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Research Article

Comparing the Efficacy of Two-Dimensional Ultrasound and Three-Dimensional Power Doppler for Diagnosing Placenta Accreta Spectrum Disorders and Predicting Complications: A Prospective Cross-Sectional Study.

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Abstract

Background: Placenta accreta spectrum (PAS) issue has become a noteworthy dangerous obstetrical issue because of its expanded rate from 0.12 to 0.31% in the last 30 years and the detailed death of roughly 7.0%. **Objectives:** To compare between the two-dimensional ultrasound and three-dimensional power Doppler for diagnosis of Placenta accrete spectrum disorders and prediction of its complications. **Patients and methods:** This were a prospective cross sectional single-institute study carried out on 86 patients suspected to have PAS-disorders by Two-dimensional ultrasound 2D US and color Doppler during ANC at Obstetrics and Gynecology department, Minia maternity University Hospital from July 2021 to July 2022. **Results:** There was highly statistically significant difference as regards histopathology findings of 2D US (MAP, Non-MAP and Total) P<0. 001. VI, FI, and VFI were significantly higher among patients with MAP compared to patients without P<0. 001. The 2D US sensitivity was 87.3%, specificity was 90.3%, NPV was 80% and PPV was 94.1% with accuracy of 88.4% in diagnosis of MAP. 70.9% of the patients suffered from hemorrhage, 6.9% suffered from bladder injury, 10.5% reported preterm birth, and 3.5% suffered from bowel injury. **Conclusion:** 3D power Doppler can be used as a complementary technique to 2D ultrasound for confirmation of the diagnosis of placental invasion owing to its high sensitivity.

Keywords: Two-dimensional ultrasound, three-dimensional power Doppler, Placenta accrete spectrum disorders

Introduction

Placenta accreta spectrum (PAS) has emerged as a significant and concerning obstetric complication. Over the past three decades, its prevalence has escalated from 0.12% to 0.31%, rendering it a growing concern. Additionally, the reported mortality rate associated with PAS stands at approximately 7.0%.(1)

The initial imaging method of choice for detecting placenta accreta spectrum disorders (PAS) during pregnancy is typically two-dimensional ultrasound assessment. This involves using both transabdominal and transvaginal approaches, along with gray scale and color Doppler imaging (CDI). Recognized sonographic indicators of PAS include the absence of a typical separation between the uterus and placenta (known as the clear zone), significant thinning of the underlying myometrium, as well as vascular alterations within the placenta (referred to as lagoons) and the region where the placenta attaches to the uterine wall (known as placental bed hypervascularization).(2)

The utilization of three-dimensional (3D) power Doppler ultrasound has emerged as a

ground-breaking approach for studying the vascularization of tissues and organs. By employing this technique, researchers can virtually reconstruct the vascular network within a specific region of interest. Through the aid of specialized VOCAL (Virtual Organ Computer Aided Analysis) TM software, they can then quantitatively evaluate the vascularization within that area by calculating specific indices. This allows for a more objective assessment of vascularization compared to traditional methods.[3]

The objective and non-invasive measurement of vascularization in a specific volume of tissue offers considerable potential, especially considering its demonstrated high reproducibility between different observers. This advantage addresses a key drawback of traditional Doppler ultrasound methods, thereby enhancing the reliability and utility of this approach.[4]

The objective of this study was to evaluate and compare the diagnostic capabilities of two-dimensional ultrasound and three-dimensional power Doppler in detecting Placenta accrete spectrum disorders and predicting associated complications.

Patients and Methods

This prospective cross-sectional study was conducted at the Obstetrics and Gynecology department of Minia Maternity University Hospital from July 2021 to July 2022. The study included 86 patients who were suspected to have Placenta accrete spectrum disorders (PAS-disorders) based on two-dimensional ultrasound (2D US) and color Doppler imaging during antenatal care.

