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Original Article

Radiology Section

Diagnostic Performance of Ultrasound in Placenta Accreta Spectrum associated with Placenta Previa: A Prospective Observational Study

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ABSTRACT

Introduction: Placenta Accreta Spectrum (PAS) represents a serious obstetric complication characterised by abnormal placental adherence to the uterine wall, resulting in severe maternal morbidity due to massive haemorrhage, need for hysterectomy, and increased perioperative complications. Ultrasonography, particularly with colour Doppler, remains the primary imaging modality for evaluating suspected PAS.

Aim: To evaluate the diagnostic performance of ultrasonography in detecting PAS in patients with placenta previa.

Materials and Methods: This prospective observational study was conducted in the Department of Radiodiagnosis and Imaging, Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab, India, from July 2024 to December 2025. A total of 65 pregnant women with placenta previa or low-lying placenta and a history of at least one previous caesarean section, with gestational age greater than 20 weeks, were included. Ultrasound examinations were performed using a Voluson E8 system with a convex probe (2-5 MHz). Grey-scale and colour Doppler imaging were used to evaluate sonographic parameters, including intraplacental lacunae, myometrial thickness, loss of retroplacental clear space, bladder line interruption, and bridging vessels. Placenta Accreta Index (PAI) scores were also calculated to assess their diagnostic value. Diagnostic accuracy was determined by calculating sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and overall accuracy.

Results: The mean age of the study population was 30.1±5.5 years. The mean gestational age was 31.0±3.9 weeks. PAS was confirmed in 26 out of 65 cases (40%). Higher PAI scores were significantly associated with PAS, with a mean score of 7.7±1.5 in PAS cases compared to 5.3±1.2 in non PAS cases (p-value <0.001). A significant association was observed between PAS and the number of previous caesarean sections, lacunar grade, myometrial thickness, and presence of bridging vessels (p-value <0.001). Ultrasonography demonstrated a sensitivity of 96.2%, specificity of 89.7%, PPV of 86.2%, and NPV of 97.2%. The area under the ROC curve was 0.91, indicating excellent diagnostic performance.

Conclusion: Ultrasonography is a highly reliable modality for antenatal detection of PAS in high-risk pregnancies.

Keywords: Abnormal placentation, Morbidly adherent placenta, Obstetric imaging, Placental invasion, Prenatal diagnosis, Uteroplacental interface

INTRODUCTION

Often overshadowed during routine obstetric ultrasound examinations, the placenta is nonetheless a cornerstone of foetal growth, maternal wellbeing, and overall pregnancy outcome. As the primary interface between mother and foetus, it performs critical functions including nutrient exchange, waste elimination, endocrine regulation, and immunologic protection. Throughout gestation, the placenta undergoes continuous growth, structural transformation, and vascular maturation [1]. Familiarity with its normal sonographic appearance across different stages of pregnancy is therefore essential for accurate interpretation and early detection of pathology [2].

A wide and varied spectrum of placental abnormalities may be encountered in clinical practice, involving placental location, development, adherence to the myometrium, vascularity, and trophoblastic proliferation. Among these, PAS disorders are of particular clinical importance due to their significant impact on maternal morbidity and are associated with serious maternal and foetal complications, including severe haemorrhage, preterm delivery, fetal growth restriction, and increased peripartum morbidity [3].

The PAS encompasses a range of abnormal placental adherence and invasion, classified by the depth of villous invasion into the uterine wall. Placenta accreta is defined as abnormal adherence of placental villi to the myometrium due to partial or complete absence of the decidua basalis and Nitabuch's layer [4]. In placenta accreta vera, chorionic villi attach directly to the myometrium without intervening decidua. In placenta increta, villi invade into the myometrium, whereas in placenta percreta, villi penetrate through the myometrium and may extend beyond the uterine serosa, sometimes involving adjacent organs such as the urinary bladder [4].

