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ORIGINAL RESEARCH

Doppler Parameters of Uterine Arteries in the Evaluation of Placenta Accreta in Patients with Placenta Previa

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Background: Placenta previa (PP) is an obstetric condition where the placenta is abnormally positioned in the lower uterine segment, potentially covering the cervical os. Placenta accreta (PA), often associated with PP, involves abnormal placental adherence to the myometrium, complicating delivery and increasing the likelihood of severe hemorrhage.

Methods: This study retrospectively analyzed medical records of 167 patients diagnosed with PP from January 2018 to December 2022. Patients were divided into two groups based on the presence (n=113) or absence (n=54) of PA. Clinical parameters, including age, gestational weeks, BMI, obstetric history, and uterine artery blood flow parameters [peak systolic velocity (PSV), resistance index (RI), pulsatility index (PI)], were compared between the two groups. Statistical analysis involved independent samples *t*-tests, chi-square tests, and logistic regression to identify significant predictors of PA severity.

Results: Significant differences were observed between the two groups in terms of gravidity, parity, abortions, cesarean sections, and uterine artery blood flow parameters. Patients with PA had higher gravidity, parity, abortion, and cesarean section rates, along with higher PSV and lower RI and PI values. Logistic regression identified PSV, RI, and PI as significant predictors of PA severity. ROC curve analysis confirmed the high predictive accuracy of these parameters, with AUC values indicating robust diagnostic performance.

Conclusion: This study highlights the importance of detailed prenatal evaluation, particularly uterine artery blood flow parameters, in predicting and managing PA in PP patients.

Keywords: placenta previa, placenta accreta, uterine artery blood flow, prenatal diagnosis

Background

Placenta previa (PP) is an obstetric complication characterized by the abnormal positioning of the placenta in the lower uterine segment, partially or completely covering the cervical os.[1] This condition can cause significant third-trimester bleeding, posing risks to both the mother and the fetus.[2] PP is classified into complete previa, where the placenta entirely covers the cervical opening, and partial or marginal previa, where the placenta lies near but does not cover the cervix.[3] The etiology of PP is associated with factors such as prior cesarean sections, uterine surgeries, multiparity, and advanced maternal age, which may predispose to abnormal implantation sites.[4] Early diagnosis using ultrasound is essential for managing PP and reducing delivery-related complications.[5]

Placenta accreta (PA) often coexists with PP, involving abnormal adherence of the placenta to the myometrium due to defective decidua basalis.[6] It is further categorized into PA vera (superficial attachment), placenta increta (invasion into the myometrium), and placenta percreta (penetration through the myometrium and serosa).[7] This condition significantly increases the risk of life-threatening hemorrhage during delivery, often requiring a multidisciplinary approach including planned cesarean section and, in some cases, peripartum hysterectomy.[8] Accurate prenatal diagnosis using ultrasound and MRI allows for detailed planning and improved outcomes.[9] Effective management of PA relies on coordinated care involving obstetricians, anesthesiologists, neonatologists, and surgical specialists.[10]

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Patients with PP complicated by PA face dual high-risk factors, making it one of the most severe obstetric complications.[6] This condition can cause spontaneous and recurrent antepartum hemorrhage, leading to anemia, infection, fetal growth restriction, and fetal distress.[11] In cases of severe bleeding, patients may experience hemorrhagic shock, necessitating emergency surgery to terminate the pregnancy, which increases the likelihood of fetal death, stillbirth, and the need for a hysterectomy.[12] These complications pose serious threats to the lives of both the mother and fetus, adversely affecting families and society, and have thus garnered significant attention from obstetricians.[13]

Diagnosing PA in the context of PP remains challenging due to its lack of specific clinical symptoms. Therefore, analyzing the antenatal risk factors and maternal-fetal outcomes associated with PP complicated by PA, as well as summarizing its clinical features, is essential to inform delivery planning and improve maternal outcomes, ultimately ensuring the safety of both mother and child.

