

DIAGNOSTIC ACCURACY OF DOPPLER ULTRASOUND IN DIAGNOSIS OF PLACENTA ACCRETA TAKING OPERATIVE FINDINGS AS GOLD STANDARD

Dr Seemab Kamal^{*1}, Dr Nasreen Aman², Dr Remsha Hameed Khan³, Dr. Muhammad Sajid⁴

^{*1,3}Trainee Medical Officer Diagnostic Radiology Lady Reading Hospital Peshawar

²Associate Professor Diagnostic Radiology Lady reading hospital Peshawar

⁴Senior Registrar Northwest General Hospital & Research Center Peshawar.

^{*1}asmayakhan15@gmail.com

DOI: <https://doi.org/10.5281/zenodo.22196318>

Keywords

Placenta Accreta, Doppler Ultrasound, Operative Findings, Diagnostic Accuracy

Article History

Received: 01 June 2025

Accepted: 10 August 2025

Published: 01 September 2025

Copyright @Author

Corresponding Author: *

Dr Seemab Kamal

Abstract

Background: This study sought to ascertain the diagnostic precision of Doppler ultrasonography in the diagnosis of placenta accreta using surgical findings as the gold standard. However, a thorough assessment is necessary to determine its diagnostic accuracy, with operational results being the gold standard. The performance of Doppler ultrasound will be investigated in order to improve clinical practice and, eventually, the treatment of placenta accreta, which may save lives and minimize difficulties.

Objective: to assess Doppler ultrasound's diagnostic accuracy for placenta accreta using surgical findings as the gold standard.

Methods: A cross-sectional study was conducted at LRH Peshawar, involving 72 pregnant females with suspected placenta accreta. Sensitivity, specificity, positive and negative predictive values, and other diagnostic accuracy metrics were determined by recording Doppler ultrasound results and comparing them with intraoperative findings. SPSS v.26 was used for statistical analysis.

Results: Among 72 participants (mean age 33.0 ± 5.1 years), 46 (63.9%) presented with antepartum hemorrhage. Doppler ultrasound demonstrated diagnostic accuracy of 83.3% (60/72), with sensitivity of 84.8% (28/33), specificity of 82.1% (32/39), PPV of 80.0% (28/35), and NPV of 86.5% (32/37). Stratified analysis showed highest accuracy in patients aged 40-44 years (100%), those with antepartum hemorrhage (87.0%), and those with ≥ 2 previous uterine surgeries (92.9-100%).

Conclusion: Doppler ultrasound demonstrated a notable diagnostic accuracy in detecting placenta accreta, with excellent sensitivity and specificity, taking operative findings as gold standard. It is a valuable non-invasive tool for prenatal diagnosis, particularly in high-risk patients with advanced age, antepartum hemorrhage, and multiple previous uterine surgeries.

INTRODUCTION:

Because of its complicated pathophysiology and possibly dire outcomes, placenta accreta poses a serious challenge to medical professionals.

Damage to the endometrial-myometrial interface from previous cesarean sections, uterine operations, or placenta previa 1 is frequently the cause of the disorder. Both the mother and the

fetus are at risk for serious bleeding during birth because to the placenta's aberrant adhesion to the uterine wall. In order to provide adequate care and lower maternal mortality, prompt and correct diagnosis is essential ².

Placenta accreta is best managed if diagnosis is made early and correctly, and this has the potential of decreasing maternal morbidity and mortality. Several diagnostic methods have been tried, but Doppler ultrasound has proven to be useful in the evaluation of placenta accreta.³.