Accurately identifying placenta accreta during pregnancy is crucial for effective prenatal monitoring, appropriate delivery planning, and immediate management. Ultrasonography remains the primary imaging modality for evaluating placental abnormalities because it is widely accessible, safe, cost-effective, and provides real-time imaging. The addition of colour and power Doppler techniques further enhances ultrasound assessment by allowing detailed evaluation of placental structure, vascularity, and the uteroplacental interface [5].

Comstock CH and Finberg HJ and Williams JW demonstrated that characteristic sonographic features, such as intraplacental lacunae, myometrial thinning, and increased vascularity, are strongly associated with the PAS [5,6]. However, these studies were largely retrospective or based on selected high-risk populations, and variability in reported diagnostic performance persists. As a result, the true accuracy of prospective prenatal diagnosis using sonography remains poorly established. The present study therefore evaluated the diagnostic performance of ultrasound in identifying PAS in women.

MATERIALS AND METHODS

A prospective observational study was conducted in the Department of Radiodiagnosis and Imaging, Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab, India from July 2024 to December 2025. The study design was approved by the Institutional Ethics Committee (IEC Approval No.: IEC/2024-334 dated 27/05/2024). Consent was obtained from all study participants after explaining the purpose of the study.

Inclusion criteria: Pregnant women with >20 weeks of gestation (as sonographic features of PAS are more reliably evaluated after mid-gestation) and a diagnosis of low-lying placenta or placenta previa, with a history of at least one previous caesarean section, were enrolled. Both low-lying placenta and placenta previa cases were included, as they represent a clinical continuum and share a similar risk for PAS.

Exclusion criteria: Pregnant women with no prior history of caesarean section and presence of other uterine surgical procedures such as myomectomy.

Patients without placenta previa or low-lying placenta, including those with a history of classical caesarean section, but normal placental location. Multiple gestation pregnancies, known uterine anomalies (e.g., bicornuate uterus). Patients with suboptimal ultrasound evaluation due to factors such as maternal obesity or advanced gestational age resulting in poor acoustic window were excluded from the study. Placenta previa was defined by the identification of placental tissue directly overlying the internal cervical os. A low-lying placenta was defined as a placenta in which the placental margin lies within 2 cm of the internal cervical os but does not cover or cross it [7].

Ultrasound imaging assessment: Ultrasound examinations were performed using a Voluson E8 ultrasound system (GE Healthcare) equipped with a C2-5 RS convex probe (2-5 MHz). A distended urinary bladder was ensured to facilitate optimal evaluation of the uterovesical interface. Colour Doppler imaging was used to assess vascularity along the utero-placental and uterine-bladder interfaces. All examinations were performed and interpreted by a single experienced radiologist with expertise in obstetric imaging; therefore, interobserver variability was not assessed. The radiologist was not blinded to the patients' clinical history at the time of image acquisition and interpretation. Although only patients beyond 20 weeks of gestation were included, ultrasound examinations were performed at varying gestational ages depending on the timing of clinical presentation, and no fixed gestational age for imaging was standardised. Patients were evaluated during the second and third trimesters, with some cases assessed near term or at delivery when clinically indicated.

Placenta Accreta Index (PAI) scoring: PAI score, as described by Rac MW et al., was also calculated to assess its diagnostic value as a supporting tool in the antenatal detection of abnormal placental invasion [8].

Sonographic parameters: Sonographic evaluation focused on the presence of intraplacental lacunae, disruption or irregularity of the uterine serosa-bladder interface, thinning of the myometrium, absence of the retroplacental hypoechoic zone, and focal outward-bulging placental tissue. Intraplacental lacunae were characterised based on their number, morphology, margin definition, and internal vascularity. Intraplacental lacunae were classified based on the grading system described by Finberg HJ and Williams JW [6].

