Prenatal Diagnosis of Placenta Accreta

Sonography or Magnetic Resonance Imaging?

Bonnie K. Dwyer, MD, Victoria Belogolovkin, MD, Lan Tran, MD, Anjali Rao, MD, Ian Carroll, MD, MS, Richard Barth, MD, Usha Chitkara, MD

Objective. The purpose of this study was to compare the accuracy of transabdominal sonography and magnetic resonance imaging (MRI) for prenatal diagnosis of placenta accreta. ***Methods.*** A historical cohort study was undertaken at 3 institutions identifying women at risk for placenta accreta who had undergone both sonography and MRI prenatally. Sonographic and MRI findings were compared with the final diagnosis as determined at delivery and by pathologic examination. ***Results.*** Thirty-two patients who had both sonography and MRI prenatally to evaluate for placenta accreta were identified. Of these, 15 had confirmation of placenta accreta at delivery. Sonography correctly identified the presence of placenta accreta in 14 of 15 patients (93% sensitivity; 95% confidence interval [CI], 80%–100%) and the absence of placenta accreta in 12 of 17 patients (71% specificity; 95% CI, 49%–93%). Magnetic resonance imaging correctly identified the presence of placenta accreta in 12 of 15 patients (80% sensitivity; 95% CI, 60%–100%) and the absence of placenta accreta in 11 of 17 patients (65% specificity; 95% CI, 42%–88%). In 7 of 32 cases, sonography and MRI had discordant diagnoses: sonography was correct in 5 cases, and MRI was correct in 2. There was no statistical difference in sensitivity ($P = .25$) or specificity ($P = .5$) between sonography and MRI. ***Conclusions.*** Both sonography and MRI have fairly good sensitivity for prenatal diagnosis of placenta accreta; however, specificity does not appear to be as good as reported in other studies. In the case of inconclusive findings with one imaging modality, the other modality may be useful for clarifying the diagnosis. ***Key words:*** magnetic resonance imaging; placenta accreta; prenatal diagnosis; sensitivity and specificity; sonography.

Abbreviations
CI, confidence interval; NPV, negative predictive value; MRI, magnetic resonance imaging; PPV, positive predictive value

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Address correspondence to Bonnie K. Dwyer, MD, 726 Rustic Ln, Mountain View, CA 94040 USA.
E-mail: dwyerbk@gmail.com

Placenta accreta is the abnormal implantation of the placenta into the uterine wall, and it complicates approximately 0.9% of all pregnancies. Clinical risk factors include placenta previa and prior uterine surgery, including cesarean delivery.[1,2] The incidence of placenta accreta has increased with the rising number of cesarean deliveries. Current estimates indicate a 25% to 50% incidence of placenta accreta in patients with placenta previa and prior cesarean delivery.[2] Complications of placenta accreta include massive hemorrhage, damage to the uterus, bladder, ureters, and bowel, and often cesarean hysterectomy to control bleeding. Prenatal diagnosis of placenta accreta can help minimize the complication rate by enabling a surgeon to plan for the type of resources needed at the time of delivery. These resources include obstetric anesthesia, appropriate surgical expertise, available blood products and cell saver technology, possibly interventional radiology for uterine artery embolization, and postoperative intensive care.

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. Its sensitivity has been reported as anywhere between 33% and 100%, and the specificity also varies widely.[3–8] More recently, MRI, with and without gadolinium, has been explored as a modality for further improving the prenatal diagnosis of placenta accreta. Several case reports and series and 1 large study have described the utility of MRI in diagnosing placenta accreta.[3,9–14] One study of MRI in 9 patients reported sensitivity of only 38% with poor specificity.[3] A more recent historical cohort study compared sonography and MRI with gadolinium and found very high sensitivity (77% and 88%, respectively) and very high specificity (96% and 100%) for both modalities.[15]

Our study aimed to describe the accuracy of sonography and MRI without gadolinium for diagnosis of placenta accreta within 3 academic institutions. In our study, both sonography and MRI were performed on the same group of women.