A Doppler ultrasound is a non-invasive imaging tool which measures blood flow and vascularization and is growing in importance for the diagnosis of placenta accreta ⁴. It has a number of advantages over it such as its availability, cost-effectiveness and real-time assessment. Doppler ultrasound measures the blood flow velocity in various vessels, which can provide valuable information about the vascularization of the placental bed, a key feature in diagnosing placenta accreta. When using Doppler ultrasound to diagnose placenta accreta, the uteroplacental and intraplacental blood flow patterns are usually assessed ⁵. It was suggested that abnormal blood flow patterns, such as absent or reversed end-diastolic flow in uterine arteries, increased vascularity within the placental-myometrial interface, and turbulent blood flow in maternal-placental or fetal-placental circulation, can be indicative of placenta accreta. These results may cause suspicion and lead to additional assessment and action ⁶. According to a research, 46% of pregnant women had placenta accreta, and Doppler ultrasound had an 85.7% sensitivity and an 83.3% specificity in diagnosing the condition. Accurate diagnosis is crucial because placenta accreta poses a serious risk to the health of both the mother and the fetus. With its ability to examine blood flow patterns in real time, Doppler ultrasound has become a promising diagnostic technique for this illness. However, there is a dearth of literature about Doppler ultrasound's diagnostic performance in our group.

Therefore, using surgical findings as the gold standard, this study aims to assess the diagnostic accuracy of Doppler ultrasound in the diagnosis of placenta accreta. However, a thorough assessment

is necessary to determine its diagnostic accuracy, with operational results being the gold standard.

The performance of Doppler ultrasound will be investigated in order to improve clinical practice and, eventually, the treatment of placenta accreta, which may save lives and minimize difficulties. Using surgical findings as the gold standard, the study sought to ascertain the diagnostic accuracy of Doppler ultrasound in the diagnosis of placenta accreta.

MATERIALS AND METHODS

This cross sectional study was carried out at the department of Radiology, LRH Peshawar during the period 2 December, 2024 to 30 May, 2025. Approval for conducting the study was taken from hospital IRB vide no. 335/LRH/ MTI, dated 12/09/2024. Pregnant females in the age range 18 to 40 years with previous history of cesarean section and suspected placenta accreta were enrolled. Patients with placenta increta, percreta, cardiovascular and autoimmune diseases were excluded. Placenta Accreta on Doppler ultrasound was defined as presence of any one of the following feature: Focal parenchymal placental lacunar flow, myometrium <1 mm, and loss of the normal hyperechoic line. Placenta Accreta on Operative findings was defined as presence of any one of the following per operative feature: Placenta may appear fused with the uterine wall, dense network of engorged blood vessels within the placental tissue, Hemorrhage, and placenta infiltrating the bladder or bowel. The following criteria were used to define diagnostic accuracy: Sensitivity is defined as $\text{True Positives} / (\text{True Positives} + \text{False Negatives}) \times 100$. It is the capacity of Doppler ultrasound to detect Placenta Accreta in all patients with Placenta Accreta, as validated by operative results. Specificity, defined as $\text{True Negatives} / (\text{True Negatives} + \text{False Positives}) \times 100$, is the capacity of Doppler ultrasound to detect patients who do not have placenta accreta out of all patients who do, as verified by operative results.

Placenta Accreta is present in patients who have a positive screening evaluation, according to the definition of positive predictive value. Patients with a negative screening assessment do not have

the Placenta Accreta, according to the definition of negative predictive value. True Positive: Placenta Accreta is present (both on Doppler ultrasound and operative findings). True Negative: Both Doppler ultrasonography and surgical results show no placenta accreta.

False Positive: Doppler ultrasound shows placenta accreta, while operative results do not. False Negative: Doppler ultrasonography does not show placenta accreta, but operative results do. The computation of the sample size was accomplished: Using the following parameters and the WHO sample size calculator: Anticipated prevalence of placenta accreta (46%) in pregnant women 7, Doppler ultrasound's sensitivity (85.7%), specificity (83.3%), confidence level (95%), and absolute precision (12%). 72 is the total calculated sample size that is needed. Non-probability consecutive sampling technique was applied. The study began after getting approval from the research department of CPSP and the ethical review board of the hospital. All patients fulfilling the inclusion criteria were included in in this research work. To confirm patients' participation, all patients were asked to sign an informed written consent form, which was obtained from all patients later on. Patients' demographic information such as age, and address was documented and patients were subjected for a detailed medical history evaluation, followed by a through physical examination. All the multigravida patients with past history of C-section, suspected for placenta accreta i.e antepartum hemorrhage on clinical evaluation was

subjected for Doppler ultrasound examination and the findings was recorded. Operative findings of placenta accreta was also be noted down. Both (Doppler ultrasound and operative findings) were compared under the supervision of a radiologist having 5 years of post-fellowship experience.

