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## Diagnostic accuracy of ultrasound and magnetic resonance (MRI) in prenatal diagnosis of abnormal placentation: An observational study

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### Abstract:

**Introduction:** One of the most prevalent causes of antepartum bleeding is placenta praevia (PP), an obstetric disease characterized by placental placement at or above the internal cervical ultrasound (US) (20 mm).

**Aim of the study:** To assess the role of US and magnetic resonance imaging (MRI) in the diagnosis of abnormal placentation in women with placenta previa.

**Subjects and Methods:** Fifty pregnant women aged 18-40 who presented with placenta previa and suspected placenta accreta were recruited. All patients underwent abdominal and pelvic US and MRI for placental assessment between 34-37 weeks of gestational age prior to elective delivery.

**Results:** 26 cases were diagnosed with placenta previa accompanied by accreta, while 24 cases had placenta previa without abnormal placentation. US suggested a diagnosis of placenta previa/accreta in 25 patients and placenta previa without accreta in 25 cases. Among these, 20 cases were true positive (80%) and five were false positive (20%), resulting in a sensitivity of 76.9% and a specificity of 79.2%. MRI suggested a diagnosis of placenta previa/accreta in 33 patients and placenta previa without accreta in 17 cases. MRI demonstrated true positive results in 25 out of 33 patients who were confirmed to have accreta. MRI showed true negative results in 16 patients (94.1%) yielding a sensitivity of 96.2% and a specificity of 66.7%.

**Conclusions:** MRI has shown increased sensitivity, while ultrasound has demonstrated increased specificity in diagnosing placenta previa and placenta accreta. More studies are required to confirm these findings.

**Keywords:** Ultrasound; Magnetic Resonance Imaging; Placenta Previa; Placenta Accreta.

## 1. Introduction

Placenta previa (PP) is a high-risk obstetric condition characterized by the placement of the placenta near or over the internal cervical os, with a distance less than 20mm [1]. It is a common cause of antepartum hemorrhage [2]. Placenta accreta (PA) is a general term used to describe abnormal placental attachment, which refers to the relationship between the chorionic villi and the uterine wall [3]. It includes three subtypes: placenta accreta, where the chorionic villi are in contact with the myometrium; placenta increta, where there is abnormal penetration of the chorionic villi into the myometrium; and placenta percreta, which involves the complete invasion of the myometrium into the uterine serosa [3].

The risk factors for the development of placenta accreta include previous delivery by caesarean section, placenta previa, and advanced maternal age [4]. Among these factors, prior caesarean section is considered the most significant predisposing factor for placenta previa and, subsequently, placenta accreta [5]. Placenta previa and previous uterine interventions also play an important role in the occurrence of placenta accreta [6].

The major morbidity associated with this abnormal placentation primarily arises from significant blood loss during delivery, often requiring a longer maternal hospital stay and

blood transfusion [7]. Additionally, pregnancies complicated by placenta accreta are believed to be associated with an increased incidence of complications such as cystotomy (injury to the urinary bladder), ureteral injury, pulmonary embolism, the need for ventilator use, reoperation, and admission to the intensive care unit (ICU) [8]. Early diagnosis of placenta accreta is crucial because, in most cases, antepartum hemorrhage occurs. Therefore, it is essential to have adequate pre-operative planning to ensure appropriate management.

The definitive diagnosis of placenta previa and placenta accreta is typically made using ultrasound [9]. During the routine anomaly scan in the second trimester, the location of the placenta is usually reported. If the placental edge is found to be reaching or overlapping the internal cervical orifice, a follow-up scan in the third trimester should be scheduled to confirm this finding and plan the management of delivery [10]. Ultrasound can provide important information about the site of the placenta, such as whether it is bulging or ballooning. It can also reveal signs of placental adherence, including the loss of a clear zone (the retroplacental zone in the myometrium), thinning of the myometrium to less than 1mm or undetectable levels, the presence of large, numerous sonolucent placental lacunae, a placental bulge, abnormal retroplacental

vascularity, and/or interruption of bladder wall integrity. These ultrasound findings help in diagnosing and assessing the severity of placenta previa and placenta accreta, guiding appropriate management and delivery planning [11].