To be eligible for inclusion, patients had to have a confirmed diagnosis of PAS-disorders during antenatal care using ultrasound and a history of one or more previous cesarean sections. Patients with medical conditions such as bleeding disorders, hypertension, diabetes mellitus, lethal fetal anomalies, or requiring emergency surgery were excluded from the study. All enrolled patients underwent both 2D gray scale ultrasound and three-dimensional power Doppler imaging. Subsequently, the patients were routinely monitored and were admitted for surgery based on local protocols. Patients who choose to withdraw from the study were excluded from further analysis.

Ethical consideration

The study protocol was approved preliminarily by the Local Ethical Committee at Minia Faculty of Medicine. Before enrollment, the study protocol was discussed in detail with the study participants, and those accepted to participate in the study signed written fully informed consents.

Methods

All patients underwent the following procedures: gathering their medical history, which included information about the mother's age, number of previous pregnancies, and any past surgeries on the uterus. The gestational age was determined based on the first day of the mother's last menstrual period, and in cases where uncertainty existed, ultrasound was used. A comprehensive examination of the patient's overall health and specifically their reproductive health was conducted. During surgery, the surgeons were responsible for evaluating the condition of the placenta, determining if it was accreta, increta, percreta, or none of these, and noting whether it was focal, partial, or total in cases of adhesive placenta. In instances of placenta percreta, any invasion of the bladder was documented, as well as the specific operative procedure used. All ultrasound scans were performed by experienced sonographers. Any measurements taken prior to termination of the pregnancy and all procedures were carried out by a team of healthcare professionals from different disciplines.

Scan technique

Certified sonographers in the US utilized the GE E8 device from Hatfield, UK to conduct examinations. The initial abdominal ultrasound was conducted with a full bladder to assess signs of placental invasion. Various techniques such as gray scale, color Doppler, power Doppler, and 3D power Doppler were employed. Transabdominal 2D ultrasound using gray scale, color, and power Doppler techniques was used to further evaluate specific sonographic criteria and record the findings for each patient. These criteria included fetal

biometry for estimating gestational age and fetal weight, determining placental location (anterior, posterior, or lateral), absence of a hypoechoic zone behind the placenta, presence of four or more placental lacunae, and myometrial thickness less than 1 mm. 2D US and color Doppler were used to examine vascularization at the placental bladder interface and count the number of bridging vessels between the placenta and bladder serosa. 3D power Doppler was utilized to investigate intraplacental hypervascularity, tortuous vascularity with "chaotic branching," and vessels involving the serosa-bladder interface in the basal view. The analysis of angioarchitecture in the lower uterine segment and placenta was conducted using 3D power Doppler specifically focused on this area. 3D volumes were obtained through automated sweeps using a motorized curved-array transducer while the women held their breath.

We assessed two perspectives: the lateral view, which allowed us to observe the intraplacental vasculature and serosa-bladder complex along the sagittal axis of the mother's pelvis, and the basal view, which displayed the serosa-bladder interface with a 90° rotation of the lateral view, observed from the bladder's direction. The scanning of the placental vascular tree was conducted using 3D static power Doppler, with a scanning angle of 85°, high image quality, and Speckle Reduction Imaging II3, while ensuring there were no fetal or maternal movements. Only the entire scanned placenta was included in the study. The 3D power Doppler volume histogram program automatically calculated the values of vascularization index (VI), flow index (FI), and vascular flow index (VFI) within the obtained volume. The final diagnosis of MAP was determined based on the examination of the hysterectomy specimen by a perinatal pathologist, which involved identifying the presence of accreta, increta, or percreta. All biopsies were fixed in 4% formaldehyde in PBS and embedded in paraffin. Paraffin sections that were 4 mm thick were placed on glass slides coated with aminopropyl triethoxysilane (Tespa) from Messmikroskope, Germany.

Preparations before the surgery

- A complete blood count (CBC) was done prior to the operation.
- Preoperative measures included ensuring that at least 4 units of packed red blood cells were cross-matched.
- The patient and her family were informed about the possibility of a cesarean section hysterectomy, and written consent, both for high-risk situations and hysterectomy, was obtained.
- Two large-bore venous accesses were required.
- Experienced obstetricians and anesthesiologists were involved in the procedure.