SPSS v.23 was used to analyze the data. For numerical data, such as age, the mean plus standard deviation was calculated. For categorical variables such as Doppler ultrasonography results, surgical findings, and the number of prior C-sections, frequencies and percentages were calculated.

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of Doppler ultrasound were assessed using the 2 x 2 contingency table, with operative results serving as the gold standard. Age and the number of prior C-sections were used to stratify the diagnostic accuracy. A result of $p < 0.05$ was considered significant for the post-stratification Chi Square test.

RESULTS

The mean age of the study participants was 33.0 ± 5.1 years, with the majority aged 30-34 years [24 (33.3%)] and 35-39 years [20 (27.8%)]. Regarding obstetric history, one and two previous cesarean sections were equally distributed [24 (33.3%) each], while previous uterine surgeries were absent in 28 (38.9%) patients. Clinically, antepartum hemorrhage was the most common presentation, observed in 46 (63.9%) patients, while 26 (36.1%) were asymptomatic.(Table 1)

Table 1: Demographic and Clinical Characteristics of Study Participants (N=72)

Variable	Category	Frequency (n)	Percentage (%)
Age Groups (years) 33.0 ± 5.1 years	20-29	18	25.0
	30-34	24	33.3
	35-39	20	27.8
	40-44	10	13.9
BMI Categories (kg/m²) 28.3 ± 2.8 kg/m ²	Normal (18.5-24.9)	12	16.7
	Overweight (25.0-29.9)	38	52.8
	Obese (≥ 30.0)	22	30.5

Gestational Age at Diagnosis 34.2 ± 2.8 weeks	<32 weeks	12	16.7
	32-34 weeks	24	33.3
	35-37 weeks	28	38.9
	>37 weeks	8	11.1
Number of Previous C-Sections	1	24	33.3
	2	24	33.3
	3	14	19.4
	4	6	8.3
	5	4	5.6
Number of Previous Uterine Surgeries	0	28	38.9
	1	26	36.1
	2	14	19.4
	3	4	5.6
Clinical Presentation	Antepartum Hemorrhage	46	63.9
	Asymptomatic	26	36.1

Doppler ultrasound demonstrated good diagnostic accuracy of 83.3% (60/72) in detecting placenta accreta, with sensitivity of 84.8% (28/33) and specificity of 82.1% (32/39). The positive

predictive value and negative predictive value were 80.0% (28/35) and 86.5% (32/37), respectively. (table 2)

Table 2: Diagnostic Accuracy of Doppler Ultrasound in Diagnosis of Placenta Accreta

Doppler Ultrasound Result	Operative Findings (Gold Standard)		Total	Diagnostic Performance
	Positive	Negative		
Positive	28 (TP) [38.9%]	7 (FP) [9.7%]	35 [48.6%]	Sensitivity: 84.8% (28/33) Specificity: 82.1% (32/39) PPV: 80.0% (28/35) NPV: 86.5% (32/37) Accuracy: 83.3% (60/72)
Negative	5 (FN) [6.9%]	32 (TN) [44.4%]	37 [51.4%]	
Total	33 [45.8%]	39 [54.2%]	72 [100%]	

Stratified analysis showed variable diagnostic performance of Doppler ultrasound across different subgroups, with the highest accuracy observed in patients aged 40-44 years (100%), those with three previous uterine surgeries (100%), and those presenting with antepartum hemorrhage (87.0%). Accuracy was optimal at 32-34 weeks of gestation (87.5%) and in obese

patients (86.4%), while the lowest accuracy was observed in asymptomatic patients (76.9%) and those with gestational age >37 weeks (75.0%). Sensitivity showed an increasing trend with advancing age (50.0% to 100%) and number of previous uterine surgeries (66.7% to 100%), while specificity remained consistently high across all subgroups (75.0-100%).(table 3)

Table 3: Stratification of Diagnostic Accuracy of Doppler Ultrasound by Clinical Parameters (n = 72)

