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" Efficacy Of 3D-Ultrasound In Detecting Morbidly Adherent Placenta "

Authors

Mohamed Taha Beheiry [1], Waleed Elsayed Elrefaie [2], Ebrahim Arafa [3] , Bedour Saied Mohamed Abdelghany [4]

[1] obstetrics and gynecology department faculty of medicine port said university

[2] Professor of Obstetrics & gynecology Department, Faculty of Medicine, Port Said University

[3] Faculty of medicine Port said university

[4] Lecturer of Obstetrics & gynecology Department, Faculty of Medicine, Port-Said University, Egypt

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ABSTRACT:

Background: Placenta Accreta Spectrum (PAS) is a life-threatening obstetric condition characterized by abnormal adherence or invasion of the placenta into the uterine wall. Early and accurate prenatal diagnosis is crucial to reduce maternal and neonatal morbidity and mortality. This study aimed to evaluate the diagnostic efficacy of three-dimensional (3D) ultrasound 3DUS in detecting PAS and its subtypes in pregnant women at ≥28 weeks of gestation.

Methods: A cross-sectional study was conducted at Kasr Al-Ainy Obstetrics and Gynecology Hospital, Cairo University, involving 35 pregnant women with a gestational age of 28 weeks or more who were clinically suspected to have morbidly adherent placenta. Inclusion criteria encompassed cases with placenta previa and suspected PAS between 28–40 weeks of gestation.

Detailed maternal history, including age, gravidity, parity, previous cesarean sections (CS), uterine surgeries (e.g., myomectomy, Dilation & Curettage D&C), and medical background, was recorded. All participants underwent standardized 3D US examination. PAS diagnosis was based on established sonographic criteria, AlAlfy criteria. The Alalfy criteria , integrating 3D power Doppler and tomographic imaging, was applied. Participants were followed until delivery, and intraoperative findings were documented for comparison. Diagnostic performance metrics (sensitivity, specificity, PPV, NPV, and accuracy) were calculated for overall PAS detection and for each subtype. Surgical management (conservative vs. hysterectomy) and maternal complications (e.g., hemorrhage, bladder injury, preterm delivery) were also analyzed.

Results: Among the 35 participants, 21 (60%) had confirmed PAS intraoperatively (12 accreta, 7 increta, 2 percreta). 3D US showed a sensitivity of 100%, specificity of 92.9%, PPV of 95.5%, and NPV of 100% for diagnosing overall PAS, with an accuracy of 97.1%. For subtype detection, the highest diagnostic performance was observed in detecting percreta (sensitivity, specificity, PPV, and NPV all 100%), followed by increta (accuracy 97.1%) and accreta (accuracy 94%). Conservative management was possible in 27 cases, while 8 underwent cesarean hysterectomy. Preterm labor occurred in 12 cases, and urinary bladder injury was noted in 10 patients.

Conclusion: 3D US demonstrates high diagnostic accuracy in detecting PAS and differentiating its subtypes, offering a reliable, non-invasive modality for preoperative assessment. Its routine application in high-risk pregnancies can guide surgical planning, reduce emergency interventions, and improve maternal and neonatal outcomes.

Keywords: Placenta Accreta Spectrum, 3D US, Prenatal Diagnosis, Cesarean Hysterectomy, Maternal Morbidity, Diagnostic Accuracy, Obstetric Imaging

Introduction

PAS represents a group of serious obstetric conditions characterized by abnormal adherence or invasion of placental villi into or beyond the myometrium. It encompasses three main subtypes: placenta accreta (villi adhere to the myometrium), placenta increta (villi invade into the myometrium), and placenta percreta (villi penetrate through the uterine serosa and may involve surrounding organs such as the bladder). The increasing incidence of PAS has become a significant concern in obstetrics, closely linked to the rising global rates of CS and uterine surgeries, including myomectomy and dilation and curettage **(Bhide et al., 2020).**

Early and accurate prenatal diagnosis of PAS is crucial. Undiagnosed or misdiagnosed cases may result in catastrophic complications, including massive obstetric hemorrhage, uterine rupture, multiorgan injury, or maternal death. The first opportunity to suspect PAS often occurs during routine mid-trimester or third-trimester obstetric ultrasounds, particularly in women with placenta previa or prior uterine surgery. A history of one or more cesarean sections combined with anterior or central placenta previa should raise a strong suspicion for PAS, and targeted imaging is recommended starting as early as 18–24 weeks of gestation in such high-risk cases **(Jauniaux & Bhide, 2021)**. However, the diagnosis may be refined or confirmed later in the third trimester using advanced imaging modalities.

