing placenta increta [25]. In our study, the myometrial wall of the lower uterine segment was analyzed with 1mm interval and＜1mm including interruptions in the myometrial wall was statistically significant for diagnosis of PPP with 64% diagnostic accuracy. Studies report that combination of multiple findings is more accurate for diagnosis of PPP. In this study, combination of placental heterogeneity, hypointense intraplacental bands and placenta recess, gave 92. 1% diagnostic accuracy of PPP which is close to 89% accuracy reported in a previous study [25].

A limitation of our study was that a small sample size was used, especially the control group which had fewer cases. Clinically, changes in imaging findings of placental signal, myometrial wall and uterine contour may occur to complete placenta previa or placenta previa associated with adhesion. Therefore, there may be some selection bias in the sample parameters. Large sample size and further clinical studies should be performed to validate our quantitative data.

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