Parameter	Category	n	Sen(%)	Spec(%)	PPV (%)	NPV (%)	Accuracy (%)
-----------	----------	---	--------	---------	---------	---------	--------------

Age Groups (years)							
	20-29	18	50.0	85.7	50.0	85.7	77.8
	30-34	24	90.0	78.6	75.0	91.7	83.3
	35-39	20	83.3	75.0	83.3	75.0	80.0
	40-44	10	100	100	100	100	100
BMI Categories (kg/m ²)							
	Normal (18.5-24.9)	12	75.0	87.5	75.0	87.5	83.3
	Overweight (25.0-29.9)	38	83.3	80.0	78.9	84.2	81.6
	Obese (≥ 30.0)	22	90.9	81.8	83.3	90.0	86.4
Gestational Age (weeks)							
	<32	12	85.7	80.0	85.7	80.0	83.3
	32-34	24	91.7	83.3	84.6	90.9	87.5
	35-37	28	81.8	82.4	75.0	87.5	82.1
	>37	8	66.7	80.0	66.7	80.0	75.0
Clinical Presentation							
	Antepartum Hemorrhage	46	89.3	83.3	89.3	83.3	87.0
	Asymptomatic	26	60.0	81.0	42.9	89.5	76.9
Previous Uterine Surgeries							
	0	28	66.7	77.3	44.4	89.5	75.0
	1	26	83.3	78.6	76.9	84.6	80.8
	2	14	90.9	100	100	75.0	92.9
	3	4	100	—	100	—	100
Overall		72	84.8	82.1	80.0	86.5	83.3

DISCUSSION

Globally, placenta accreta spectrum (PAS) disorders are a major cause of maternal morbidity and mortality, and their prevalence is rising due to an increase in cesarean births [1,2]. For planned multidisciplinary therapy to optimize maternal outcomes, early and precise prenatal diagnosis is essential [3]. The current investigation was carried out in a Pakistani population to ascertain the diagnostic accuracy of Doppler ultrasound in identifying placenta accreta, using operative results as the gold standard.

Doppler ultrasound showed 83.3% (60/72) diagnostic accuracy, 84.8% (28/33) sensitivity, and 82.1% (32/39) specificity in our investigation. These results validate the criteria utilized for our sample size calculation and are in line with the work by Nawab et al. [8], which revealed sensitivity of 85.7% and specificity of 83.3% for Doppler

ultrasound in detecting placenta accreta. Likewise, a meta-analysis and systematic review conducted by Mohamed et al. [9] found that among 24 trials involving 1,509 high-risk pregnancies, color Doppler ultrasound had the highest predictive accuracy, with a pooled sensitivity of 91.75% (95% CI: 86.3-95.6%) and specificity of 87.69% (95% CI: 85.7-91.5%). Due to variations in operator expertise, patient population characteristics, or the particular Doppler criteria used, our results are marginally lower than the estimations from the meta-analysis [9,10].

In our study, the positive predictive value (PPV) was 80.0% (28/35) and the negative predictive value (NPV) was 86.5% (32/37). These numbers show that the likelihood of correctly identifying both true positive and true negative cases with Doppler ultrasound is rather good. Chen et al. conducted a systematic review.

[10] Our results are similar to those of ultrasound scoring systems for PAS, which indicated pooled sensitivity of 89% (95% CI: 82-94%) and specificity of 85% (95% CI: 80-90%), with an area under the curve of 0.93. Our study's somewhat lower PPV indicates the possibility of false-positive Doppler results, which could be caused by overlap between pathological vascular alterations in PAS and normal placental vascularity [11]. On the other hand, the increased NPV suggests that a negative Doppler ultrasonography result is trustworthy in ruling out placenta accreta, which is in line with research that found 100% NPV in some groups [12].