Materials and Methods

Study Design

This is a retrospective study. A total of 167 women in the third trimester who underwent prenatal ultrasound examinations at our hospital between 2018 and 2022 were included in the study. All participants consented to Doppler evaluation, which was successfully performed at 30 gestational weeks. The time interval between the ultrasound assessment and delivery varied among individuals due to differences in gestational progression and obstetric indications. We collected medical records from the 167 patients with complete information who delivered in our hospital and were diagnosed with PP. The patients were divided into two groups based on the presence of PA: 54 cases without PA and 113 cases with PA. The study included variables such as age, gestational weeks, body mass index (BMI), incidence of bleeding during pregnancy, number of pregnancies, number of deliveries, number of miscarriages, number of cesarean sections, type of surgery (emergency or elective), and uterine artery blood flow parameters, including peak systolic velocity (PSV), resistance index (RI), pulsatility index (PI). The data were compared between the two groups of patients with PP, with and without PA, focusing on the number of pregnancies, deliveries, miscarriages, cesarean sections, and uterine artery blood flow parameters (PSV, RI, PI). The study was approved by the Second Hospital of Hebei Medical University. All patient were informed of the nature of the study, and written informed consent was derived from each participant.

Participants

Inclusion Criteria

Diagnosis of pernicious PP or pernicious PP with PA confirmed by color Doppler ultrasound and MRI before delivery, supported by intraoperative exploration and/or postoperative pathology. No history of massive bleeding in previous deliveries. Fetal gestational age $\geq$ 28 weeks, single live fetus, normal development on ultrasound without apparent deformities.

Exclusion Criteria

Presence of diabetes, severe preeclampsia, pulmonary hypertension, hematologic diseases, severe cardiovascular or cerebrovascular diseases, or other pregnancy complications or comorbidities. Twin or multiple pregnancies on ultrasound. Concurrent surgical procedures such as myomectomy or ovarian cystectomy. Incomplete maternal data or other factors affecting the study results.

Definitions

Pernicious PP refers to a history of cesarean section or myomectomy with the current pregnancy's placenta attaching to the uterine lower segment at the site of the previous surgical scar, reaching or covering the internal cervical os, significantly increasing the incidence of placental adhesion, accreta, and life-threatening hemorrhage. PA occurs due to poor primary decidual development or endometrial damage, inflammation leading to reduced or absent decidua basalis, causing abnormal placental villi invasion. It is classified into three types based on the depth of myometrial invasion and whether adjacent organs are affected:

Placenta accreta (PA): The diagnosis of placenta accreta was confirmed postnatally based on the presence of any of the following clinical criteria: (1) In cases of vaginal delivery, failure of placental separation after more than 20 minutes, accompanied by manual removal difficulties (eg, placental fragmentation or incomplete removal), with significant hemorrhage requiring uterine compression sutures or hysterectomy. (2) During cesarean section, inability of the placenta to detach spontaneously, with profuse bleeding at the placental attachment site necessitating surgical intervention such as compression sutures or hysterectomy. (3) Histopathological confirmation of placental villi invading the myometrium in hysterectomy specimens.

Placenta percreta (PP): Placental villi penetrate the entire myometrium, reaching or surpassing the serosa layer, necessitating instrumental separation or local excision of placental tissue during surgery, often leaving only the serosal layer and potentially causing uterine rupture.

Imaging Diagnosis Criteria

Color Doppler ultrasound clearly shows the relative positions of the lower uterine segment, placenta, and internal cervical os, and reveals blood flow behind the placenta. PA appears as irregular anechoic areas within the placenta, with cloudy echo flow, loss or interruption of the normal low echo band behind the placenta, and myometrial thinning or disappearance, with a thickness of less than 1 mm. If the bladder is invaded, the strong echo of the bladder serosa adjacent to the uterus disappears, and uterine-bladder wall blood flow increases.

Uterine artery Doppler measurements were obtained approximately 1 cm distal to the crossing point of the uterine artery over the external iliac artery (ie, distal to the crossover, away from the uterus). The measurement site was carefully identified based on anatomical landmarks, in accordance with the updated guidelines of the International Society of Ultrasound in Obstetrics and Gynecology. The insonation angle between the ultrasound beam and the direction of blood flow was maintained between 0° and 60°, preferably approaching 0°. Angle correction was consistently applied through probe positioning, alignment of the sample volume, and use of angle correction software, ensuring accurate assessment of flow velocity.