Magnetic resonance imaging (MRI) of the placenta is becoming increasingly important in preoperative planning for placenta previa and accreta [12]. MRI features have been identified as indicative of abnormal invasive placenta

(AIP), and overall, placental MRI has shown good predictive accuracy in detecting AIP. These MRI signs may include one or more of the following: uterine bulge, placental bulge, myometrial thinning or interruption, and abnormal vascularity [13].

The purpose of our observational study was to evaluate the role of ultrasound (US) and magnetic resonance imaging (MRI) in the diagnostic accuracy of abnormal placentation in women with placenta previa.

## **2. Subjects and methods**

### ***2.1. Subjects***

This prospective observational study enrolled fifty pregnant women who were diagnosed with placenta previa in their third trimester. The study took place at the Department of Obstetrics and Gynecology at El-Fayoum University Hospital from November 2018 to January 2020. The patients were examined between 34 and 37 gestational weeks, following approval from the ethical committee. Prior to initiating any study procedures, eligible women who agreed to participate provided written informed consent.

#### ***Inclusion criteria***

They were pregnant women aged 18–40 years old, diagnosed with placenta previa, low-lying placenta, or antepartum hemorrhage, and those who had a previous history of caesarean section (CS) or uterine surgery.

#### ***Exclusion criteria***

Patients with a history of bleeding problems, intake of anticoagulants, or antepartum hemorrhage prior to 24 gestational weeks were excluded from the study.

### ***2.2. Methods***

The classification of placenta previa, including low-lying, marginal, complete, and central types, was determined by assessing the position of the placenta in relation to the internal cervical OS.

Detailed history was taken from the participants, including personal history (name, age, address, occupation, and any habits), current pregnancy history (date of last menstrual period, history of antepartum hemorrhage, previous ultrasound scanning, laboratory investigations, and intake of any medications), menstrual history (regularity and date of last menstrual cycle), obstetric history (gravidity, parity, mode of delivery, number of living offspring, abortions and mode of their termination, and any other obstetric complications), and surgical history, especially previous CS, myomectomy, or endometrial curettage. Proper general, abdominal, and pelvic examinations were done, followed by laboratory investigations in the form of a complete blood count, kidney and liver functions, coagulation profile, and urine analysis. All of the patients were subjected to both ultrasound (US) and magnetic resonance imaging (MRI) of the pelvis prior to elective delivery.

### ***Ultrasound scan***

In this study, placental evaluation was performed using a combination of transabdominal and transvaginal scans, along with color and pulsed-wave Doppler imaging. During the transabdominal scan, the bladder volume was adjusted to ensure clear visualization of the serosa-bladder interface, which aided in better visualization of newly formed vessels in the vesico-placental interface. The imaging was conducted using a GE Voluson 730 ultrasound machine equipped with a 3.5 MHz abdominal convex probe and a 7.5 MHz endo-vaginal probe. The scans were performed by an operator with over 10 years of experience in obstetric ultrasound. The ultrasound criteria used for diagnosing placenta previa included the following findings: (i) prominent or multiple placental lakes; (ii) absence or thinning of the hypoechoic myometrial zone behind the placenta to less than 2 mm; (iii) highly pulsatile venous flow patterns within the placental lacunae; (iv) increased vascularity at the interface between the uterine serosa and the urinary bladder wall; (v) focal disruption of the uterine serosa-bladder wall complex; and (vi) focal mass-like elevation of the placenta into the bladder. These specific ultrasound criteria were utilized to accurately diagnose placenta previa and assess its characteristics in the study population.