Materials and Methods

Approval was obtained by the individual institutional review boards at Stanford University, University of Washington, and Mount Sinai medical centers. These are 3 tertiary care centers with a large volume of obstetric patients. Retrospective searches using databases and codes from the *International Classification of Diseases, Ninth Revision*, for placenta previa, placenta accreta, cesarean delivery with placental abnormalities, and cesarean hysterectomy were performed at each institution for 6 years (2001–2006). We identified patients who underwent both prenatal transabdominal sonography and MRI to evaluate for suspected diagnosis of placenta accreta. At Stanford and Mount Sinai, these patients included a subset of patients thought to be clinically at risk either by history or because of suspicious sonographic findings suggestive of placenta accreta. At the University of Washington, only patients with sonographic findings suspicious for placenta accreta were referred to MRI to confirm the diagnosis.

Imaging

Sonograms and MRIs were read by an attending perinatologist or radiologist at the original institution. All of the attending physicians were fellowship trained in their respective fields. For the purpose of the study, reports were retrospectively reviewed by the senior authors at the coordinating center, each of whom had more than 5 years of experience. Sonographic findings were considered positive for accreta if the report concluded a high probability of placenta accreta. Findings that were considered suggestive of placenta accreta included loss of the retroplacental hypoechoic clear zone, loss of the bladder wall-uterine interface, presence of placental lacunae (vascular spaces), and presence of hypervascularity of the interface between the uterine serosa and the bladder wall on color Doppler imaging.[7,8] Magnetic resonance imaging findings were considered positive for placenta accreta if the report concluded a high probability of placenta accreta. Findings considered suggestive of placenta accreta included focal thinning or absence of the myometrium at the site of placental implantation, a nodular interface between the placenta and the uterus, a mass effect of the placenta on the uterus causing an outer bulge, heterogeneous signal intensity within the placenta, dark intraplacental bands on T2-weighted images, and loss of the tissue plane between the placenta and bladder wall.[3,13,14] For both sonography and MRI, if the report concluded low or no probability of placenta accreta, the findings were considered negative.

To take into consideration the fact that imaging studies are not always definitive, we did a second analysis designating studies as correct, incorrect, or inconclusive. Examples of studies designated inconclusive included the following: (1) a study in which a single nonspecific feature of placenta accreta was seen on imaging, but the overall study was thought to have low probability; and (2) a study that was limited by poor quality.

Imaging Protocols

Transabdominal Sonography

Sonography with gray scale and color Doppler imaging was performed by registered sonographers and by a perinatologist or radiologist. At Stanford University, examinations were performed on Acuson Sequoia ultrasound systems (Siemens Medical Solutions, Mountain View, CA). The entire placental volume was imaged in the transverse and longitudinal planes with a 4- or 6-MHz curved array transducer. At Mount Sinai, examinations were performed on a Voluson 730 Expert system using a 5-MHz transducer (GE Healthcare, Milwaukee, WI) or ATL HDI 3500 system using a 4-MHz transducer (Philips Medical Systems, Bothell, WA). At the University of Washington, examinations were performed with an iU22 system using a C5–2 MHz curved array transducer (Philips Medical Systems).

Magnetic Resonance Imaging Without Gadolinium

At Stanford University and the University of Washington, MRI was performed on a 1.5-T whole-body MRI scanner (GE Healthcare). The maternal pelvis was imaged in the axial, coronal, and sagittal planes with an 8-channel phased array cardiac coil. After a 3-plane localizing scan, T1-weighted fast gradient echo sequences were acquired in the sagittal, coronal, and axial planes through the maternal abdomen with repetition/echo times of 165/2.5 milliseconds, a flip angle of 90°, a 384 × 192 data matrix, and a slice thickness of 5 mm. The field of view was usually 38 cm but was occasionally increased to optimize for the uterine size. T2-weighted single-shot fast spin echo sequences were acquired in the axial, sagittal, and coronal planes with repetition/echo times of 6000/160 milliseconds, a 288 × 224 data matrix, a slice thickness of 5 mm, and a typical field of view 38 cm. Intravenous gadolinium was not used in any of the MRI studies.