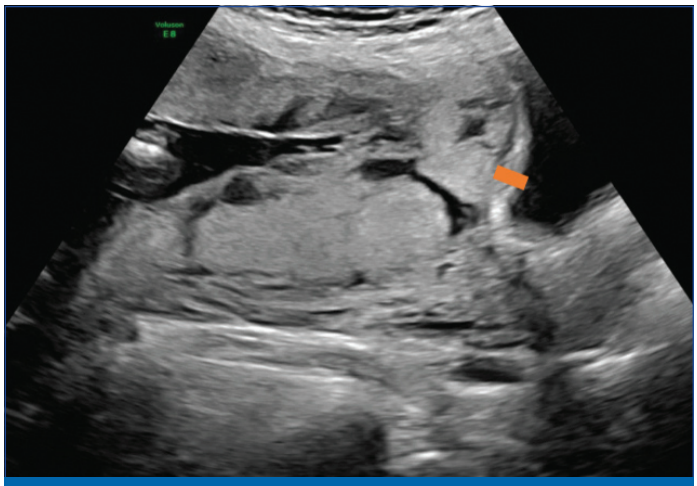
Grade 0- indicated absence of lacunar spaces.

Grade 1- was assigned when one to three small lacunae were identified.

Grade 2- corresponded to the presence of four to six lacunae that were larger and more irregular in appearance.

Grade 3- was defined by numerous lacunar spaces diffusely distributed throughout the placenta, often exhibiting a large and distorted morphology.

Myometrial thickness was assessed using greyscale ultrasound in both the sagittal and transverse planes to ensure optimal visualisation of the placenta-myometrium interface. Measurements were obtained at the thinnest identifiable retroplacental segment, defined as the region between the placental tissue and the uterine serosa [Table/Fig-1]. Calipers were placed perpendicular to the uterine wall, extending from the inner myometrial border adjacent to the placenta to the outer uterine serosal surface, avoiding oblique measurements. Measurements were performed in both planes, and two to three readings were obtained, with the smallest value recorded for analysis. A myometrial thickness of less than 1 mm in a localised segment was considered suggestive of PAS, in accordance with established ultrasonographic diagnostic criteria described by American College of Obstetricians and Gynecologists (ACOG) [9].



[Table/Fig-1]: Greyscale ultrasound image showing measurement of retroplacental myometrial thickness at the thinnest segment.

Disruption or irregularity of the uterine serosa-bladder interface was defined as loss of the continuous hyperechoic line between the uterus and bladder. Loss of the retroplacental hypoechoic zone was defined as absence or interruption of the normal hypoechoic layer between the placenta and myometrium. Focal outward-bulging placental tissue was defined as localised contour abnormality with placental tissue extending beyond the expected uterine margin.

Magnetic Resonance Imaging (MRI) was not included as a secondary modality, as the study was specifically designed to evaluate the diagnostic accuracy of ultrasound as a primary and standalone screening tool for PAS.

Reference standard (Final Diagnosis): The final diagnosis (reference standard) of PAS was established based on intraoperative findings at the time of delivery or histopathological confirmation in patients undergoing hysterectomy.

STATISTICAL ANALYSIS

The statistical analysis was carried out utilising Statistical Package for the Social Sciences (SPSS) software version 23.0. Continuous variables were summarised using either the mean and standard deviation or the median and range, while categorical variables were displayed as frequencies and percentages. The relationship between categorical variables was analysed using the Chi-square test or Fisher's exact test, contingent on the data distribution and sample size. The diagnostic effectiveness of colour doppler ultrasonography in the prenatal detection of PAS was evaluated by calculating sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy. A p-value <0.05 was regarded as statistically significant.

RESULTS

The study population consisted of 65 pregnant women with placenta previa and low-lying placenta. Among them, 29

patients (44.6%) belonged to the 18-30 years age group, while 36 patients (55.4%) were in the 30-40 years age group. The mean age of the study population was approximately 30.1±5.5 years. The mean gestational age assessed by ultrasound was 31.0±3.9 weeks.

Among the 65 study participants, 47 (72.3%) patients had a history of two previous caesarean deliveries. A single prior caesarean section was noted in 10 (15.4%) of cases, while 8 (12.3%) of patients had undergone three previous caesarean sections. The association between the number of previous caesarean sections and placental accreta was not statistically significant (χ^2=4.68, p-value=0.096) [Table/Fig-2].