Postoperative findings

- A CBC was conducted after the surgery.
- Any complications such as bleeding, bladder or bowel injury, or disseminated intravascular coagulation (DIC) were documented.
- The type of delivery, whether conservative or radical surgery, was recorded.
- The length of the hospital stay was noted.

Statistical analysis

The results were analyzed using SPSS software program (IBM, Ver. 22, 2020, USA) by One-way ANOVA and Chi-square tests. Correlation analysis was applied to evaluate the relation between the presence of PD and its complications as independent variate and constitutional and lab data. The area under the curve (AUC) was compared to the area under the reference line to evaluate the significance of the AUC as predictor at 0.05 as a cutoff point for differentiation. This sample size calculated according to previous study El Gelany et al., the incidence of placenta previa is 0.9%. using the sample size equation at 2% precision, the required sample size is 86 cases.[5]

Results

The age of the patients in the study ranged from 24 to 42 years, with a mean age of 31.86 ± 5.48 years. The mean body mass index (BMI) was 26.78 ± 3.5 kg/m2. The number of previous cesarean sections (CS) varied from 2 to 5, and the gestational age ranged from 30 to 38 weeks, with a mean gestational age of 34.69 ± 2.54

weeks. The patients had a mean parity of 2.56 ± 1.2 and a mean gravidity of 3.76 ± 1.57.

In terms of diagnosis, 51 patients were identified as having morbidly adherent placenta (MAP) based on the criteria observed from 2D ultrasound findings. Among them, 48 patients were confirmed to have MAP through histopathological examination. However, in the remaining 3 patients, two experienced easy separation of the placenta during cesarean delivery, and the other patient underwent hysterectomy due to bleeding, yet histopathological examination did not provide evidence of MAP. This resulted in a false positive rate of 9.7%.

The ages of the patients were between 24 and 42 with mean age of 31.86 ± 5.48 years, meanwhile mean BMI is 26.78 ± 3.5 kg/m2, the mean parity of patients was 2.56 ± 1.2, and mean gravidity was 3.76 ± 1.57. The number of previous CS ranged from 2 – 5. (Table 1)

Table (1): Demographic characteristics of the studied patients.

	Patients (n=86)	
	Mean ± SD	Range
Age (years)	31.86 ± 5.48	24 – 42
BMI (kg/m^2)	26.78 ± 3.5	21 – 32
No. of previous CS	2.92 ± 0.898	2 – 5
GA (weeks)	34.69 ± 2.54	30 – 38
Parity (Mean ± SD)	2.56 ± 1.2	2-6
Gravidity (Mean ± SD)	3.76 ± 1.57	2-11

CS: Caesarean section GA: Gestational age BMI: Body mass index

33.7% of the patients had accreta, 22.1% had increta, 8.1% had percreta and 36.1% had non-MAP. (Table 2)

Table (2): PAS distribution among the patients according to histopathology findings.

	Patients (n=86)	
	N	**%**
Non-MAP	31	36.1%
Accreta	29	33.7%
Increta	19	22.1%
Percreta	7	8.1%

Non-MAP: Non-Morbid adherent placenta

There was highly statistically significant difference as regards histopathology findings of 2D US (MAP, Non-MAP and Total) P<0.001. (Table 3)

Table (3): Comparison of 2D US findings according to histopathology findings.

2D	**Histopathology findings**				**Total**	**P**
	MAP		**Non-MAP** (Normal separation or histopathology)			
	N	**%**	**N**	**%**		
MAP	48	87.3%	3	9.7%	51 (59.3%)	**<0.001**
Non-MAP	7	12.7%	28	90.3%	35 (40.7%)	
Total	55	100%	31	100%		

MAP: Morbid adherent placenta

This table showed that VI, FI, and VFI were significantly higher among patients with MAP compared to patients without P<0.001. (Table 4)

Table (4): 3D Power Doppler vascular indices distribution of the studied patients according to presence of MAP.