Management of PAS is multifaceted and depends on several factors, including the type and severity of PAS, the gestational age at diagnosis, the woman's reproductive desires, and the resources available at the treating facility. In most cases, planned cesarean hysterectomy between 34–36 weeks gestation is considered the safest approach, particularly in cases of increta or percreta. This strategy reduces the risk of hemorrhage, emergency hysterectomy, and maternal death. Conservative approaches, including leaving the placenta in situ or using uterine-sparing techniques, may be considered in selected cases such as focal accreta, hemodynamic stability, and strong desire for future fertility. However, conservative management carries risks of delayed hemorrhage, infection, and potential need for subsequent hysterectomy **(Shamshirsaz et al., 2022).**

The diagnostic modalities for PAS have evolved significantly. Traditionally, two-dimensional (2D) transabdominal and transvaginal US have been the mainstay of PAS screening. Key grayscale signs include loss of the retroplacental clear zone, placental lacunae, myometrial thinning (<1 mm), and bladder wall interruption. Color Doppler enhances the assessment by revealing turbulent blood flow and bridging vessels between the placenta and bladder or uterine wall. Despite its widespread use, 2D US has limitations in delineating the depth and vascular architecture of abnormal placental invasion, especially in complex cases such as posterior placenta or previous uterine surgeries **(Collins et al., 2019).**

In recent years, three-dimensional 3D US and 3D power Doppler have emerged as superior diagnostic tools. These modalities provide enhanced spatial resolution, allowing for multiplanar assessment of placental architecture and vascular invasion. The use of 3D techniques has been associated with increased sensitivity and specificity in PAS detection. The "Alalfy criteria," a scoring system based on 3D power Doppler findings such as chaotic vascularity, bridging vessels, and myometrial interruption, has shown high diagnostic accuracy in differentiating accreta subtypes **(Alalfy et al., 2021)**. Furthermore, 3D tomographic ultrasound imaging (TUI) enables detailed visualization of placental invasion planes and has been increasingly incorporated into high-risk obstetric assessments.

Magnetic resonance imaging (MRI) is also used as a complementary tool, particularly in cases where US is inconclusive or where posterior placentation obscures the view. MRI provides excellent soft tissue contrast and is particularly useful in mapping percreta invasion into surrounding structures. However, it is more expensive, less accessible in low-resource settings, and typically reserved for selected cases or preoperative planning **(Zhou et al., 2023).**

Recent research has also explored the integration of artificial intelligence and machine learning in the interpretation of PAS imaging. These technologies show promise in improving diagnostic accuracy, minimizing inter-observer variability, and enabling early, non-invasive prediction models. However, their clinical application remains in developmental stages and requires further validation before routine adoption **(Zhou et al., 2023).**

In summary, PAS is a life-threatening condition that necessitates early recognition and individualized management. The diagnostic approach should be tailored based on clinical risk factors and imaging findings. Advanced imaging technologies such as 3D US have demonstrated substantial potential in enhancing prenatal diagnostic accuracy. This study aims to evaluate the efficacy of 3D US in identifying PAS in pregnant women at high risk, comparing its predictive performance with intraoperative findings, and assessing associated maternal and neonatal outcomes.

Patients and Methods

This cross-sectional study was conducted at Kasr Al-Ainy Obstetrics and Gynecology Hospital, Cairo University, involving 35 pregnant women with suspected PAS disorders at ≥28 weeks' gestation. Participants were recruited via convenience sampling from emergency, inpatient, and antenatal care settings. Inclusion criteria included women aged 18–40 years with clinical or sonographic suspicion of PAS, typically in association with placenta previa. Exclusion criteria were fundal placental location, PPROM, or refusal of transvaginal US.

Each participant had detailed history-taking, physical examination, and 3D US imaging using the Voluson E10 BT21 device With Low-frequency probe (with 1.0-5.0 MHz) were used for for good visualization of the deep structures like placenta and fetal parts.

. US assessment included 3D tomographic imaging and power Doppler based on the Alalfy criteria for PAS diagnosis. Key sonographic features assessed included placental lacunae, loss of clear zone, myometrial thinning, bridging vessels, and bladder wall invasion. Findings were categorized into non-adherent, accreta, increta, or percreta.
All patients were followed through delivery, and intraoperative findings served as the diagnostic gold standard. Management (conservative vs. hysterectomy) and maternal/neonatal outcomes were recorded. Data were analyzed using SPSS v24. Sensitivity, specificity, PPV, NPV, and diagnostic accuracy were calculated. The study was ethically approved, and informed consent was obtained from all participants.

Results:

1. Sociodemographic Data

Table 1: Age Distribution of Participants

Age Group (Years)	Number of Participants	Percentage (%)
15–20	2	5.7%
20–30	12	34.3%
30–40	17	48.6%
>40	4	11.4%
Total	**35**	**100%**

Most participants (48.6%) were aged 30–40, aligning with the increased PAS risk in advanced maternal age.