Number of previous caesarean sections	Placental accreta present n (%)	Placental accreta absent n (%)	Total (n)
1	1 (10.0)	9 (90.0)	10
2	22 (46.8)	25 (53.2)	47
3	3 (37.5)	5 (62.5)	8
Total	26	39	65

[Table/Fig-2]: Association between number of previous caesarean sections and placental invasion.

Lower lacunar grades (Grades 0 and 1) were predominantly associated with lower PAI scores and were mainly seen in non-PAS cases [Table/Fig-3].

Placental adherence	Total (n)	Grade 0 n (%)	Grade 1 n (%)	Grade 2 n (%)	Grade 3 n (%)
Non PAS	39	25 (64.1)	11 (28.2)	3 (7.7)	0
Accreta vera	14	3 (21.4)	3 (21.4)	8 (57.2)	0
Increta	4	0	2 (50.0)	2 (50.0)	0
Percreta	8	0	0	3 (37.5)	5 (62.5)
Total	65	28	16	16	5

[Table/Fig-3]: Association between lacunar grade and type of placental adherence.

Lacunar grade showed a significant association with the pattern of placental adherence [Table/Fig-4].

Lacunar grade	PAS (n=26)	Mean PAI±SD (PAS)	No PAS (n=39)	Mean PAI±SD (No PAS)	p-value
Grade 0-1	2 (7.7%)	4.1±0.9	23 (59.0%)	4.8±1.1	<0.001*
Grade 2	10 (38.5%)	6.9±1.0	12 (30.8%)	5.6±1.0	
Grade 3	14 (53.8%)	8.6±1.2	4 (10.2%)	6.3±1.3	

[Table/Fig-4]: Distribution of Placenta Accreta Index (PAI) scores according to intraplacental lacunar grading in PAS and non PAS groups.

Myometrial thickness showed a statistically significant relationship with the extent of placental invasion (χ^2=44.23, p-value <0.001) [Table/Fig-5].

Myometrial thickness (mm)	Total patients (n)	Placental invasion n (%)	No placental invasion n (%)
<1	28	24 (85.7)	4 (14.3)
1-3	9	2 (22.2)	7 (77.8)
>3	28	0	28 (100)
Total	65	26 (40)	39 (60)
p-value		<0.001	

[Table/Fig-5]: Association between sagittal smallest Myometrial Thickness (MM) and placental invasion.

Patients with bridging vessels had markedly higher odds of placental invasion compared to those without bridging vessels (odds ratio 66.0; 95% confidence interval 13.48-323.05; p-value <0.001) [Table/Fig-6].

The mean PAI score was significantly higher in patients with PAS than in those without PAS (7.7±1.5 vs 5.3±1.2, p-value <0.001) [Table/Fig-7].

Bridging vessels	Number of patients	Placental invasion n (%)	No. placental invasion n (%)	OR (95% CI)	p-value
Present	25	22 (88.0)	3 (12.0)	66.0 (13.48-323.05)	<0.001
Absent	40	4 (10.0)	36 (90.0)	1.00 (Reference)	-
Total	65	26	39		

[Table/Fig-6]: Association between bridging vessels and placental invasion.

Variable	PAS (n=26)	No PAS (n=39)	p-value
Previous caesarean section			
<2 CS	4 (15.4)	35 (89.7)	0.096
≥2 CS	22 (84.6)	4 (10.3)	
Bridging vessels			
Present	22 (84.6)	3 (7.7)	<0.001*
Absent	4 (15.4)	36 (92.3)	
Smallest myometrial thickness (mm)			
<1	24 (92.3)	4 (10.3)	<0.001*
1-3	2 (7.7)	7 (17.9)	
>3	0	28 (71.8)	
Intraplacental lacunae grade			
Grade 0-1	2 (7.7)	23 (59.0)	<0.001*
Grade 2-3	24 (92.3)	16 (41.0)	
Placenta Accreta Index (PAI) score			
Mean±SD	7.7±1.5	5.3±1.2	<0.001*

[Table/Fig-7]: Comparison of parameters between PAS and non-PAS groups.