At Mount Sinai, MRI was performed on a 1.5-T whole-body MRI scanner (GE Healthcare or Siemens Medical Solutions). Details were identical to those described above, except that a 6-channel body matrix coil was used. T2-weighted sequences used a 256 × 218 data matrix and a slice thickness of 6mm. T1-weighted sequences were acquired at the attending physician's discretion.

Outcomes

Maternal delivery records and delivery databases were reviewed for delivery outcomes. Placenta accreta was defined by clinical criteria at the time of delivery and by pathologic diagnosis. If pathologic findings were not available, then placenta accreta was defined by clinical criteria alone, including an adherent placenta and maternal hemorrhage. Pathologic findings were not available for patient 2 because hysterectomy was not performed. For patients 6 and 12, pathologic findings were not available in the database. For patient 15, the pathologic findings were inconclusive because the uterine specimen was fragmented.

Statistics

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for both sonography and MRI. The sensitivity and specificity values of sonography and MRI were compared by the McNemar test. In a separate analysis, the percentages of sonographic and MRI findings that were correct, incorrect, and inconclusive were compared by the McNemar test.

Logistic regression was used to look for an association between placental location, a history of prior uterine surgery, and the ability of sonography and MRI to correctly diagnose placenta accreta. A post hoc power analysis was also calculated. All calculations were performed with SAS version 9.1 software (SAS Institute Inc, Cary, NC).

Results

A total of 32 patients who were clinically at high risk for placenta accreta and underwent both sonography and MRI prenatally were identified (14 at Stanford University, 11 at Mount Sinai, and 7 at the University of Washington). Sixty-six percent of the patients had placenta previa; 81% had prior uterine surgery; and 47% had both. Table 1 shows baseline characteristics of the patients included in the study. Fifteen of these 32 patients had a diagnosis of placenta accreta clinically at delivery, by pathologic examination, or both. These patients are detailed in Table 2.

Table 3 shows the sensitivity, specificity, PPV, and NPV of sonography and MRI for their ability to predict placenta accreta within this high-risk

Table 1. Baseline Characteristics of Patients Included in the Study

Clinical Characteristic	Patients, n (%) (N=32)
Placenta location	
Anterior	14 (44)
Posterior	12 (38)
Lateral	1 (3)
Central	13 (41)
Placenta previa	21 (66)
Prior uterine surgery	26 (81)
Placenta previa and prior uterine surgery	15 (47)

cohort. Sonography had sensitivity of 93% (95% confidence interval [CI], 80%–100%) and specificity of 71% (95% CI, 49%–93%). Magnetic resonance imaging had sensitivity of 80% (95% CI, 60%–100%) and specificity of 65% (95% CI, 42%–88%). We found no significant difference in the sensitivity and specificity of sonography and MRI (sensitivity: sonography, 93%, versus MRI, 80%; $P = .25$; specificity: sonography, 71%, versus MRI, 65%; $P = .5$). Sonography and MRI were discordant in their diagnosis in 7 of 32 cases (22%; 95% CI, 8%–36%). In these, sonography was correct in 5 cases, and MRI was correct in 2 cases. This was not statistically significant.

Images from a patient who had true-positive sonographic and MRI findings are shown in Figure 1. Images from patients with discordant sonographic and MRI findings are shown in Figures 2 and 3.

Table 4 shows the number of times sonographic and MRI diagnoses were correct, incorrect, and inconclusive. There were no cases in which both sonography and MRI were inconclusive. The number of times that sonography and MRI were inconclusive was compared by the McNemar test, and no statistically significant difference was found. When sonography was inconclusive, MRI provided the correct diagnosis in 4 of 5 cases. When MRI was inconclusive, sonography provided the correct diagnosis in 7 of 8 cases.

Logistic regression revealed that the ability of sonography or MRI to correctly diagnose placenta accreta was not affected by placental location or by a history of uterine surgery.