	Non-MAP (n=31)	MAP (n=55)	P
Vascularization index (VI) Mean ± SD	21.78 ± 5.71	34.3 ± 2.13	**<0.001**
Flow index (FI) Mean ± SD	40.45 ± 1.89	44.85 ± 0.980	**<0.001**
Vascularization flow index (VFI) Mean ± SD	10.82 ± 3.8	17.65 ± 1.2	**<0.001**

The 2D US sensitivity was 87.3%, specificity was 90.3%, NPV was 80% and PPV was 94.1% with accuracy of 88.4% in diagnosis of MAP. (Table 5)

Table (5): Diagnostic value of 2D US.

Statistic	Value	95% CI
AUC	.888	0.802 – 0.946
Sensitivity	87.27%	75.52% - 94.73%
Specificity	90.32%	74.25% - 97.96%
Positive Predictive Value (PPV)	94.12%	84.45% - 97.92%
Negative Predictive Value (NPV)	80%	66.48% - 88.97%
Accuracy	88.37%	79.65% - 94.28%

AUC: Area under curve

The VI sensitivity was 96.5%, specificity was 93.3%, NPV was 88.2% and PPV was 92.8% with accuracy of 95.4% in diagnosis of MAP. (Table 6)

Table (6): Diagnostic value of VI ≥ 18.

Statistic	Value	95% CI
AUC	.890	0.802 -.907
Sensitivity	96.50%	87.47% - 99.56%
Specificity	93.30%	78.58% - 99.21%
Positive Predictive Value (PPV)	92.8%	87.39% - 99.02%
Negative Predictive Value (NPV)	88.2%	78.76% - 98.27%
Accuracy	95.35%	88.52% - 98.72%

This table showed that 70.9% of the patients suffered from hemorrhage, 6.9% suffered from bladder injury, 10.5% reported preterm birth, and 3.5% suffered from bowel injury. (Figure 1) (Table 7).

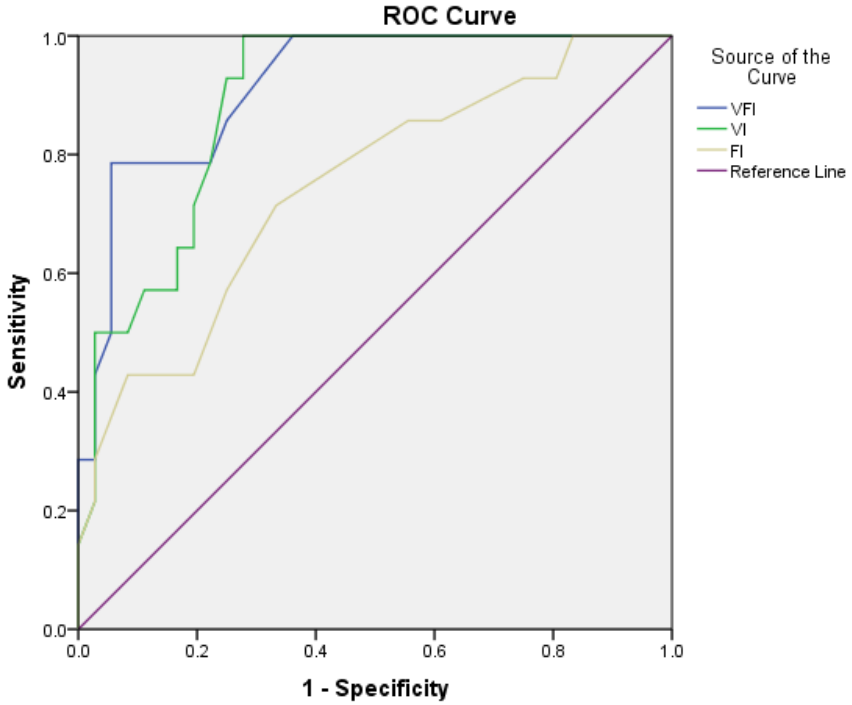

Figure (1): ROC curve for 3D Doppler indices as a diagnostic for PAS.

Table (7): Complications distribution among the patients.