### ***Magnetic resonance imaging***

Magnetic resonance imaging (MRI) was conducted using a high-performance 1.5-T superconducting system (Signa HDxt 1.5 T; General Electric Healthcare, Milwaukee, WI, USA). To optimize the evaluation of the uterine wall, the women were instructed not to empty their bladders for 6 hours prior to the examination, resulting in a partially full bladder during the study. The use of a partially filled bladder with urine, providing bright T2-weighted image signals, improved the visualization of the uterine wall. Depending on the patient's size and gestational age, a 12-channel HD body array coil or body coil was used. The imaging protocol started with a 17-second localizer scan in the three orthogonal planes. Subsequent sequences were acquired in the axial, sagittal, and coronal planes to study the organ of interest, with each sequence serving as a scout for subsequent imaging. T2-weighted imaging was performed using a single-shot fast spin-echo sequence (SSFSE) in all orthogonal planes. In addition to diagnosing placenta previa, MRI signs for placenta accreta/percreta included: (a) heterogeneity in the signal pattern of the placenta; (b) uterine bulging; (c) focal interruptions in the myometrial wall; (d) dark T2-weighted intra-placental bands; (e) tenting of the bladder; and (f) placental tissue invading the pelvic structures. The MRI scans were evaluated

by a radiologist with 10 years of experience in placental MRI evaluation, and all images were interpreted in conjunction with the results of the ultrasound scans. No contrast medium was used during the MRI. The total scanning time was approximately 30 minutes.

### **2.3. Statistical analysis**

Data analysis was done using the Statistical Package of Social Science (SPSS) software version 18 on Windows 7. Simple descriptive analysis in the form of numbers and percentages for qualitative data, arithmetic means as central tendency measurement, and standard deviations as a measure of dispersion for quantitative parametric data. Quantitative data included in the study was first tested for normality by a one-sample Kolmogorov-Smirnov test in each study group, and inferential statistical tests were selected.

An independent student t-test was used to compare measures between two independent groups of quantitative data. A one-way ANOVA test was utilized in comparing more than two independent groups of quantitative data. When there are more than two groups, chi-square was used to analyze the qualitative data. Sensitivity and specificity tests were performed for testing a new test with the ROC curve "Receiver Operating Characteristic.

## **3. Results**

The average age of the research participants was  $30.8 \pm 4.9$ . Most of the included patients were multiparas and underwent previous uterine surgery. history of antepartum hemorrhage was absent in 34 patients (68%) and present in 16 patients (32%), as shown in **Table 1**

**Table 1:** Age description and frequency of different medical history among study group.

Parameters		(n=50)
Age (years)		30.8± 4.9
Medical history		
Parity	Nullipara	1 (2%)
	Multipara	49 (98%)
Previous uterine surgery	Negative	1 (2%)
	Positive	49 (98%)
History of antepartum hemorrhage	Absent	34 (68%)
	Present	16(32%)

It was observed in ultrasound findings that 50% of the cases had complete centralis placenta previa, while 8% showed incomplete centralis previa, and 42% showed marginal or lateral previa. Additionally, 52% of the cases had thinning of the myometrium, 64% had vascular lacunae, and 50% had accreta. In terms of intraoperative diagnosis, 52% of the cases were diagnosed with accreta, with 32% classified as focal type and 20% as total accreta (**Table 2**).

**Table 2:** Frequency of different ultrasound findings and operational accreta among study group.

Variables		US
Placental position	Previa marginal or lateral	21 (42%)
	Previa incomplete centralis	4 (8%)
	Previa complete centralis	25 (50%)
Myometrium thinning	Absent	24 (48%)
	Present	26 (52%)
Vascular lacunae	Absent	18 (36%)
	Present	32 (64%)
Accreta	Absent	25 (50%)
	Present	25 (50%)
Operational Accreta	Absent	24 (48%)
	Focal accreta	16 (32%)
	Total accreta	10 (20%)

In the MRI findings, it was observed that 66% of the cases had accreta, with 50% showing focal myometrial invasion and 16% displaying total accreta. Additionally, 66% of the cases had a myometrial bulge, and 8% showed bladder invasion, as shown in **Table 3**.

**Table 3:** Frequency of different MRI findings among study group.

Variables		MRI
Accreta	Absent	17 (34%)
	Focal accrete	25 (50%)
	Total accrete	8 (16%)
Myometrium bulge	Absent	17 (34%)
	Present	33 (66%)
Bladder invasion	Absent	46 (92%)
	Present	4 (8%)

Regarding the intraoperative diagnosis, 52% of the patients had an accreta, 32% had a focal type, and 20% had a total accreta. In cases of antepartum hemorrhage, a higher percentage (75%) did not show any accreta during intraoperative diagnosis. Statistical analysis revealed no significant difference between different intra-operative accreta findings in terms of mean age, parity, and previous uterine surgery ( $p < 0.05$ ). There is a statistically significant difference between different intra-operative accreta findings as regards findings of

both ultrasound and MRI, with 20% false positive in ultrasound versus 28% of focal and 12.5% of total accreta diagnosis by MRI ( $p < 0.05$ ), as shown in **Table 4**.