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2. Surgical History and Risk Factors

Table 2: Number of Cesarean Sections (CS) and PAS Incidence

Number of CS	Total Cases	PAS Cases	PAS Percentage (%)
Fresh Abdomen	2	0	0%
Previous 1 CS	3	1	33%
Previous 2 CS	5	3	60%
Previous 3 CS	9	5	55.6%
Previous ≥4 CS	16	12	75%

Risk of PAS increased significantly with the number of previous CS . 75% of women with ≥4 CS developed PAS.

Additional Surgical Risk Factors:

- **Myomectomy:** 6 patients had prior myomectomy; 4 developed PAS (66.7%).
- **D&C:** 21 had previous D&C; 16 developed PAS (76.2%).

Both myomectomy and D&C were strongly associated with PAS development, likely due to uterine scarring.

In the following table we present the summery of surgical risk factors and type of placenta

Statistical Associations

- **Number of Previous CS:** Strong positive association with PAS (**ρ = 0.90, p = 0.037**).
- **Myomectomy:** No significant association with PAS (**p = 1.0**).
- **D&C:** Significant association with PAS (**OR = 5.76, p = 0.033**).

Table 3: surgical isk factors of PAS summery

Number of CS	myomectomy	D&C	PAS	Details
Fresh abdomen **2**	1	1	0	PAS alone = 0
				PAS with myomectomy = 0
				PAS with D&C = 0
				PAS with both = 0
Prev 1Cs **3**	0	1	1	PAS alone = 0
				PAS with myomectomy = 0
				PAS with D&C = 1
				PAS with both = 0
Prev 2Cs **5**	1	2	3	PAS alone = 1
				PAS with myomectomy = 1
				PAS with D&C = 2
				PAS with both =1
Prev 3Cs **9**	2	5	5	PAS alone =
				PAS with myomectomy = 2
				PAS with D&C = 3

				PAS with both = 2
Prev 4 Cs or more **16**	2	12	12	PAS alone = 0
				PAS with myomectomy = 1
				PAS with D&C = 10
				PAS with both = 1

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3. **3D US Prediction vs. Intraoperative Findings**

Table 4: 3D US Predicted Placental Invasion

Type	Number	Percentage (%)
Non-adherent Placenta	13	37.1%
Placenta Accreta	12	34.3%
Placenta Increta	8	22.9%
Placenta Percreta	2	5.7%

Table 5: Intraoperative Placental Findings

Type	Number	Percentage (%)
Non-adherent Placenta	14	40%
Placenta Accreta	12	34.3%
Placenta Increta	7	20%
Placenta Percreta	2	5.7%

There was close alignment between 3D US predictions and surgical findings, particularly in Increta and Percreta.

Diagnostic Accuracy Metrics for Each Type:

- **Accreta:** Sensitivity 91.7%, Specificity 95.7%, PPV 91.7%, NPV 95.7%, Accuracy 94%.
- **Increta:** Sensitivity 100%, Specificity 96.4%, PPV 87.5%, NPV 100%, Accuracy 97.1%.
- **Percreta:** All metrics 100%.

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4. **Overall PAS Prediction (PAS vs. Non-PAS)**

Table 6: 3D US Predicted PAS vs. Actual Findings

	Actual PAS (21)	Actual Non-PAS (14)	Total
Predicted PAS (22)	21 (TP)	1 (FP)	22
Predicted Non-PAS (13)	0 (FN)	13 (TN)	13
Total	**21**	**14**	**35**

High diagnostic accuracy of 3D US in distinguishing PAS from non-PAS: Sensitivity 100%, Specificity 92.9%, PPV 95.5%, NPV 100%, Accuracy 97.1%

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5. **Management Outcomes**

Table 7: Conservative Management vs. Hysterectomy

Type of Placenta	Conservative	Hysterectomy
Non-adherent	13	1
Placenta Accreta	5	7
Placenta Increta	0	7
Placenta Percreta	0	2
Total	**18**	**17**

All increta and percreta cases had been undergone hysterectomy, while non-adherent and some accreta cases were conservatively managed based on stability and surgical judgment.

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6. Complications

A. Preterm Labor

Table 8: Preterm Labor Incidence

Type of Placenta	Preterm Cases
Non-adherent	3
PAS	9

Preterm labor was more frequent in PAS cases due to the need for early termination related to hemorrhagic risk.

B. Antepartum Hemorrhage Table 9: Antepartum Hemorrhage Cases

Type of Placenta	Hemorrhage Cases
Non-adherent	9
PAS	17

Antepartum hemorrhage was common in both groups, slightly more pronounced in PAS patients.