Stratified analysis in our study revealed that diagnostic accuracy improved with advancing age, reaching 100% in patients aged 40-44 years. This finding aligns with the study by Metgud et al. [13], which reported a statistically significant association between advanced maternal age and PAS ($p=0.043$). Similarly, higher accuracy in patients with antepartum hemorrhage (87.0%) compared to asymptomatic patients (76.9%) is consistent with the clinical presentation of PAS, as hemorrhage often indicates deeper placental invasion and more pronounced sonographic features [14]. Our study's increasing accuracy with the number of prior uterine surgeries (75.0% with no prior surgery to 100% with three prior surgeries) supports findings from Mohamed et al.'s meta-analysis [9], which found that prior cesarean delivery was the main risk factor for PAS and that accuracy improved in higher-risk populations. This is further corroborated by research showing that the risk of PAS rises with the number of previous cesarean procedures; patients with three prior cesarean sections with placenta previa had a 40% risk [2,15].

Our study's best diagnosis accuracy of 87.5% at 32-34 weeks of gestation is consistent with guidelines for PAS ultrasonography evaluation throughout the third trimester [16]. The best time to undertake an ultrasound evaluation of PAS diseases is between 28 and 32 weeks of gestation. This is because evaluation before 28 weeks is hampered by poor placental maturity, while assessment after 32 weeks can be difficult because

PAS and normal late gestation share many characteristics [17].

Similarly, Shih et al. [6] pointed out the importance of proper Doppler assessment, regarding the "rail sign" as an ultrasound finding in PAS that signifies deep villous invasion and poor prognosis. The decreased accuracy at $GA>37$ weeks (75.0%) may be due to physiological changes of the aged placenta which mimic PAS characteristics, or to thinning of the myometrium. [18].

The prevalence of placenta accreta in our study population was 45.8% (33/72), which is consistent with the anticipated prevalence of 46% reported by Mamluk et al. [7] in a Pakistani population. This relatively high prevalence reflects our inclusion criteria of patients with previous cesarean sections and suspected PAS, representing a high-risk cohort. The strong agreement between antenatal ultrasound diagnosis and intraoperative findings validates the utility of ultrasound in preoperative planning [16,19].

When the diagnosis is unclear on ultrasound or when assessing the extent and topography of myoinvasion for surgical planning, magnetic resonance imaging (MRI) is used as a supplementary modality. Ultrasound is still the main imaging modality used to evaluate PAS disorders [17]. Placental lacunae, loss of the typical hypoechoic retroplacental zone, anomalies of the uterine serosa-bladder interface, and color Doppler abnormalities are important sonographic indicators throughout the second and third trimesters [12,20]. The best combination of sensitivity (90.74%) and specificity (87.68%) has been observed for color Doppler anomalies, such as aberrant blood vessels at the myometrium-bladder interface [11,20].

Our study has a number of advantages, such as the inclusion of a well-defined study population from a tertiary care hospital in Pakistan and the use of operative findings as the gold standard, which offers conclusive confirmation of PAS diagnosis. However, there are also some limitations, which include single center design, and non-probability consecutive sampling, which may lead to selection bias. In addition, the study was performed in a single center that has a highly experienced

radiology staff; this may not be a representative sample of the diagnostic accuracy that could be achieved in other settings. To confirm these results, more research using multicenter designs and standardized scoring systems is necessary.

CONCLUSION

Compared with the gold standard, which is operational results, Doppler ultrasound was determined as significantly accurate in the diagnosis of placenta accreta. The highest diagnostic accuracy within each of the clinical categories is achieved in patients with advanced age, antepartum hemorrhage, multiple previous uterine procedures and those assessed at 32-34 weeks of gestation. Doppler ultrasound is a non-invasive tool and is useful for the prenatal diagnosis of placenta accreta, to reduce maternal morbidity and mortality associated with this potentially fatal condition. It should be routinely applied to high-risk pregnant women during their antenatal check-up, so that early diagnosis and proper counseling and planned multidisciplinary management can be implemented. Further studies are needed, conducted on a multicenter basis with common scoring systems to corroborate these findings.