Sensitivity and specificity tests for ultrasound and MRI in comparison with the final intraoperative diagnosis illustrated that MRI is more sensitive than ultrasound in diagnosis with accreta, with sensitivity (96.2%) and specificity (66.7%) versus 76.9% and 79.2%, respectively, as shown in **Table 5**.

**Table 4:** Comparisons of ultrasound and MRI findings in different intra-operative diagnosis of accreta among study group.

Variables	Intraoperative Accreta			P-value	
	Absent	Focal	Total		
US	Absent	19 (76%)	5 (20%)	1 (4%)	<0.001
	Present	5 (20%)	11 (48%)	9 (36%)	
MRI	Absent	16 (94.1%)	1 (5.9%)	0 (0%)	<0.001
	Focal accreta	7 (28%)	14 (56%)	4 (16%)	
	Total accreta	1 (12.5%)	1 (12.5%)	6 (75%)	

Data are presented frequency (%).  $P < 0.005$  is significant.

**Table 5:** Sensitivity and specificity of ultra sound in comparison with intraoperative findings in diagnosis of accreta among study group.

Variable	Sensitivity	Specificity	+ve predictive test	-ve predictive test	AUC
US	76.9%	79.2%	80%	76%	78%
MRI	96.2%	66.7%	75.8%	94.1%	81.4%

US: ultrasound, MRI: Magnetic resonance imaging

## 4. Discussion

Placenta previa (PP) is a high-risk obstetric condition characterized by the placenta being located near or covering the internal cervical OS at a distance of less than 20mm. It is a common cause of antepartum hemorrhage [14]. Placenta Accreta Spectrum (PAS) is a term used to encompass both abnormal adherence and abnormal invasion of the placenta [15]. The global incidence of PP at term is increasing due to rising rates of caesarean sections. It is well-established that PP is associated with significant maternal morbidity and adverse perinatal outcomes [16]. This study found that advanced

maternal age is associated with a slight increase in the incidence of placenta previa and accreta. The cases in this study ranged in age from 21 to 40 years old, with a mean age of 30.8 years old. A study by Rosenberg et al. (2011) reported a similar mean age of incidence (30.4 years old) but with a narrower age range of 30 to 35 years old [17]. It is worth noting that this effect may be influenced by increased parity.

The incidence of abnormal invasion of the placenta (AIP) has been increasing globally, largely due to the rise in caesarean section rates and placenta previa [18]. In our study, it was



found that approximately 98% of placenta previa cases had a history of previous uterine surgery, such as caesarean section, myomectomy, or curettage. Furthermore, 52% of these cases were diagnosed with placental accretion, confirming the association between an abnormal placenta and uterine scarring. According to Marshall et al. [18], the incidence of placenta previa increases in parallel with the number of previous uterine surgeries, ranging from 10 in 1000 deliveries with one previous caesarean delivery to 28 in 1000 deliveries with three or more previous caesarean deliveries. The co-incidence of placenta previa and accreta was reported to be approximately 52.7%, with 32.7% having focal accreta and 20% having total invasion of the myometrium (total accreta). Another systematic review indicated that the incidence of accreta placentation ranges from 3.3–4.0% in women with placenta previa and no previous caesarean delivery, compared to 50–67% in women with three or more previous caesarean deliveries [19]. In a study conducted by Balachandar et al. (2020), it was found that the rate of placenta previa increased by 11% between 2007 and 2017, parallel to a 10.4% rise in the cesarean section rate [14].