	Patients (n=86)	
	N	%
Hemorrhage	61	70.9%
Bowel injury	3	3.5%
Bladder injury	6	6.9%
Preterm birth	9	10.5%

Discussion

The findings of our study indicated that the age of the patients ranged from 24 to 42 years, with an average age of 31.86 ± 5.48 years. The mean body mass index (BMI) was 26.78 ± 3.5 kg/m2. The number of previous cesarean sections (CS) varied from 2 to 5, and the gestational age ranged from 30 to 38 weeks, with an average gestational age of 34.69 ± 2.54 weeks. The patients had an average parity of 2.56 ± 1.2 and an average gravidity of 3.76 ± 1.57.

In terms of diagnosis, our results revealed that 51 patients were identified as having morbidly adherent placenta (MAP) based on the criteria observed from 2D ultrasound findings. Among them, 48 patients were confirmed to have MAP through histopathological examination. However, in the remaining 3 patients, two experienced easy separation of the placenta during cesarean delivery, and the other patient underwent hysterectomy due to bleeding, yet the histopathological examination did not provide evidence of MAP. This resulted in a false positive rate of 9.7%.

Furthermore, 35 patients were diagnosed as non-MAP according to the criteria observed in 2D ultrasound findings. Among them, 7 patients were identified as having MAP through histopathological examination, while the placenta separated easily during cesarean delivery in the remaining 28 patients. A significant difference was observed when comparing 2D ultrasound findings with histopathological examination results.

Our findings demonstrated that the sensitivity of 2D ultrasound (US) in diagnosing morbidly

adherent placenta (MAP) was 87.3%, with a specificity of 90.3%. The negative predictive value (NPV) was 80%, and the positive predictive value (PPV) was 94.1%. The overall accuracy of 2D US in diagnosing MAP was 88.4% [6-9].

Regarding 2D US parameters, our results align with Haidar et al., [6] who reported a sensitivity of 82.6%, specificity of 88.9%, PPV of 85.5%, and NPV of 85% in the diagnosis of MAP. Another study by Antonio et al. (7) reported a sensitivity of 77.43% and specificity of 95.02% for detecting placenta accreta using 2D US. Cali et al., [8] found a sensitivity of 73%, specificity of 86%, PPV of 60%, and NPV of 90% in their study. Shih et al., [9] reported a sensitivity rate of 74% for the presence of four or more lacunae.

Additionally, our results indicated that the distribution of 3D power Doppler vascular indices among the patients studied correlated with the histopathological diagnosis of MAP. There was no statistically significant difference observed concerning the flow index (FI); however, there were statistically significant differences regarding the vascularization index (VI) and vascularization flow index (VFI).

Our findings contradict the study conducted by Firmansha et al., where they utilized a cross-sectional design and included 34 women clinically diagnosed with PAS. They observed that the FI value was significant (p=0.015) when comparing vascular indices to the gross pathological appearance. Additionally, the FI value increased as the PAS grading progressed from accreta to increta and percreta. However, their study did not find any statistically significant difference regarding the Vascularization index (VI) and Vascularization flow index (VFI), possibly due to the small sample size of only 34 patients. Interestingly, we observed a significant increase in FI values as placental invasion increased based on gross pathological features (p=0.015), whereas this relationship was not observed in the other two vasculature indices. Macroscopically, we found lower FI values in cases of shallower placental invasion, aligning with the histopathology results that showed higher FI values in percreta compared to increta, in contrast to the other indices.[10]

Our findings indicated that the distribution of 3D Doppler indices among the patients studied correlated with the presence of MAP. Patients with MAP had significantly higher values of VI, FI, and VFI compared to patients without MAP.

These results are consistent with the findings of Abdel-Hamid et al. who categorized the patients into two groups (group A and group B) based on the collected data: patients without MAP (group A) and patients with MAP (group B). When comparing the 3D Doppler indices between pregnancies with MAP and those without, they found that the mean values of VI and VFI were significantly higher in the confirmed MAP group ($p<0.001$ for both). However, their results disagreed with ours regarding the FI values, as they found similar FI values in both groups (p=0.181) [11].

