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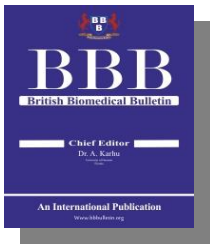

Original

Pre-Operative Detection of Placental Invasion by USG & MRI in Case of Placenta Previa and its Correlation with Clinical Findings and Outcome

Leela R*[1], Mamata N[1], Sudha Rani V[1] and Narender Reddy P[2]

[1]Department of Obstetrics and Gynecology, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar 505 001, Telangana State, India
[2]Department of Radiology, Department of Obstetrics and Gynecology, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar 505 001, Telangana State, India

A R T I C L E I N F O

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Corresponding author: Department of Obstetrics and Gynecology, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar 505 001, Telangana State, India.
E-mail address:
leelavinod.lv@gmail.com

A B S T R A C T

Objective: The purpose of this study was to evaluate transabdominal pelvic ultrasound and MRI for the prenatal diagnosis of placenta previa and its correlation with clinical outcome.
Materials and Methods: A historical cohort pilot study was performed at our institution to identify women at risk of placenta accreta who had undergone both prenatal ultrasound and MRI. Findings at ultrasound and MRI were compared with the final diagnosis, which was established with clinical findings at delivery and pathologic examination of specimens. Volume measurements were made of low-signal-intensity intraplacental bands on T2-weighted MR images. Risk factors for placental insufficiency were recorded.
Results: US and MRI showed no significant difference in sensitivity and specificity in diagnosing abnormal placentation (97 to 100% and 9 to100%, respectively). MRI was more sensitive than US for the detection of myometrial invasion and the type of abnormal placentation (73.5% and 47%, respectively). The difference between pre- and post-operative hemoglobin values and estimated blood loss were the most significant risk factors for abnormal placentation, added to risk factors known for placenta previa. Post-partum surgical complications and prolonged hospital stay were more common in the cases of placenta previa with abnormal placentation, however statistically insignificant.

Introduction

Placenta previa is an obstetric complication in which the placenta is inserted partially or wholly in the lower uterine segment and it is a leading cause of antepartum hemorrhage. Placenta accreta is a pathological condition in which the placental trophoblast invades the endometrium beyond the Nitabuchs layer due to a defect in the decidua basalis[1]. In more severe cases, the trophoblast invades the myometrium (placenta increta) or the serosa and beyond (placenta percreta). In a series of studies by Miller *et al*. including 62 pathologically confirmed cases of abnormal placentation, 76% were accreta, 18% were increta, and 6% were percreta[2]. Placenta accreta complicates approximately 0.9% of all pregnancies. Clinical risk factors include placenta previa and prior uterine surgery, including cesarean delivery[3]. Current estimates indicate a 25% to 50% incidence of placenta accreta in patients with placenta previa and prior cesarean delivery. Incidence of placenta accreta is markedly increased with the number of previous cesarean sections, the risk of placenta accreta increased with woman who had one cesarean section than with those with an unscarred uterus about 8 folds and then increased 4-fold with woman who had 2 or more cesarean sections[4] In addition, pregnancies complicated by placenta accreta are thought to be associated with increased incidence of cystotomy, ureteral injury, pulmonary embolism, need for ventilator use, reoperation, and intensive care unit (ICU) admission[5]. Another important factors are placenta previa, smoking, maternal age over 35 years, grand multiparity and recurrent miscarriage[1,6]. Once a rare occurrence, placenta accreta is becoming an increasingly common complication of pregnancy, mainly due to the increasing rate of cesarean delivery over the past 50 years[7].

Abnormal placental adherence to/or invasion into the myometrium prevents normal separation of the placenta at the time of delivery, potentially resulting in life-threatening uterine hemorrhage or retained products of conception. Given the significant morbidity associated with this diagnosis, the ability to accurately diagnose placenta accreta is essential as it allows both the patient and the obstetrician to be prepared for potential complications of delivery and to proceed with antenatal care to minimize blood loss during and after delivery[8]. Prenatal diagnosis of placenta accreta has historically been difficult, and the accuracy of sonography compared with magnetic resonance imaging (MRI) remains in question. The accuracy of sonography using gray scale and color Doppler techniques for prenatal diagnosis of placenta accreta varies widely in different studies. Wong *et al*. reported that using a composite scoring system of 6 sonographic findings performed with gray-scale and Doppler sonography had 89% sensitivity and 98% specificity for the diagnosis of placenta accreta[9]. Its sensitivity has been reported as anywhere between 33% and 100%, and the specificity also varies widely[10-14] Magnetic resonance imaging (MRI) is more costly than US and requires both experience and expertise in the evaluation of abnormal placental invasion. Although most studies have suggested comparable diagnostic accuracy of MRI and US for placenta accrete, MRI is considered an adjunctive modality and adds little to the diagnostic accuracy of US. However, MRI is important when there are ambiguous US findings or suspicion of posterior placenta accreta, with or without placenta previa.