Antepartum hemorrhage (APH) is defined as bleeding from the genital tract during the second half of pregnancy. It is a significant symptom of placenta previa and a major cause

of perinatal mortality and maternal morbidity, estimated to affect approximately 0.5% of all pregnancies [20]. Women with placenta previa are at a roughly 4-fold increased risk of experiencing second-trimester vaginal bleeding, and 20%–80% of placenta previa cases result in APH [20]. However, in our study, this percentage was found to be 34% of the study group.

Transvaginal ultrasound (TVS) improves the accuracy of placental localization, particularly in cases where the placenta is posterior or when transabdominal ultrasound (TAS) results are unclear [21]. In this study, ultrasound confirmed the diagnosis of accreta in 50% of patients who had myometrial thinning less than 2mm, with or without numerous venous lacunae in the placental-myometrium interface. MRI detected accreta in 66% of cases, based on findings such as myometrial bulging, the absence of intervening fat between the bladder and myometrium, and/or invasion of the urinary bladder. Among these cases, 50% were diagnosed as focal accreta and 16% as total accreta. It is reported that up to 50% of cases are suspected antenatally in the UK [22].

Ultrasound imaging is the most commonly used method for diagnosing disorders related to abnormal placental invasion prenatally. However, the terminology used to

describe different categories of ultrasound signs has been inconsistent and complex [23]. Additionally, most studies lack detailed histopathologic correlations, which may explain why no single ultrasound sign or combination of signs has been found to be specific for determining the depth of abnormal placentation and accurate for differentiating between adherent and invasive placentation [23]. In order to address this issue, the European Working Group on Abnormally Invasive Placentas (EWAIP) and the AIP international expert group have recently proposed a standardized description of ultrasound signs used in the diagnosis of disorders related to abnormal placental invasion [24].

The ultrasound signs of adherent and invasive placentation can vary depending on various factors such as gestational age, thickness and composition of the placental bed, the number of previous uterine scars and the presence of scar defects between pregnancies, the depth of invasion, and the lateral extension of the villous tissue [25, 26]. To improve the screening, diagnosis, and management of disorders related to abnormal placental invasion, it is crucial to conduct prospective studies that establish correlations between prenatal imaging findings, clinical data at delivery, and histopathology [26]. Research protocols should be standardized and utilized by both clinicians

and pathologists to better define the ultrasound signs that may be useful in screening women at high risk for these disorders [26].

The timing of a confirmatory ultrasound examination in the third trimester has varied between 32 and 36 weeks of gestation, depending on the extent of placenta previa over the internal cervical OS. This timing is based on the perceived risk of antenatal hemorrhage, but there is no strong evidence indicating that it significantly impacts the care of asymptomatic women [27]. When performed by skilled operators, ultrasound has shown excellent overall performance, with a sensitivity of 90.72% and a specificity of 96.94%. Among the various ultrasound signs, abnormality of the uterus-bladder interface demonstrated the highest specificity of 99.75% for predicting placenta accreta [28]. Abnormal vasculature on color Doppler imaging (CDI) had the best predictive accuracy, with a sensitivity of 90.74% and a specificity of 87.68% [28]. Ultrasound has proven to be highly sensitive and specific in detecting abnormal placental invasion in the third trimester, particularly in patients with a low anterior placenta and a history of previous caesarean sections. The prevalence of abnormal invasion of the placenta in these women has been reported to be as high as 1 in 5 [28].

A study conducted by Patru et al. (2019) demonstrated that ultrasound scans using various markers, particularly abnormal blood vessels at the myometrium-bladder interface and intra-placental lacunae, can accurately diagnose the presence of placenta accreta [29]. The study found that ultrasound identified placenta accreta in 23.9% of cases, compared to 26% diagnosed intraoperatively [29]. Additionally, our study revealed that ultrasound identified abnormal invasion of the placenta (AIP) in 50% of women with placenta previa, which was confirmed in 52% of cases intraoperatively. Comparatively, intraoperative diagnosis showed that ultrasound had a false positive rate of 20%, while MRI had a false positive rate of approximately 40%.