Our findings demonstrated that the distribution of 3D Power Doppler vascular indices among the patients studied correlated with their histopathological diagnosis. There was no statistically significant difference observed in relation to the Flow index (FI); however, there were statistically significant differences noted concerning the Vascularization index (VI) and Vascularization flow index (VFI).

These outcomes contradict the findings of Firmansha et al., who conducted a cross-sectional study involving 34 clinically diagnosed women with PAS. They compared the vascular indices to the gross pathological appearance and found that the FI value was significant (p=0.015).

The FI value also increased as the PAS grading progressed from accreta to increta and percreta. However, in their results, there was no statistically significant difference observed in relation to the Vascularization index (VI) and Vascularization flow index (VFI). This discrepancy may be because their study had a small sample size of only 34 patients enrolled. Notably, our results revealed a significant increase in FI values with further placental invasion based on gross pathological features (p=0.015), while such a relationship was not observed in the other two vasculature indices. Macroscopically, a lower FI value was found in cases of shallower placental invasion.

In line with this finding, the histopathology results also demonstrated a higher FI value in percreta compared to increta, unlike the other indices [10].

Furthermore, our results indicated that the 2D ultrasound criteria for diagnosing MAP, including Retroplacental Myometrial thickness, Placenta lacunae, and bladder-serosa interface hypervascularity, had a sensitivity and specificity of 78.18% and 83.87%, 87.9% and 83.87%, and 83.3% and 87.1%, respectively. Additionally, the 3D power doppler criteria, specifically vascular bridging, exhibited higher sensitivity and specificity of 90.91% and 84.2%, respectively, in the diagnosis of MAP compared to the 2D ultrasound criteria.

Our findings align with the results reported by **Abdelhamid et al.** in the diagnosis of MAP. They found that a myometrial thickness of less than 1mm had a sensitivity of 79%, specificity of 60%, positive predictive value (PPV) of 77.7%, and negative predictive value (NPV) of 63.8%. Additionally, having more than 4 lacunae had a sensitivity of 67.7%, specificity of 77.7%, PPV of 56.5%, and NPV of 66%.

The presence of vascularity between the placenta and uterus had a sensitivity of 74%, specificity of 81.5%, PPV of 86.7%, and NPV of 65.9%. However, when using 3D ultrasound parameters for predicting placenta accreta, intraplacental hypervascularity had a sensitivity of 96.6%, specificity of 81%, PPV of 89%, and NPV of 93%. Torturous vascularity had a sensitivity of 88.7%, specificity of 78.9%, PPV of 87%, and NPV of 81%. These findings support the notion that 3D power doppler can serve as a valuable diagnostic tool and is superior to 2D ultrasound [12].

Our findings indicated that the diagnostic accuracy of a VI ≥ 18 was 96.5% sensitivity and 93.3% specificity, which outperformed 2D ultrasound (87.27% and 90.32% respectively) in detecting MAP. This aligns with the results of Abdelhamid et al., who found that a 3D Doppler VI ≥ 16 could predict MAP with 100% sensitivity and 100% specificity, surpassing the performance of 2D ultrasound (60.0% and 89.1% respectively). In addition, severe MAP occurred in 51.2% of cases, and a 3D Doppler VI > 33.1 predicted this severity with 73.9% sensitivity and 86.4% specificity, which was again superior to 2D ultrasound.[12]

Regarding complications, 70.9% of patients experienced hemorrhage, 6.9% had bladder injury, 10.5% reported preterm birth, and 3.5% suffered from bowel injury. In terms of bladder injuries, our study found only 6 cases, which was lower than the rate reported by Abdelhamid et al., this decrease in bladder injury rate can be attributed to a change in bladder dissection technique [12].

Conclusion

The use of 3D Doppler ultrasound is more precise compared to 2D ultrasound for diagnosing placenta accreta and determining the level of attachment based on postpartum histopathology and intraoperative results. Additionally, 3D power Doppler can serve as a supplementary method to 2D ultrasound, offering confirmation of placental invasion diagnosis due to its high sensitivity.

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