A prospective series of 300 cases published in 2005 showed that MRI was able to outline the anatomy of the invasion and relate it to the regional anastomotic vascular system[15]. Some investigators have

advocated the use of gadolinium-based contrast agents to improve the specificity of MRI in diagnosing placenta accreta by better defining the outer placental surface and myometrium and distinguishing placenta accreta from percreta[16-19]. Although no detrimental effects of gadolinium-based contrast agents on the human fetus have been convincingly shown, these agents do cross the placenta. The American College of Radiology guidance document for safe MRI practice recommends that intravenous gadolinium should be avoided during pregnancy and should be used only if absolutely essential[20]. The purpose of this study was to evaluate transabdominal pelvic ultrasound and MRI for the prenatal diagnosis of placenta previa and its correlation with its clinical outcome.

Materials and Methods

This prospective study was carried out on one hundred pregnant women presenting with placenta previa in the department of obstetrics and gynecology, Chalmeda Anand Rao Institute of Medical Sciences , Karimnagar, from Sep - 2012-Sep -2014 (2yr study).

Inclusion criteria

All those patients who were at a high risk of abnormal placentation (placenta accrete, increta and percreta) regarding their clinical history of either one or all of the following: placenta previa, previous uterine interventional procedures (e.g. cesarean sections, dilation & curettage and myomectomy, maternal age of 35 years or more and grand multiparity[5,6,18]. The age of the patients ranged from 20 to 42 years (mean age: 31years).

Exclusion criteria

The patients without prepartum US and MRI examinations and a full post-partum record were not included.

US followed by MRI studies were performed on one hundred patients with elective delivery at 36 weeks gestation. All US gray-scale and Doppler studies were performed by registered sonographers and interpreted by an accompanied radiologist.

Ultrasound examination was done in a high resolution B-mode with a Doppler flow imager apparatus (Siemens Acuson X300) using a transabdominal (3.5 MHz) curvilinear probe. Gray-scale B-mode trans abdominal ultrasound examination was first underwent to screen the placenta with careful examination for homogencity. Ultrasound examination was preferred to undergo when the bladder was partially filled for optimal examination of the uterine serosa at the bladder wall interface. Measurement of the smallest myometrial thickness was obtained at the site of placental implantation. All cases were subjected to transabdominal color Doppler evaluation where color signals were used to evaluate the variable uteroplacental vascular morphological patterns. With careful attention to the placental-myometrial interface and the placenta, in cases with placenta previa, we also evaluate the presence of abnormal intra placental lakes.

All cases underwent MRI examination in the radiodiagnosis department using a machine (GE signal 1.5 T) with an abdominal surface coil. All patients were positioned supine. The following sequences are used, axial, sagittal and coronal T2WI were taken. Axial cuts with fat saturated fast spin-echo T2WI and TIWI were obtained. Women were asked to follow Breath-holding techniques as possible as can be tolerated.

Placenta previa was subdivided according to the position of the placenta in relation to the internal cervical os (according to Elsayes *et al*.) into: low-lying, marginal, complete, and central[21]. US findings regarded as consistent with placenta accreta

included the following: loss of the retroplacental hypoechoic clear zone, loss of the bladder wall-uterine interface, presence of placental lacunae (vascular spaces), abnormal color Doppler imaging pattern as the presence of hypervascularity of the interface between the uterine serosa and the bladder wall, turbulent flow within placental lacunae and reduced myometrial thickness[22,23].

In our study we used MRI criteria established by Lax *et al*.[24]. The most useful findings on placenta accreta/percreta in MRI included: uterine bulging, heterogeneous signal intensity within the placenta, dark intraplacental bands on T2-WI, focal defects in the myometrial wall, tenting of the bladder, direct visualization of invasion of pelvic structures by placental tissue.

The delivery plan was made according to the suggested degree of placenta previa on imaging and presence/absence of abnormal placentation. The ability of US and MRI to properly detect and assess placenta accreta was correlated with findings at CS, which were considered the gold standard of reference.