The main MRI features of placenta accreta include abnormal uterine bulging, dark intra-placental bands on T2-weighted imaging, heterogeneous signal intensity within the placenta, disorganized vasculature of the placenta, and disruption of the uteroplacental zone. The sensitivity and specificity of MRI in diagnosing placenta accreta can vary widely, ranging from 75% to 100% and 65% to 100%, respectively [30]. Comparing the sensitivity and specificity of ultrasound and MRI to the final intraoperative diagnosis, it was found that MRI is more sensitive than ultrasound in diagnosing placenta accreta. MRI demonstrated a sensitivity of 96.2% and a specificity of 66.7%, whereas

ultrasound had a sensitivity of 76.9% and a specificity of 79.2%.

An observational study concluded that the combination of MRI and ultrasound provides additional diagnostic information in imaging of placenta previa with suspected placenta accreta, which can potentially lead to reduced hospital stays and unnecessary interventions, ultimately resulting in a favorable outcome [31]. The same study found that MRI is more sensitive and specific than ultrasound in placenta accreta diagnosis, in which MRI showed a sensitivity of 72.73% and a specificity of 100%, while ultrasound demonstrated a sensitivity of 63.64% and a specificity of 91.67% [31]. A recent randomized trial analyzed the accuracy of diagnosis, different types of diseases, and the imaging characteristics of MRI and ultrasound in diagnosing placenta accreta and non-placenta accreta cases [32]. The findings of the trial indicated that MRI had higher diagnostic accuracy and sensitivity compared to ultrasound [32]. The MRI group also had a lower rate of missed diagnoses compared to the ultrasound group. Furthermore, the MRI group had a higher detection rate of central type, marginal type, and partial type cases compared to the ultrasound group [32]. There were notable differences in imaging characteristics between the two groups, including increased or thickened blood vessels

in the placenta, an uneven signal in the placenta, and an unclear boundary between the placenta and the uterus [32]. Another study concluded that both ultrasound and MRI are accurate imaging modalities for diagnosing abnormal placentation [33]. However, MRI was found to be more sensitive than ultrasound in detecting the degree of placental invasion. The presence of abnormal placentation increased the patient's morbidity. Additionally, this study showed that when the diagnosis was established using ultrasound or MRI, there was no significant difference in postoperative complications or hospitalization time due to pre-operative planning [33].

From 2000 to 2016, a total of 80 caesarean hysterectomies were performed. Out of these, 52 cases (68%) had a preoperative diagnosis of placenta accreta, while the remaining 16 cases (32%) were diagnosed intraoperatively during the caesarean delivery. Among the majority of patients (n = 38; 76%), there was a preoperative diagnosis of placenta previa and at least one prior caesarean delivery [34]. In the pathology report, 48 patients (96%) were confirmed to have placenta accreta, while 2 patients (4%) showed no evidence of invasion. This indicates an overall positive predictive

value of 96% for the clinical diagnosis, with a false-positive rate of 4% [34].

Prospective studies are required to evaluate the role of late ultrasound and Doppler in assessing the risks of hemorrhage and emergency caesarean sections in cases of an abnormally implanted placenta. These studies can also help determine the optimal time and mode of delivery. Large prospective population-based studies are needed to determine if ultrasound is a cost-effective tool for diagnosing placenta accreta spectrum in women with a history of one or more previous caesarean sections and who present with placenta previa in the second trimester of pregnancy. Comparative studies that involve ultrasound imaging, including ultrasound and MRI, are necessary to assess the diagnostic accuracy of evaluating the depth and topography of villous invasion in adjacent organs. Future studies focusing on the diagnosis and management of placenta accreta spectrum should adopt a standardized evidence-based approach. This includes systematically correlating ultrasound signs with detailed clinical diagnoses at delivery and, whenever possible, confirming the grade of villous invasiveness through pathological examination.

## Conclusion

Magnetic resonance imaging (MRI) has shown increased sensitivity, while ultrasound has demonstrated increased specificity in

diagnosing placenta previa and placenta accreta. More studies are required to confirm these findings.

#### **Ethical consideration and patient consent:**

The study was approved by the Faculty of Medicine, Fayoum University Research Ethical Committee. Approval and consent to participate were gained by obtaining informed written consent from individuals who were invited to take part in the research.

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**Conflicts of Interest:** The authors have no conflicts of interest.

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