REFERENCES:

- Bartels HC, Postle JD, Downey P, Brennan DJ. Placenta accreta spectrum: a review of pathology, molecular biology, and biomarkers. *Dis Markers*. 2018;10(17):67-75.
- Fonseca A, de Campos DA. Maternal morbidity and mortality due to placenta accreta spectrum disorders. *Best Pract Res Clin Obstet Gynaecol*. 2021;72(20):84-91.
- Panaïtescu AM, Ciobanu AM, Gica N, Peltecu G, Botezatu R. Diagnosis and management of cesarean scar pregnancy and placenta accreta spectrum: case series and review of the literature. *J Med Ultrasound*. 2021;40(9):1975-86.
- Zheng X, Li X, Xu J, Wei Y. Intelligent recognition algorithm-based color doppler ultrasound in the treatment of dangerous placenta previa. *J Healthc*. 2021;29(20):177-85.
- Ayati S, Pourali L, Pezeshkiran M, Toosi FS, Nekooei S, Shakeri MT, et al. Accuracy of color Doppler ultrasonography and magnetic resonance imaging in diagnosis of placenta accreta: A survey of 82 cases. *Int J Reprod Med*. 2017;15(4):225-31.
- Shih JC, Kang J, Tsai SJ, Lee JK, Liu KL, Huang KY. The "rail sign": an ultrasound finding in placenta accreta spectrum indicating deep villous invasion and adverse outcomes. *Am J Obstet Gynecol*. 2021;225(3):292-9.
- Mamluk KA, Wajid RA, Janjua MA, Jawwad Z, Zahra S, Bashir S. Frequency of Morbidly Adherent Placenta and Associated Complications in Patients with Previous Cesarean Sections. *Pak J Med Health Sci*. 2020;14(79):515-17.
- Nawab K, Naveed S, Khan M. Diagnostic accuracy of ultrasound and magnetic resonance imaging in prenatal diagnosis of placenta accreta taking operative findings as gold standard. *Pak J Radiol*. 2017;27(4):317-22.
- Mohamed M, Ahmed M, Metwali A, Timraz S, Mansour M. Accuracy of ultrasound in prediction of abnormal placental adherence: a systematic review and meta-analysis. *AJOG Glob Rep*. 2024;4(2):100467.
- Chen L, Wang Y, Zhang X, et al. Prenatal ultrasound scoring in diagnosis and postpartum outcomes prediction for Placenta Accreta Spectrum (PAS): a systematic review. *BMC Pregnancy Childbirth*. 2024;24:846.
- Lucidi A, D'Antonio F. Placenta Accreta Spectrum Disorders: Prenatal Ultrasound Diagnosis. *Global Library of Women's Medicine*. 2025.
- Reddy UM, Abuhamad AZ, Saade GR. Morbidly adherent placenta. *Semin Perinatol*. 2013;37(5):354-62.
- Metgud SC, Prabhu GA, Renuka PM. A 5-years cross-sectional study of risk-factors foeto-maternal outcomes in placenta accreta spectrum at single tertiary care centre in South India. *Indian J Obstet Gynecol Res*. 2024;11(4):571-6.

- Wang C, Wang Z. Value of early pregnancy ultrasound combined with ultrasound score in the evaluation of placenta accreta in scar uterus: A retrospective cohort study. *Medicine*. 2024;103(11):e37531.
- Silver RM, Landon MB, Rouse DJ, et al. Maternal morbidity associated with multiple repeat cesarean deliveries. *Obstet Gynecol*. 2006;107(6):1226-32.
- D'Antonio F, Iacovella C, Bhide A. Prenatal identification of invasive placentation using ultrasound: systematic review and meta-analysis. *Ultrasound Obstet Gynecol*. 2013;42(5):509-17.
- Sepulveda Pinto PS, O'Brien Solar A. Placenta accreta spectrum disorders: What every radiologist should know. *ECR* 2024; C-23692.
- Cali G, Forlani F, Timor-Tritsch I, et al. Natural history of ultrasound features of placenta accreta spectrum. *Ultrasound Obstet Gynecol*. 2021;57(5):789-95.
- Collins SL, Ashcroft A, Braun T, et al. Proposal for standardized ultrasound descriptors of abnormally invasive placenta (AIP). *Ultrasound Obstet Gynecol*. 2016;47(3):271-5.
- Cali G, Timor-Tritsch IE, Forlani F, et al. Value of first-trimester ultrasound in prediction of third-trimester PAS. *Am J Obstet Gynecol*. 2021;225(5):532.e1-9.