Given the potential physiological differences between the right and left uterine arteries, Doppler measurements were obtained separately from each side at the level of the artery origin or at the internal cervical os. Spectral waveforms were recorded for both arteries, and the mean values of bilateral PI and RI were calculated for subsequent analysis. All Doppler ultrasound examinations were performed by three dedicated senior sonographers (attending physicians or above) from the same ultrasound department at our hospital. Standardized scanning protocols and consistent anatomical references were strictly followed to ensure data reliability and minimize inter-operator variability.

Statistical Analysis

The data were processed and statistically analyzed using SPSS 23.0 software. Normally distributed measurement data are expressed as mean ± standard deviation. Differences between two groups were compared using the independent samples *t*-test, while differences among multiple groups were compared using one-factor ANOVA. Categorical data are expressed as percentages (%) and analyzed using the chi-square (χ^2) test. Multivariate correlation analysis was conducted using Logistic regression analysis. Data that did not follow a normal distribution were expressed as medians and compared among multiple groups using the Kruskal–Wallis test. A p-value of less than 0.05 was considered statistically significant.

Results

Clinical Parameters in PP Patients with or without PA

Table 1 presents the clinical characteristics of 167 patients with placenta previa (PP), divided into two groups: those without placenta accreta (PA) (n = 54) and those with PA (n = 113). No statistically significant differences were observed between the groups in terms of maternal age (31.09 ± 4.21 years in the non-PA group vs 31.81 ± 4.33 years in the PA group, P = 0.3173), gestational age at delivery (34.37 ± 3.63 weeks vs 34.64 ± 2.54 weeks, P = 0.5833), BMI (27.51 ± 3.99 kg/m² vs 26.40 ± 3.63 kg/m², P = 0.0767), incidence of antenatal hemorrhage (42.59% vs 50.44%, P = 0.5378), or type of surgery (emergency vs elective; 42.59% emergency in the non-PA group vs 46.02% in the PA group, P = 0.1862).

Table 1 Clinical Parameters in PP Patients with or without PA

	PP Patients without PA (n=54)	PP Patients with PA (n=113)	*P* value
Age (years) [a]	31.09 ± 4.21	31.81 ± 4.33	0.3173
Gestational age (weeks) [a]	34.37 ± 3.63	34.64 ± 2.54	0.5833
BMI (kg/m^2) [a]	27.51 ± 3.99	26.40 ± 3.63	0.0767
Hemorrhage during pregnancy (N, %)			0.5378
Yes	23 (42.59)	57 (50.44)	
No	31 (57.41)	56 (49.56)	
Gravidity (numbers) [b]	2 (1.75~3.00)	4 (3.00~4.00)	<0.0001
Parity (numbers) [b]	1 (0.00~1.00)	1 (1.00~2.00)	0.0010
Numbers of abortion [b]	0 (0.00~1.00)	1 (0.00~2.00)	0.0034
Numbers of cesarean sections [b]	0 (0.00~1.00)	1 (1.00~1.00)	0.0005
Types of surgery (N, %)			0.1862
Emergency surgery	23 (42.59)	52 (46.02)	
Elective surgery	31 (57.41)	61 (53.98)	
Parameters of the uterine artery blood flow [a]			
PSV (cm/s)	34.54 ± 4.12	44.35 ± 4.23	<0.0001
RI	0.49 ± 0.08	0.33 ± 0.06	<0.0001
PI	0.60 ± 0.07	0.41 ± 0.11	<0.0001

Notes: [a]Data were presented as Mean ± SD. [b]Data were presented as median (interquartile range).
Abbreviations: PP, placenta previa; PA, placenta accreta; PSV, peak systolic velocity; RI, resistance index; PI, pulsatility index.