Discussion

Our multicenter study showed that sonography and MRI without the use of gadolinium appear to have similar accuracy for correctly diagnosing placenta accreta. Our study also found that in this clinical setting, the specificity of both sonography and MRI might not be as high as previously thought. When either sonography or MRI was

Table 2. Characteristics of Patients with Placenta Accreta

Patient	Placental Location by Imaging Studies	Prior Surgery	Diagnosis Made Clinically at Delivery or by Pathologic Examination	C-Hyst
1	Previa, complete	CD × 3	Increta	Yes
2	Previa, complete, posterior	CD × 1, D&C × 1	Focal accreta[a]	No
3	Previa, complete, posterior	CD × 2	Accreta	Yes
4	Previa, complete	CD × 5	Accreta	Yes
5	Previa, anterior	CD × 2	Accreta	Yes
6	Previa, complete, anterior	CD × 2	Percreta	Yes
7	Previa, anterior	CD × 2, D&C × 2	Accreta	Yes
8	Low-lying, anterior	CD × 2	Percreta	Yes
9	No previa, anterior	D&C × 1	Increta	Yes
10	Low-lying, posterior	D&C × 1	Accreta	Yes
11	Previa, posterior	None	Accreta	Yes
12	Previa, complete, anterior	CD × 1	Percreta	Yes
13	Right lateral	CD × 1, right corneal rupture	Accreta	Yes
14	Previa, complete	CD × 3, D&C × 1, myomectomy × 1	Increta	Yes
15	Previa, complete	CD × 1	Increta/percreta	Yes

CD indicates cesarean delivery; C-Hyst, cesarean hysterectomy; and D&C, dilation and curettage.
[a]Pathologic findings not available because no hysterectomy was performed; clinical diagnosis listed.

inconclusive, the other imaging modality provided the correct diagnosis in 80% to 88% of cases. This suggests that sonography and MRI may be complementary in cases with uncertainty in diagnosis of placenta accreta.

A recent study comparing sonography and MRI with gadolinium for prenatal diagnosis of placenta accreta was published by Warshak et al.[15] They reported on 39 cases of confirmed placenta accreta with an unpaired study design. Sonography had sensitivity of 77% and specificity of 96%. Magnetic resonance imaging with gadolinium had sensitivity of 88% and specificity of 100%. Similar to our study, the differences in sensitivity and specificity between sonography and MRI did not meet statistical significance. Both studies were underpowered to detect a significant difference in accuracy between sonography and MRI given the expected difference noted above.

Notably, in the study by Warshak et al,[15] the specificity was better for both sonography and MRI than in our study. These differences could be due to ascertainment/referral bias (ie, patient population studied) and differences in random sampling. The difference in the specificity of sonography between studies could also be due to the fact that transvaginal sonography was used in their study but was not routinely used in our study. It has been suggested that transvaginal sonography may improve accuracy for antenatal diagnosis of placenta accreta by improving the near-field resolution of the interface between the placenta and the lower uterine segment, especially in cases of placenta previa or a posterior placenta.[16] It has also been suggested that the accuracy of sonography could also be affected by the frequency of the abdominal transducer used (a higher frequency will improve spatial resolution for superficial structures) or by the degree of bladder filling, especially when transvaginal sonography is not used.[17,18] The difference in the specificity of MRI could be due to the use of gadolinium. Warshak et al[15] used gadolinium because they thought that it more clearly delineated the outer placental surface relative to the myometrium, thereby adding specificity. The use of gadolinium in pregnancy is controversial given that the molecule crosses the placenta, enters the fetal circulation, and is excreted by the fetal kidney. Its fetal effects are unknown.

Table 3. Sensitivity, Specificity, PPV, and NPV of Sonography Versus MRI

	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Sonography	93	71	74	92
MRI	80	65	67	79
P[a]	.25	.5		

[a]McNemar paired analysis.

Specific concern has been raised because of the association between gadolinium and nephrogenic systemic fibrosis in adult patients with renal failure. Because the kidney is considered immature in children younger than 1 year, the European Medicines Agency warns that gadolinium should be used with caution in this age group. There is thus a theoretic concern regarding the fetus as well.[19,20]

The strength of our study was that it directly compared the accuracy of sonography and MRI in the same group of patients. Furthermore, it described the sensitivity and specificity of MRI without the use of gadolinium, which is the approach used in most institutions. Therefore, this study provides real-world information about the diagnostic accuracy of these imaging modalities at 3 academic institutions in a group of patients who were at high risk for placenta accreta.