Electronic medical records were used to determine estimated blood loss (EBL), the pre- and post-operative hemoglobin level difference (HB-dC), the need for transfusion of packed red blood cells (PRBC), coagulation factors and platelets, as well as the amount of blood products transfused in each case, presence or absence of CS hysterectomy, SICU admission and the length of hospital stay. Statistical analysis was performed using IBM SPSS statistics (V. 22.0, IBM Corp., USA, 2013).

Results

Out of 100 pregnant women diagnosed with placenta previa, 66 were diagnosed as having placenta previa with no abnormal placentation, 34 were diagnosed with US as having associated abnormal placentation. MRI, on the other hand, diagnosed 32 patients as having abnormal placentation. The examples of US and MRI findings are shown in the following figures. (See figure 1-3 and table 1-6.)

Discussion

It is very important to obtain perfect diagnosis of placenta accreta prenatally, this gives optimal management planning to decrease morbidity[25]. Ultrasound examination with color Doppler imaging and MRI have all been used in the diagnosis of placenta accreta with varying specificity and sensitivity. Ultrasound and color Doppler examination are the first step for the diagnosis of placenta accreta. MRI is used as a complementary tool when ultrasound examination is equivocal or when the placenta hardly visualized on ultrasound examination[26].

A few authors have suggested that MR imaging due to its multiplanar imaging abilities and excellent soft tissue resolution can better define areas of abnormal placentation, identify levels of invasion, and ultimately change surgical management, and thus should be routinely used [15]. Others have suggested that MR imaging is most clearly indicated when there is a posterior placenta or when the US findings are ambiguous. MRI has been shown beneficial in some cases when ultrasound findings are equivocal or non-diagnostic[11]. Our current work is a prospective study to determine the true need for MR imaging in radiological diagnostics of patients with abnormal placentation. The sensitivity and specificity of US in diagnosing abnormal placentation was 94% and 97%, while of MRI 100% and 100%, respectively, showing no statistically significant difference. Masselli *et al*. confirmed that pelvic US using color Doppler is highly reliable to diagnose or exclude the presence of placental adhesive disorders (PAD) and found MRI to be an excellent tool for staging and topographic evaluation of PAD[19]. They had stated that

MR and US Doppler showed no statistical difference in identifying patients with PAD, while MRI was statistically better than US Doppler in characterizing the topography of invasion. MRI showed accuracy of 100% in assessing the depth of placental infiltration versus 75% for US.

Another study by Warshak *et al*., comparing US and post-contrast MR imaging performance in the diagnostics and evaluation of placenta accreta, reported that ultrasound had a sensitivity of 77% and specificity of 96%, while MRI with gadolinium had a sensitivity of 88% and specificity of 100% [16]. Statistically high values in that study could be a result of routine trans-vaginal ultrasound examinations performed in addition to trans-abdominal US, as well as of using gadolinium in MRI examinations, since, according to them, it delineated more clearly the outer placental surface relative to the myometrium.

Teo *et al*. described only MRI features of suspected placental invasion in a limited retrospective review, which included seven patients with Ultrasound findings indicative of placental invasion[27]. They reported that the described MRI features were useful in establishing the presence and depth of placental invasion. In previously mentioned studies, the differences in the sensitivity and specificity between sonography and MRI were not statistically significant. Similarly, in our study, the difference between US and MRI was not found to be statistically significant for diagnosing abnormal placentation. However, when comparing the ability to evaluate the degree of placental invasion, we found a statistically significant difference, with MRI sensitivity of 73.5% and US sensitivity of 47%. The specificity of US in our study was higher, which may be due to the fact that we used trans-vaginal ultrasound.

Placenta percreta was more frequent in our study than in the literature[13] which is mostly due to the presence of multipara patients with repeated CS. In our study, the most frequent ultrasound findings for abnormal placentation were: thinned myometrial zone below 1 mm or loss of its visualization (94%), abnormal color Doppler imaging pattern at placenta-myometrium interface (88%) and placental lacunae with turbulent flow (82%). The first finding was frequently seen in cases of placenta previa without abnormal placentation. However, the other two signs were significantly less common in cases without abnormal placentation, making it a more important diagnostic finding, which is consistent with the literature[22] in our study, the most common MRI signs of abnormal placentation were uterine bulge (87%), heterogeneity of placenta (87%) and dark intraplacental bands (75%). Lax *et al*. showed similar results and described uterine bulge as a focal outward contour bulge and disruption of the normal pear shape of the uterus[24]. Marked heterogeneous signal intensity in the placenta with increased vascularity is associated with placental invasion and may represent either areas of hemorrhage in the placenta or the lacunae. Dark intraplacental bands can also be seen in patients with PA, appearing as nodular or linear areas of low signal intensity on T2-weighted images.