In contrast, several obstetric history variables differed significantly between the two groups. The PA group had a higher gravidity (3.53 ± 1.30 vs 2.59 ± 1.37, P < 0.0001), parity (1.21 ± 0.60 vs 0.85 ± 0.74, P = 0.0010), number of abortions (1.25 ± 1.02 vs 0.76 ± 0.93, P = 0.0034), and number of prior cesarean sections (1.12 ± 1.25 vs 0.46 ± 0.75, P = 0.0005). Significant differences were also observed in uterine artery Doppler parameters. The PSV was markedly higher in the PA group (44.35 ± 4.23 cm/s) compared to the non-PA group (34.54 ± 4.12 cm/s, P < 0.0001). Conversely, the RI and PI were significantly lower in patients with PA (RI: 0.33 ± 0.06 vs 0.49 ± 0.08, P < 0.0001; PI: 0.41 ± 0.11 vs 0.60 ± 0.07, P < 0.0001).

The Effects of Clinical Parameters on the Severity of PP Patients with PA

A multivariate logistic regression analysis was performed to identify the clinical parameters significantly associated with the severity of PA in patients with PP. The analysis included factors that were statistically significant in the univariate analysis: gravidity, parity, times of abortion, times of cesarean sections, and uterine artery blood flow parameters (PSV, RI, PI). As shown in Table 2, gravidity (OR = 1.47, 95% CI: 0.08–22.38, P = 0.8204), parity (OR = 0.57, 95% CI: 0.01–28.79, P = 0.7855), number of abortions (OR = 1.39, 95% CI: 0.08–50.60, P = 0.8532), and number of cesarean sections (OR = 2.93, 95% CI: 0.63–20.49, P = 0.2797) were not significantly associated with the severity of PA (P > 0.05). In contrast, uterine artery Doppler parameters demonstrated significant associations. PSV was positively associated with an increased risk of severe PA (OR = 1.42, 95% CI: 1.13–2.00, P = 0.0144). RI showed a strong inverse relationship (OR = 2.42×10^{-13}, 95% CI: 3.35×10^{-23}–3.32×10^{-7}, P = 0.0013), as did PI (OR = 1.37×10^{-6}, 95% CI: 7.43×10^{-13}–0.04, P = 0.0244). These results suggest that while obstetric history factors such as gravidity, parity, abortion history, and

Table 2 Multivariate Logistic Regression Analysis of the Effects of Clinical Parameters on the Severity of PP Patients with PA

Risk Factors	OR	95% CI	|Z|	*P* value
Gravidity	1.47	0.08 to 22.38	0.227	0.8204
Parity	0.57	0.01 to 28.79	0.272	0.7855
Numbers of abortion	1.39	0.08 to 50.60	0.185	0.8532
Numbers of cesarean sections	2.93	0.63 to 20.49	1.081	0.2797
PSV	1.42	1.13 to 2.00	2.447	0.0144
RI	2.42e-13	3.35e-23 to 3.32e-7	3.227	0.0013
PI	1.37e-6	7.43e-13 to 0.04	2.251	0.0244

Abbreviations: OR, odds ratios; CI, confidence interval; PP, placenta previa; PA, placenta accreta; PSV, peak systolic velocity; RI, resistance index; PI, pulsatility index.

cesarean deliveries are not independently predictive of PA severity, uterine artery blood flow parameters—particularly PSV, RI, and PI—serve as significant indicators and may aid in risk stratification during prenatal assessment.

Predictive Value of Uterine Artery Blood Flow Parameters

To evaluate the predictive value of uterine artery blood flow parameters for PA in patients with PP, Receiver Operating Characteristic (ROC) curve analyses were conducted. The parameters analyzed included PSV, RI, and PI. The results, as summarized in Table 3 and illustrated in Figure 1, show that all three parameters are significant predictors of PA in PP patients. The Area Under the Curve (AUC) values for PSV, RI, and PI were 0.9517, 0.9571, and 0.9294, respectively, indicating high predictive accuracy ($P < 0.0001$ for all).

Specifically, PSV demonstrated an AUC of 0.9517 with a sensitivity of 89.74% and specificity of 84.00%. The RI had an AUC of 0.9571 with a sensitivity of 90.68% and specificity of 87.76%. The PI showed an AUC of 0.9294 with a sensitivity of 88.50% and specificity of 75.93%. These findings indicate that uterine artery blood flow parameters, particularly PSV and RI, are robust predictors of PA in patients with PP.