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.

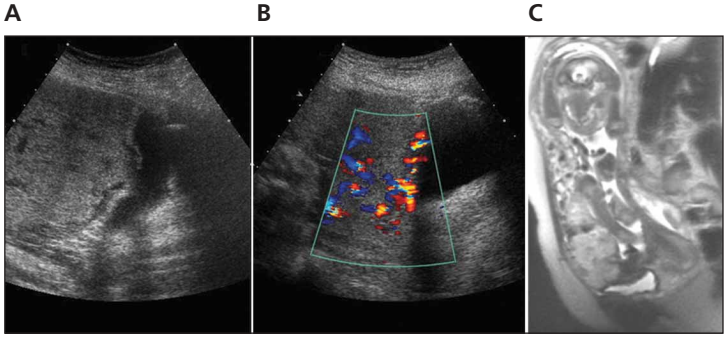

Figure 2. Discordant true-positive sonographic and false-negative MRI findings for diagnosis of placenta accreta in the same patient. **A** and **B**, Gray scale sonograms. Placenta previa is present. Note the placental lacunae and the poor definition of the placental-uterine interface. **C**, T2-weighted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

One limitation of our study was ascertainment bias. At all 3 institutions, patients underwent sonography and MRI because they were thought to be at high risk for accreta on the basis of their clinical history or sonographic findings. However, criteria for MRI referral were not uniform. Thus, if high-risk patients with strongly suggestive negative or positive sonographic findings were systematically not referred for MRI, our study would have underestimated the sensitivity and specificity of sonography because only patients with both studies were included. On the other hand, if high-risk patients with definitively positive sonographic findings were systematically the only ones referred for MRI, our study would have overestimated the sensitivity and specificity of MRI. Given the retrospective nature of this study, unfortunately this bias was unavoidable. Another limitation of our study was that 4 of the 15 cases of placenta accreta were diagnosed on the basis of clinical criteria alone because pathologic findings were not sent (1 case), were not available within the databases (2 cases), or were inconclusive (1 case).

On the basis of our data and those from prior studies, it is difficult to determine the superiority of either sonography or MRI for accurately diagnosing placenta accreta. The diagnostic abilities of sonography and MRI appear to be comparable.

Ideally, a prospective study needs to be done to compare the accuracy of sonography versus MRI in patients who are at high risk for placenta accreta. According to our calculation, 194 patients would need to have both sonography and MRI in a paired study design to have 80% power to detect a difference at the $P = .05$ level. In an unpaired study design, an even larger number of patients would be required. Given the large number of patients required, a multiinstitutional study would be necessary to make this feasible. Until such a study can be done, it seems that either sonography or MRI can be used prenatally to diagnose placenta accreta with reasonable accuracy in patients who are at risk. If one test is inconclusive, the use of the other imaging modality may provide more diagnostic information.

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.

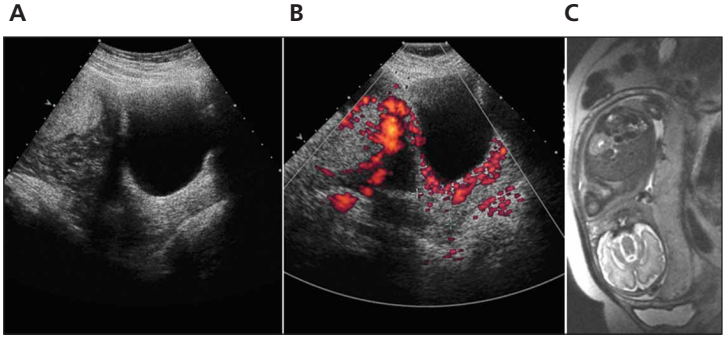

Table 4. Sonographic and MRI Findings That Were Correct, Incorrect, and Inconclusive for Diagnosing Placenta Accreta (N = 32)

	Correct, n (%)	Incorrect, n (%)	Inconclusive, n (%)
Sonography	22 (69)	5 (16)	5 (16)
MRI	19 (59)	5 (16)	8 (25)
P[a]	.27	.69	.24

[a]McNemar paired analysis.

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