Although there is evidence of morbidity related to placenta previa, the presence of abnormal placentation was a significant factor for adding more morbidity risk[28]. Blood loss is considered the most significant morbidity factor[28]. In our study, we found that the estimated blood loss and hemoglobin differences between pre and post-operative values were the most significant morbidity risk factors for abnormal placentation with placenta previa, added to risk factors known for placenta previa alone. Postpartum SICU admission, prolonged hospital stay and CS hysterectomy were more common in the cases of placenta previa associated with abnormal placentation. However, they were statistically insignificant

in the current study. This can be attributed to the fact that treatment plans were changed owing to accurate diagnosis of abnormal placentation, rendering less complication and morbidity, which is consistent with a study by Eller *et al*.[29].

Conclusion

We concluded that early and systematic detection of abnormal placentation is a crucial step in planning delivery and subsequent management to overcome the morbidity associated with abnormal placentation. Both gray scale ultrasound and color Doppler examination are highly accurate in predicting the radiological patterns of placenta accreta. These imaging modalities are excellent methods for the prediction of maternal morbidity and planning as pre-delivery precaution.

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Conflict of interest

The authors declare no conflict of interest.

Source of interest

None.

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Table 1. Statistical evaluation of Ultrasound, MRI and surgical assessment

	US	MRI	Post surgical
True negative	66 (66%)	68 (68%)	68 (68%)
True positive	30 (30%)	32 (32%)	32 (32%)
False positive	2 (2%)	0 (0%)	0 (0%)
False negative	2 (2%)	0 (0%)	0 (0%)
Total	100 (100%)	100 (100%)	100 (100%)

The incidence of true negative, true positive, false positive and false negative cases in US, MRI and surgical assessment are shown in the Table 1.

Table 2. Statistical evaluation of US and MRI in diagnosis of abnormal placentation

Imaging modality	Sensitivity %	Specificity	PPV	NPV
Ultrasonography	94	97	94	97
MRI	100	100	100	100

The sensitivity of US and MRI was 94% and 100%, and the specificity 97% and 100%, respectively .Positive predictive value (PPV) of US and MRI was 94% and 100% and negative predictive value (NPV) of US and MRI was 97% and 100%, respectively.

Table 3. Abnormal placentation type demonstrated by US, MRI and verified by intra-operative findings

Abnormal placentation type	Intra-operative diagnosis		Imaging studies diagnosis			
	Number	%	US number	%	MRI number	%
Accreta	12	35%	16	47%	8	24%
Increta	8	24%	12	35%	12	35%
Percreta	12	35%	4	12%	12	35%
Normal	2	6%	2	6%	2	6%
Total	34	100%	34	100%	34	100%

Table 4. Ultrasound signs of abnormal placentation in patients with placenta previa (34 cases)

Ultrasound signs of abnormal placentation	Number of positive cases	% from positive cases	Number of negative cases	% from negative cases
1: Placental lacunae with turbulent flow	28/34	82%	16/66	24%
2: Thinned myometrial zone below 1 mm or loss of visualization	32/34	94%	33/66	50%
3: Loss of retroplacental clear space	20/34	58%	30/66	45%
4: Gap in the retroplacental blood flow	16/34	47%	12/66	18%
5: Abnormal Color Doppler Imaging patterns in the form of disruption and increased color Doppler flow at placenta myometrium interface	30/34	88%	11/66	15%

The frequency of US and MRI signs of abnormal placentation in cases with placenta previa is shown in Table 4 and Table 5.