Maternal and Infant Outcomes Comparison

Table 4 presents a comprehensive comparison of maternal and infant outcomes between PP patients with and without PA. Patients with PA exhibited significantly higher intraoperative blood loss (1673.19 ± 1481.57 mL) compared to those without PA (543.70 ± 280.44 mL, $P < 0.0001$) and longer operation times (118.00 ± 29.91 min vs 98.00 ± 27.81 min, $P < 0.0001$). They also had extended hospital stays (11.12 ± 4.90 days) relative to the non-PA group (9.26 ± 5.70 days, $P = 0.0315$). Although rates of hysterectomy and ICU admissions did not significantly differ between the groups, PA patients required transfusions more frequently (60.18% vs 11.11%, $P < 0.0001$). There were no significant disparities in fetal weight or Apgar scores.

Table 3 The Value of the Parameters of the Uterine Artery Blood Flow in Predicting PA in PP Patients

	AUC	SE	95% CI	*P* value	Classification Cutoff	Specificity (%)	Sensitivity (%)
PSV	0.9517	0.0162	0.92 to 0.98	<0.0001	0.5	84.00	89.74
RI	0.9571	0.0155	0.93 to 0.99	<0.0001	0.5	87.76	90.68
PI	0.9294	0.0193	0.89 to 0.97	<0.0001	0.5	75.93	88.50

Abbreviations: AUC, Area under the ROC curve; SE, Std. Error; CI, confidence interval; PP, placenta previa; PA, placenta accreta; PSV, peak systolic velocity; RI, resistance index; PI, pulsatility index.

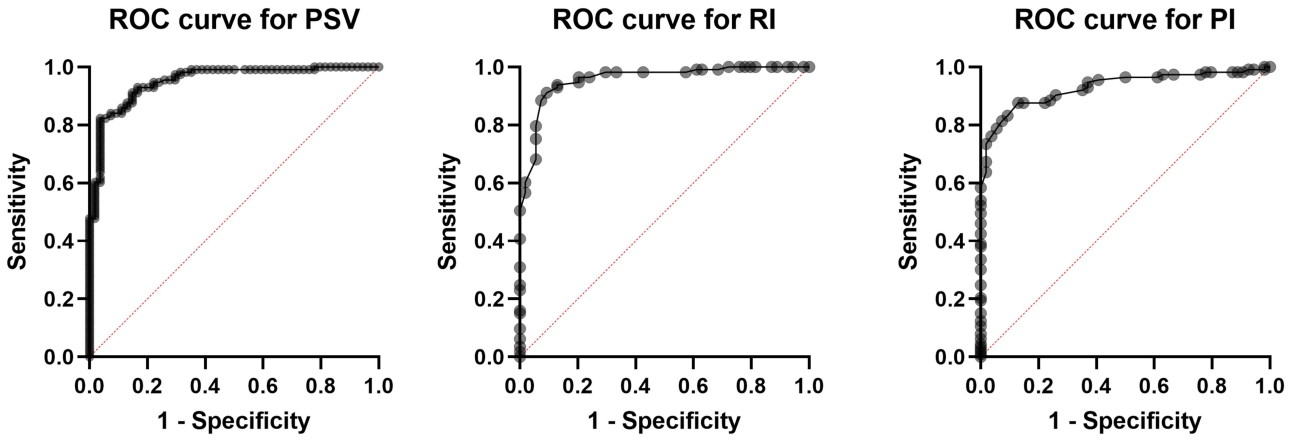

Figure 1 ROC curve analyses. The values of the parameters of the uterine artery blood flow in predicting placenta accreta in placenta previa patients were analyzed by ROC curves. ROC curve for PSV: negative predictive power (%), 84.00; positive predictive power (%), 89.74. ROC curve for RI: negative predictive power (%), 87.76; positive predictive power (%), 90.68. ROC curve for PI: negative predictive power (%), 75.93; positive predictive power (%), 88.50.