In the present study, loss of the retroplacental clear space was significantly associated with PAS. This finding was observed in 21 of 26 PAS cases, compared with only three of 39 non PAS cases, and the association was statistically significant (p-value <0.001). Loss of the retroplacental clear space demonstrated a sensitivity of 80.8% (21/26) and specificity of 92.3% (36/39), with a PPV of 87.5% and NPV of 87.8% [Table/Fig-8].

Gray-scale criterion	PAS present (n=26)	PAS absent (n=39)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	p-value
Loss of retroplacental clear space	21	3	80.8	92.3	87.5	87.8	<0.001

[Table/Fig-8]: Association between retroplacental clear space and placental invasion on greyscale ultrasound.

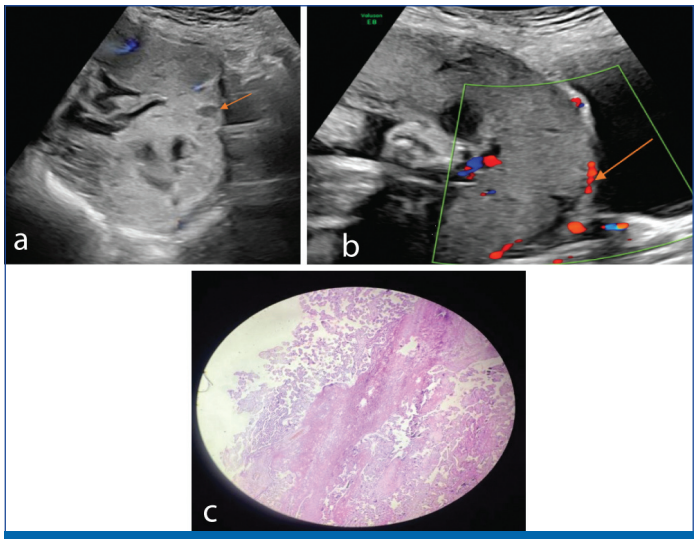
Bladder line interruption was observed in 10 of 26 PAS cases, while none of the 39 non PAS cases demonstrated this finding. The sign demonstrated low sensitivity at 38.5%, but exhibited perfect specificity at 100%, coupled with a PPV of 100% and a NPV of 70.9%. There was a statistically significant correlation between bladder line interruption and PAS (p <0.001).

Focal exophytic placental masses were observed exclusively in PAS cases (10/26) and were absent in all non PAS cases (0/39), yielding a specificity and PPV of 100%. However, the sensitivity was low (38.5%), indicating that although this finding is highly specific, it is infrequent. The NPV was 70.9%, with an overall diagnostic accuracy of 75.4%. The association between focal exophytic masses and PAS was found to be statistically significant (p-value <0.001) [Table/Fig-9].

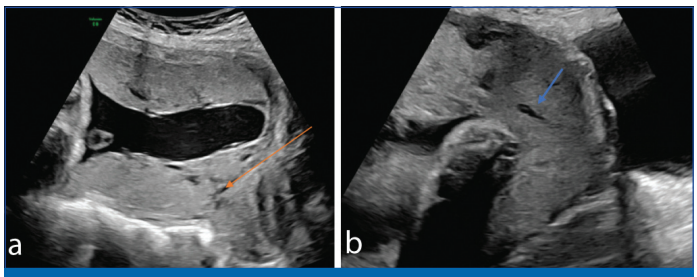
Sonographic feature	TP	FP	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	p-value
Focal exophytic masses	10	0	38.5	100	100	70.9	75.4	<0.001

[Table/Fig-9]: Distribution and diagnostic accuracy of focal exophytic placental masses for the detection of Placenta Accreta Spectrum (PAS).
TP: True positive; FP: False positive; FN: False negative; TN: True negative; PPV: Positive predictive value; NPV: Negative predictive value