Table 5. MRI signs of abnormal placentation in patients with placenta previa (32 cases)

MRI signs of abnormal placentation	Number of positive cases	% from positive cases	Number of negative cases	% from negative cases
Thinned myometrial zone	16/32	50%	20/68	30%
Absent myometrial zone	22/32	68%	5/68	7.30%
Focal interruption of myometrial zone	20/32	60%	0/68	0%
Uterine bulge	28/32	87%	20/68	30%
Heterogeneity of placenta	28/32	87%	18/68	26%
Dark placental band in T2WI	24/32	75%	5/68	7.30%
Signs of invasion	18/32	56%	0/68	0%
Tenting of UB	1-32	3%	0/68	0%

Table 6. Risk factors for patients with placenta previa and abnormal placentation

Risk factor		n	Mean	SD	t	p	Sig.
HB_Pre_op	Abnormal	10	11.39	0.8185			
	Normal	32	11.434	0.679	−0.156	0.879	NS
HB_Post_op	Abnormal	10	7.64	1.3451			
	Normal	32	8.934	1.759	−2.457	0.024	S
HB_dC	Abnormal	10	−0.3319	0.09216			
	Normal	32	−0.2182	0.14904	−2.895	0.008	HS
Est_Bl_loss	Abnormal	10	4050	895.9787			
	Normal	32	3150	1642.971	2.218	0.035	S
Bl_Tx	Abnormal	10	4.8	1.8738			
	Normal	31	4.903	2.6753	−0.135	0.894	NS

In our study HB-difference (HB-dC) between pre- and post-operative values and estimated blood loss were the most significant risks factors for abnormal placentation added to risk factors known for placenta previa Postpartum SICU admission, prolonged hospital stay and CS hysterectomy were more common in the cases of placenta previa associated with abnormal placentation. However, they were statistically insignificant (P value was 0.831 and 0.365, respectively).

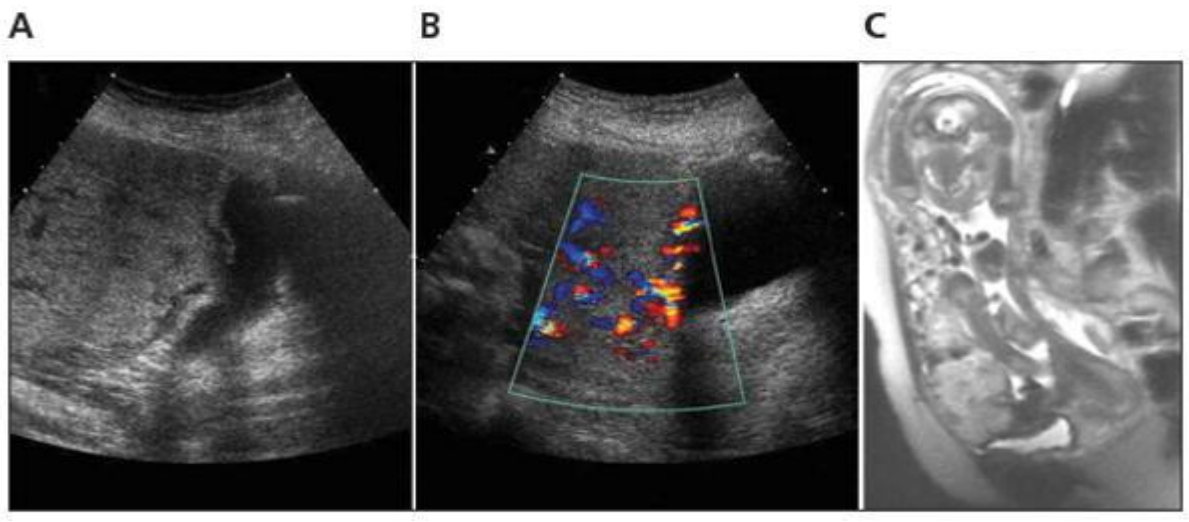

Figure 1. Concordant true-positive sonographic and MRI findings for diagnosis of placenta accreta in the same patient. A, Gray scale sonogram. Note the loss of the bladder wall-uterine interface and the bulge of the placenta into the bladder. B, Color Doppler sonogram Note the presence of hypervascularity of the interface between the uterine serosa and the bladder wall. Placental lacunae are also present. C, T2-weighted MRI. Note the absence of the myometrium at the site of placental implantation, the nodular interface between the placenta and the uterus, and the dark intraplacental bands