Univariate Analysis of Maternal and Infant Outcomes in PP Patients with PA

Table 5 provides results from univariate logistic regression analysis examining maternal and infant outcomes in PP patients with PA. The analysis revealed significant associations in several key parameters between the PA and non-PA groups. Specifically, intraoperative blood loss (OR 1.004, 95% CI 1.003 to 1.006, P < 0.0001), operation time (OR 1.025, 95% CI 1.013 to 1.040, P = 0.0002), hospital stays (OR 1.085, 95% CI 1.010 to 1.178, P = 0.0366), and transfusion requirements (OR 12.090, 95% CI 5.105 to 33.64, P < 0.0001) were all significantly higher in the PA group compared to the non-PA group. No significant differences were observed in rates of hysterectomy, ICU admissions, fetal weight, or Apgar scores between the two groups.

Discussion

This study investigates the clinical and ultrasound parameters associated with the severity of PA in patients with PP, a combination that represents a high-risk obstetric condition. Among 167 patients diagnosed with PP, we identified that uterine artery Doppler parameters—specifically, PSV, RI, and PI—are significantly associated with PA severity. In

Table 4 Maternal and Infant Outcomes in Two Groups

	PP Patients without PA (n=54)	PP Patients with PA (n=113)	*P* value
Intraoperative blood loss (mL)	543.70 ± 280.44	1673.19 ± 1481.57	<0.0001
Operation time (min)	98.00 ± 27.81	118.00 ± 29.91	<0.0001
Hospital stays(days)	9.26 ± 5.70	11.12 ± 4.90	0.0315
Hysterectomy (N, %)	1 (1.85)	2 (1.77)	0.9705
Transfusion (N, %)	6 (11.11)	68 (60.18)	<0.0001
ICU (N, %)	2 (3.70)	4 (3.54)	0.9579
Fetal weight (g)	2429.07 ± 741.82	2546.36 ± 651.85	0.3001
Apgar score	8.00 ± 1.60	8.39 ± 0.92	0.1114

Note: Data were presented as Mean ± SD.
Abbreviations: PP, placenta previa; PA, placenta accreta.

Table 5 Univariate Analysis of Maternal and Infant Outcomes in PP Patients with PA

	OR	95% CI	|Z|	*P* value
Intraoperative blood loss (mL)	1.004	1.003 to 1.006	5.118	<0.0001
Operation time (min)	1.025	1.013 to 1.040	3.789	0.0002
Hospital stays(days)	1.085	1.010 to 1.178	2.090	0.0366
Hysterectomy (N, %)	0.955	0.090 to 20.800	0.037	0.9703
Transfusion (N, %)	12.090	5.105 to 33.64	5.261	<0.0001
ICU (N, %)	0.954	0.180 to 7.038	0.053	0.9576
Fetal weight (g)	1.000	1.000 to 1.001	1.039	0.2987
Apgar score	1.273	0.942 to 1.727	1.577	0.1149

Abbreviations: OR, odds ratios; CI, confidence interval; PP, placenta previa; PA, placenta accreta.

contrast, traditional obstetric history factors such as gravidity, parity, history of abortion, and cesarean section were not independently predictive of disease severity.

The coexistence of PP and PA poses significant risks of massive obstetric hemorrhage and maternal morbidity.[14] This dual pathology often necessitates a multidisciplinary approach involving obstetricians, maternal-fetal medicine specialists, radiologists, and sometimes urologists or vascular surgeons, to ensure comprehensive preoperative planning and intraoperative management.[15] Early and accurate diagnosis is paramount for optimizing outcomes in PP with PA cases.[16]

Prenatal ultrasound and MRI play pivotal roles in identifying placental abnormalities and assessing the extent of placental invasion.[17] Tailored interventions such as scheduled cesarean hysterectomy or conservative management approaches can be planned more effectively when the risk of invasive placentation is identified antenatally.[18]

Our results contribute to a growing body of literature emphasizing the role of hemodynamic markers in the prenatal assessment of the placenta accreta spectrum. Recent studies have introduced novel ultrasound markers and advanced diagnostic scoring systems for placenta accreta spectrum.[19,20] Future research should explore the integration of these novel markers with uterine artery Doppler indices to develop composite prediction models. Additionally, large-scale, multicenter prospective studies are needed to validate the predictive performance of PSV, RI, and PI across different populations and ultrasound settings.