C. Postpartum Hemorrhage (PPH) Table 10: PPH Cases

Type of Placenta	PPH Cases
Non-adherent	3
Accreta	1
Increta/Percreta	0

Most PPH occurred in conservatively managed non-adherent or accreta cases; hysterectomy likely reduced risk in increta/percreta.

D. Bladder Injury Table 10: Bladder Injury Cases

Type of Placenta	Cases
Non-adherent	1
Accreta	4
Increta	3
Percreta	2

Bladder injury rates were highest in deeper invasion types, consistent with surgical complexity.

Discussion

This study assessed the diagnostic performance of three-dimensional 3D US in detecting PAS disorders among pregnant women beyond 28 weeks of gestation at Kasr Al-Ainy Hospital. Our findings affirm that 3D US is a valuable modality with high diagnostic accuracy for differentiating between placenta accreta, increta, and percreta. These results are consistent with recent literature underscoring the utility of advanced imaging modalities in the timely identification of abnormal placental invasion **(Jauniaux et al., 2020; D'Antonio et al., 2021).**

In our sample, the sensitivity and specificity of 3D US in diagnosing PAS types were found to be high, with optimal detection of placenta percreta. The volumetric imaging capability and multi-planar reconstruction inherent to 3D US provided enhanced visualization of placental architecture, uterine serosa, and adjacent structures, aiding in more accurate preoperative diagnosis. This aligns with previous findings suggesting that 3D US may outperform conventional 2D US in specific diagnostic scenarios, especially in assessing the depth of myometrial invasion and the disruption of the uterine-bladder interface **(Zhao et al., 2022).**

The study demonstrated that early antenatal suspicion based on previous cesarean sections, placenta previa, and anterior low-lying placenta should prompt detailed 3D evaluation. In our study, patients with a history of two or more cesarean deliveries and concurrent placenta previa had a markedly higher incidence of PAS, particularly placenta increta and percreta. This corroborates current understanding that cumulative uterine trauma significantly predisposes patients to abnormal placentation **(Silver & Branch, 2020).**

Management outcomes varied based on the severity of PAS. Conservative management was successful in some accreta and a few increta cases, but percreta necessitated hysterectomy in most patients. These findings support the individualized approach to PAS management, as endorsed by recent guidelines **(Collins et al., 2021).** Importantly, the role of accurate antenatal imaging cannot be overstated, as it enables optimal multidisciplinary planning, reduces intraoperative blood loss, and improves maternal outcomes.

Notably, we encountered complications such as preterm labor, hemorrhage, and bladder injury. These were more frequent in percreta cases, emphasizing the importance of distinguishing the degree of invasion antenatally. Similar trends have been observed in recent studies that highlight bladder wall disruption and excessive intraoperative bleeding as major risks in undiagnosed percreta **(Jauniaux & Bhide, 2021).**

While 3D US showed excellent diagnostic performance, MRI was not routinely employed in our study, which may have limited comparative analysis. However, recent meta-analyses suggest that in experienced hands, 3D US may be nearly equivalent to MRI in assessing PAS severity, particularly in resource-limited settings (Bhide et al., 2023). Furthermore, 3D power Doppler imaging offers additional insights into abnormal vascularity, aiding in diagnosis, although its utility may be limited by operator dependency and fetal position **(D'Antonio et al., 2020).**

One of the main strengths of our study is its focus on 3D US as a standalone modality in a real-world tertiary care context. However, limitations include the small sample size and the single-center nature, which may restrict generalizability. Future multicenter studies with larger populations and standardized imaging protocols are warranted to validate these findings and explore the potential of 3D imaging in risk stratification and surgical planning.

In conclusion, 3D US demonstrates high diagnostic accuracy in detecting PAS and can effectively guide clinical decision-making. Its integration into routine screening protocols, especially for high-risk patients, may significantly improve maternal and fetal outcomes through timely diagnosis and tailored management strategies.

Conclusion

PAS is a life-threatening obstetric condition that requires timely diagnosis and careful management to reduce maternal morbidity and mortality. This study demonstrated that three-dimensional 3D US is a highly effective, non-invasive imaging modality for the prenatal identification of PAS, particularly in high-risk pregnancies beyond 28 weeks of gestation. The enhanced spatial resolution and vascular assessment provided by 3D US allowed accurate differentiation between accreta, increta, and percreta subtypes, with diagnostic findings correlating strongly with intraoperative outcomes.

Our findings highlight the value of incorporating 3D US into routine screening for women with known risk factors such as previous cesarean sections and placenta previa. Early and precise diagnosis through advanced imaging facilitates multidisciplinary planning, optimizes delivery timing, and helps minimize complications such as hemorrhage, bladder injury, and the need for emergency hysterectomy. While further large-scale, multicenter studies are warranted, this research supports the integration of 3D US as a cornerstone in the diagnostic workup and management planning for PAS.

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