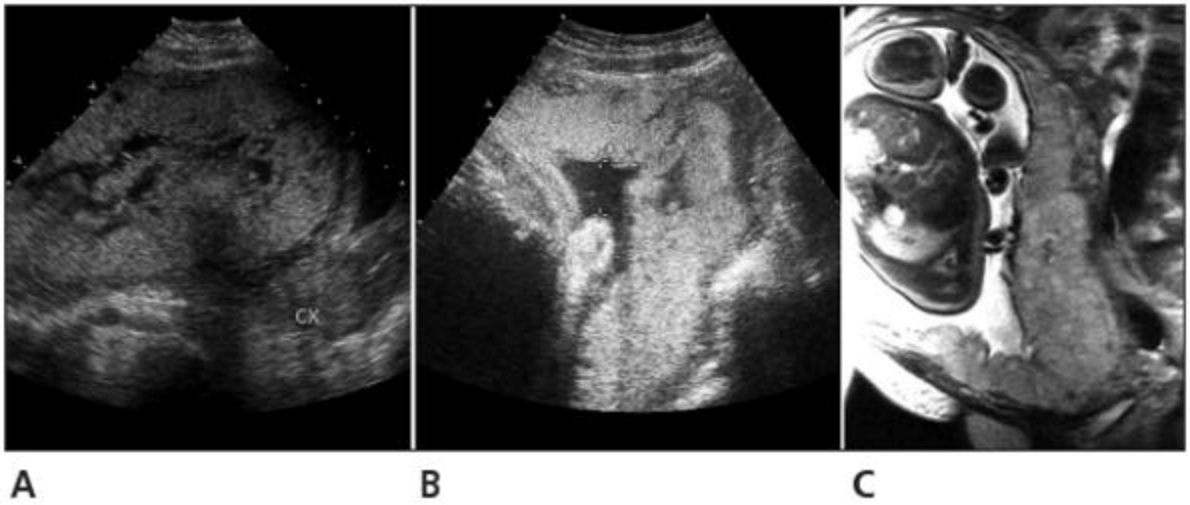

Figure 2. Discordant true-positive sonographic and false-negative MRI findings for diagnosis of placenta accreta in the same patient. A and B, Gray scale sonograms. Placenta previa is present. Note the placental lacunae and the poor definition of the placental-uterine interface. C, T2-weighted MRI. Note the relatively homogeneous placenta and the preservation of the placental-uterine interface

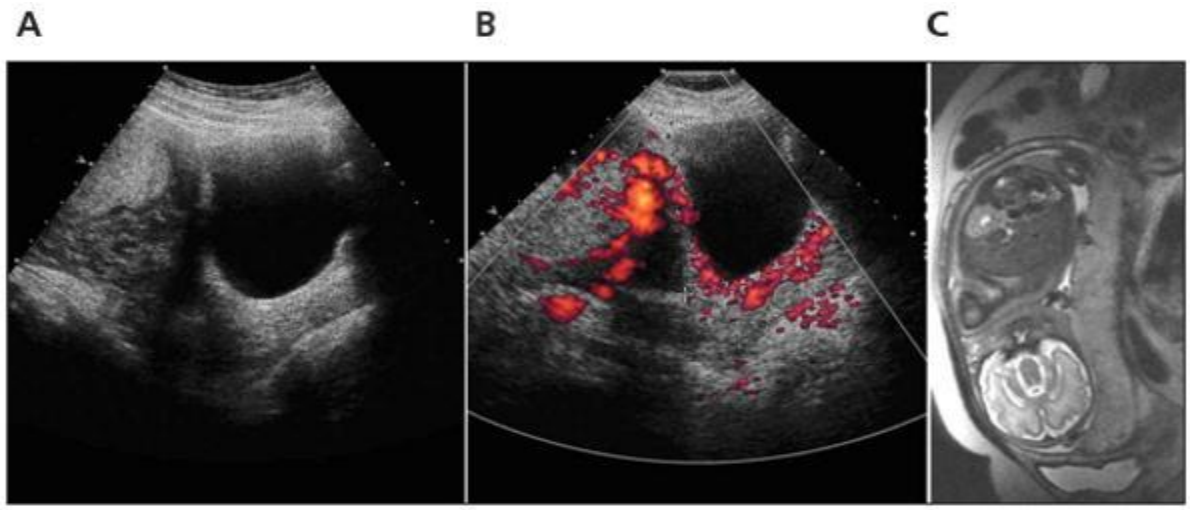

Figure 3. Discordant false-positive sonographic and true-negative MRI findings for diagnosis of placenta accreta in the same patient. A, Gray scale sonograms. Note the presence of placental lacunae. B, Color Doppler sonogram. Note the presence of placental lacunae and hypervascularity of the interface between the uterine serosa and the bladder wall. C, T2-weighted MRI. Note the preserved myometrium at the site of placental implantation and the preserved tissue plane between the placenta and the bladder wall