Advances in imaging technology, machine learning-assisted diagnostic algorithms, and incorporation of circulating biomarkers or genetic indicators may further improve the accuracy and individualization of PA risk prediction. Exploring the underlying pathophysiology of altered uterine perfusion in PA may also yield insights for therapeutic intervention.[21] For instance, women with multiple prior cesarean sections or myomectomies are at heightened risk due to the scarred uterine environment conducive to abnormal placental attachment.[22] These insights underscore the necessity of tailored prenatal care protocols for high-risk pregnancies, aiming to preemptively identify and manage complications associated with PP and PA.[23]

Multivariate logistic regression revealed that while obstetric history parameters such as gravidity, parity, and cesarean section history did not significantly correlate with PA severity, uterine artery blood flow parameters emerged as pivotal predictors. Specifically, PSV, RI, and PI demonstrated significant associations with PA severity. Higher PSV and lower RI and PI values were consistently observed in patients with more severe forms of PA, reflecting compromised uteroplacental hemodynamics and increased risk of invasive placentation.

The robustness of these hemodynamic markers in predicting PA severity underscores their clinical utility in risk stratification and preoperative planning. By integrating these parameters into routine prenatal ultrasound evaluations, clinicians can enhance diagnostic accuracy, refine management strategies, and optimize maternal and fetal outcomes.

Moreover, our findings support the integration of advanced imaging technologies and multidisciplinary consultations in the management of complex obstetric cases, ensuring comprehensive care delivery tailored to individual patient needs.

This study is strengthened by its focus on quantifiable, non-invasive ultrasound parameters with clear clinical relevance. A relatively large sample size and standardized diagnostic criteria add to the robustness of our analysis. The use of multivariate logistic regression enhances the validity of our findings by adjusting for confounding factors. Early identification of high-risk patients allows for timely referral to specialized centers equipped to manage complex obstetric conditions. Tailored management strategies, including planned cesarean delivery with concurrent hysterectomy or conservative management with placental retention techniques, can be optimized based on the severity of placental invasion assessed prenatally.

Furthermore, our findings advocate for the adoption of standardized protocols integrating maternal-fetal medicine expertise, radiological imaging, and surgical expertise in managing PP with PA. These protocols aim to mitigate intraoperative complications, minimize blood loss, and reduce the need for emergency interventions, thereby improving maternal outcomes and preserving fertility when possible. By delineating the roles of various healthcare providers and fostering interdisciplinary collaboration, our study underscores the importance of a unified approach in achieving favorable maternal and neonatal outcomes in complex obstetric scenarios.

Despite the strengths of our study, several limitations warrant consideration. The retrospective nature and single-center design may limit the generalizability of our findings to broader populations. Variability in clinical practices and patient demographics across different healthcare settings could influence the applicability of our results in diverse geographical regions and healthcare systems.

Moreover, the absence of experimental data, such as biomarker analyses or animal models, precludes a comprehensive understanding of the underlying pathophysiological mechanisms driving placental abnormalities in PP with PA. Future research endeavors should prioritize prospective multicenter studies with larger, more diverse cohorts to validate our findings rigorously. Incorporating advanced imaging modalities, biomarker analyses, and genomic studies may elucidate novel biomarkers and therapeutic targets for early detection and targeted interventions in high-risk pregnancies.

Conclusions

In conclusion, our study highlights the significant value of uterine artery Doppler parameters—particularly decreased PI and RI—in the prenatal evaluation of placenta accreta among patients with placenta previa. These findings suggest that uterine artery Doppler assessment can serve as a practical, non-invasive tool for early risk stratification. Incorporating this approach into routine antenatal screening may facilitate timely referral, multidisciplinary planning, and improved maternal and neonatal outcomes. Future prospective studies are warranted to validate these results and further integrate uterine artery Doppler analysis into standardized diagnostic protocols for high-risk pregnancies.

Data Sharing Statement

The raw data could be obtained upon reasonable request to the corresponding author.

Ethics Approval and Consent to Participate

The study was approved by the Second Hospital of Hebei Medical University, the study was performed in strict accordance with the Declaration of Helsinki, Ethical Principles for Medical Research Involving Human Subjects.

Informed Consent

All patients were informed of the nature of the study, and written informed consent was derived from each participant.

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Disclosure

The authors declare they have no conflict of interest regarding this research study.

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