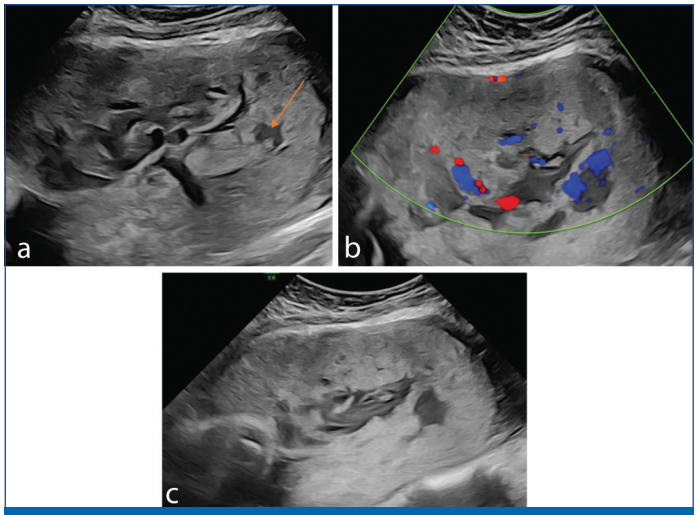
Representative cases demonstrating the spectrum of sonographic findings, including both PAS and non PAS cases are illustrated in [Table/Fig-10-12].



[Table/Fig-10]: Ultrasound images of a 40-year-old pregnant patient presenting with bleeding: (a) Greyscale image shows placenta covering the internal os with posterior extension along the left lateral wall and marked myometrial thinning in the lower uterine segment, indenting the urinary bladder (arrow); (b) Colour Doppler image demonstrates a bulky placenta with prominent vascular channels and bridging vessels (arrow); (c) Histopathological specimen (post-hysterectomy) confirming placenta increta. (Hematoxylin and Eosin stain, 10x).



[Table/Fig-11]: Ultrasound images of a 32-year-old pregnant patient: a) Greyscale image shows placenta covering the internal os (arrow) with few placental lakes (blue arrow) and no evidence of myometrial thinning; b) Corresponding image demonstrating absence of features suggestive of Placenta Accreta Spectrum (PAS).



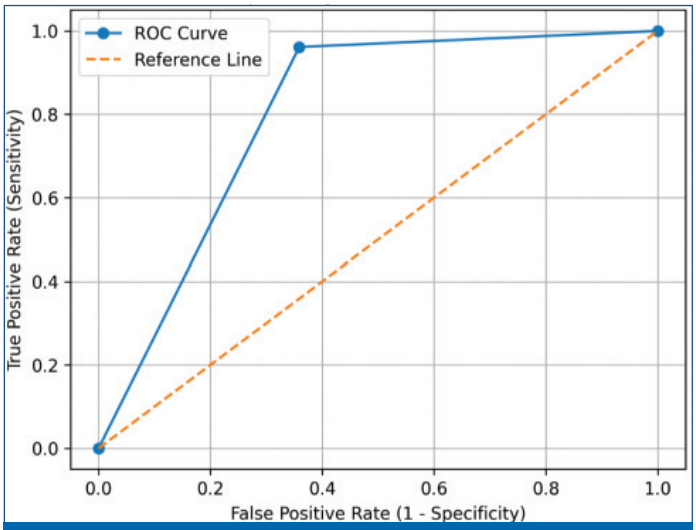
[Table/Fig-12]: Ultrasound images of a 26-year-old pregnant patient with complaints of bleeding: a) Greyscale image shows placenta covering the internal os with posterior extension along the left lateral wall and presence of placental lacunae (arrow); b) Colour Doppler image demonstrates a bulky placenta with prominent vascular channels (arrow), suggestive of abnormal placental invasion; c) Grey scale image shows heterogenous placenta covering internal os.

Among the confirmed PAS cases, 17 cases were confirmed histopathologically following hysterectomy, while nine cases were diagnosed based on intraoperative findings.

Ultrasonography demonstrated high diagnostic performance for detecting the PAS, with a sensitivity of 96.2% and a specificity of 89.7%. The PPV and NPV were 86.2% and 97.2%, respectively. The overall diagnostic accuracy of ultrasound in diagnosing PAS was 92.3%. The Area Under the ROC Curve (AUC) for ultrasonography in diagnosing PAS was 0.91, indicating excellent diagnostic performance [Table/Fig-13,14].

USG diagnosis	PAS present (Reference standard)	PAS Absent (Reference standard)	Total
PAS	25 (TP)	4 (FP)	29
Non PAS	1 (FN)	35 (TN)	36
Total	26	39	65

[Table/Fig-13]: USG diagnosis and final diagnosis.
(TP: True positive; FP: False positive; FN: False negative; TN: True negative)



[Table/Fig-14]: ROC curve.

DISCUSSION

In the present study, the majority of patients were between 30 and 40 years of age, reflecting the well-established association between advanced maternal age and abnormal placentation. Previous literature has consistently reported maternal age ≥35 years as an independent risk factor for PAS [10].

In the present study, placental accreta was more commonly observed in patients with a history of two previous caesarean sections (46.8%) than in those with one (10.0%). These findings were consistent with the classic study by Clark SL et al., in which out of 97,799 patients, 292 (0.3%) had a placenta previa [11]. The risk of placenta previa was 0.26% with an unscarred uterus and increased almost linearly with the number of prior caesarean sections to 10% in patients with four or more [11].

Comstock CH et al., reported that their evaluation involved 2002 patients over a 12-year period [12]. Of the 14 patients with a confirmed diagnosis of placenta accreta who had ultrasound examinations between 15 and 20 weeks of gestation, the diagnosis was strongly suspected in 86% of the patients (12/14 patients). There were 18 false-positive cases (54.5%; 18/33 patients), most of which were due to a lack of visualisation of the echolucent area between the placenta and the myometrium (obliteration of the 'clear space') during the third trimester [12].

In a meta-analysis by Pagani G et al., 20 studies (3209 pregnancies) were included. Ultrasound had an overall good diagnostic accuracy in identifying the depth of placental invasion with sensitivities of 90.6%, for placenta accreta, the corresponding specificities were 97.1%. Placental lacunae had sensitivities of 74.8%, 88.6%, and 76.3% for the detection of placenta accreta, increta, and percreta, respectively. Sensitivity and specificity of loss of the clear zone in identifying placenta accreta were 74.9% and 92.0%, whereas the corresponding figures for placenta increta and percreta were 91.6% and 76.9%, and 88.1% and 71.1% [13].

In a systematic review by Maged AM et al., the overall sensitivity was 0.8703, specificity was 0.8634. The estimates of the odds ratio, negative likelihood ratio, and positive likelihood ratio were 34.225, 0.155, and 4.990, respectively. The overall estimates of loss of retroplacental clear zone sensitivity and specificity were 0.820 and 0.898, respectively, with a negative correlation of 0.129. The overall estimates of myometrial thinning, loss of retroplacental clear zone, the presence of bridging vessels, placental lacunae, bladder wall interruption, exophytic mass, and uterovesical hypervascularity sensitivities were 0.763, 0.780, 0.659, 0.785, 0.455, 0.218, and 0.513, while specificities were 0.890, 0.884, 0.928, 0.809, 0.975, 0.865, and 0.994, respectively [14].

Limitation(s)

The limitation of this study was the absence of blinding the radiologist to clinical history, which may have introduced observer bias and influenced image interpretation. However, this reflects real-world clinical practice, where prior clinical information is often available at the time of ultrasound evaluation. The study was conducted in a high-risk referral population, which may limit generalisability to low-risk settings. Although all patients underwent ultrasound examination after 20 weeks of gestation, imaging was not performed at a standardised gestational age. This study does not particularly focus on changes in appearance of PAS depending on gestational age. The heterogeneous reference standard may have introduced verification bias, as histopathological confirmation was unavailable in all cases.

CONCLUSION(S)

This study confirms that ultrasonography is an exceptionally dependable primary imaging technique for diagnosing PAS in high-risk pregnancies before birth. Key predictors such as increasing number of prior caesarean sections, high lacunar grade, severe myometrial thinning, bridging vessels, and elevated PAI score significantly improve diagnostic confidence. Early and accurate identification of PAS using ultrasound enables optimal multidisciplinary planning and may substantially reduce maternal morbidity.

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- iThenticate Software: May 20, 2026 (14%)

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