Perinatal assessment of complex cesarean delivery: beyond placenta accreta spectrum

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Multiple cesarean deliveries are known to be associated with long-term postoperative consequences because of a permanent defect of the lower uterine segment wall and the development of thick pelvic adhesions. Patients with a history of multiple cesarean deliveries often present with large cesarean scar defects and are at heightened risk in subsequent pregnancies of cesarean scar ectopic pregnancy, uterine rupture, low-lying placenta or placenta previa, and placenta previa accreta. Moreover, large cesarean scar defects will lead to progressive dehiscence of the lower uterine segment with the inability to effectively reapproximate hysterotomy edge and repair at birth. Major remodeling of the lower uterine segment associated with true placenta accreta spectrum at birth, whereby the placenta becomes inseparable from the uterine wall, increases the rates of perinatal morbidity and mortality, especially when undiagnosed before delivery. Ultrasound imaging is currently not routinely used to evaluate the surgical risks of patients with a history of multiple cesarean deliveries, beyond the risk assessment of placenta accreta spectrum. Independent of accreta placentation, a placenta previa under a scarred, thinned partially disrupted lower uterine segment, covered by thick adhesions with the posterior wall of the bladder, poses a surgical risk and requires fine dissection and surgical expertise; however, data on the use of ultrasound to evaluate uterine remodeling and adhesions between the uterus and other pelvic organs are scarce. In particular, transvaginal sonography has been underused, including in patients with a high probability of placenta accreta spectrum at birth. Based on the best available knowledge, we discuss the role of ultrasound imaging in identifying the signs suggestive of major remodeling of the lower uterine segment and in mapping the changes in the uterine wall and pelvis, to enable the surgical team to prepare for all different types of complex cesarean deliveries. The need for postnatal confirmation of the prenatal ultrasound findings for all patients with a history of multiple cesarean deliveries, regardless of the diagnosis of placenta previa and placenta accreta spectrum, is discussed. We propose an ultrasound imaging protocol and a classification of the level of surgical difficulty at elective cesarean delivery to stimulate further research toward the validation of ultrasound signs by which these signs may be applied to improve surgical outcomes.

Key words: increta, placenta accreta spectrum, placenta accreta, preoperative evaluation, transvaginal sonography, ultrasound imaging

Introduction

One of the first uses of the then-new technique of ultrasound imaging in the 1960s was the prenatal diagnosis of placenta previa.[1–3] This was a breakthrough in the obstetrical management of a condition previously associated with very high maternal mortality, even when a cesarean delivery (CD) could be performed.[4] Evaluating the placental position is now an integral part of the midpregnancy fetal anatomy transabdominal ultrasound examination.[5] The development of high-resolution transvaginal sonography (TVS) has transformed the diagnosis and management of placenta previa by allowing to accurately identify the low placental edge and its relation to the internal os of the cervix throughout pregnancy.[6]

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CD is the recommended mode of delivery for a patient diagnosed with placenta previa.[7] The surgical procedure can be complex, particularly when the placenta is anterior and/or covering the internal os of the cervix. The main intraoperative risk is massive obstetrical hemorrhage (MOH), which may require a hysterectomy to control.[7] Immediate preoperative[8] and/or intraoperative[9] ultrasonography has been proposed to precisely determine the placental location and the optimal place for uterine incision; however, overall, there are few studies on the role of preoperative ultrasound in the evaluation of intraoperative risks in patients diagnosed with placenta previa beyond the risk assessment of placenta accreta spectrum (PAS).

There are limited data on the prevalence of placenta previa before the 1990s. A national US epidemiology study of data collected between 1979 and 1987 found that placenta previa complicated approximately 5 per 1000 deliveries annually and was fatal in 0.03% of

cases.[10] Between the time of the first prenatal diagnosis of placenta previa and the end of the 20th century, CD rates in the United States have increased by 400%.[11] Over the last 2 decades, epidemiologic data have demonstrated an association between previous CD and higher rates of not only placenta previa but also placenta abruption and PAS in subsequent pregnancies.[12−17] Of particular concern is the increase in the rates of maternal morbidity and mortality associated with placenta previa accreta in subsequent pregnancies.[18,19] However, data on the role of ultrasound imaging in identifying additional intraoperative risks associated with major uterine remodeling and pelvic adhesions in these cases are limited.

To date, CD is the most commonly performed major operation worldwide and is often the first surgical procedure performed independently by residents or trainees in the field of obstetrics and gynecology in the United States and Europe.[20] A recent analysis of the latest available data (2010−2018) from 154 countries covering 94.5% of live births showed that 21.1% of women gave birth via CD.[21] By 2030, 28.5% of women worldwide are predicted to be delivered via CD, with the greatest increase in Eastern Asia.[21] Thus, with an ongoing increase in the rate of CD worldwide, a likely increase in surgical complications and in the number of surgically complex CDs will occur. Ultrasound imaging is currently not routinely used to evaluate the surgical risks of patients with a history of multiple CDs beyond those associated with PAS. Our review addressed the new challenges associated with the surgical consequences of the increasing CD rates and evaluated the role of ultrasound imaging in the management of complex CDs.

Postsurgical effects of the cesarean section procedure

Uterine remodeling and cesarean scar integrity

Muscles do not heal by regenerating new muscular fibers and thus cannot be functionally repaired.[22] In general, muscles do not heal by regenerating muscle fibers but by forming "foreign" substances, including collagen. The scarification process of the uterine myometrium includes a permanent deposit of collagen and fibrin in and around the hysterotomy incision, and scar areas often show tissue edema, inflammation, and elastosis with myofiber disarray.[23] Apoptosis with decreased myometrial volume density has been found in scar tissue up to 3 years after surgery,[24] indicating that uterine remodeling continues well beyond the postoperative period.[25] Most uterine scar-related defects are surrounded by thick-walled vessels,[26] uterine artery resistance is increased, and the volume of uterine blood flow is decreased after CD compared with vaginal delivery.[27] These data suggest a possible relationship between scarification and permanent changes in the vascularization of the scarred area that may contribute to the long-term process of myometrial remodeling.

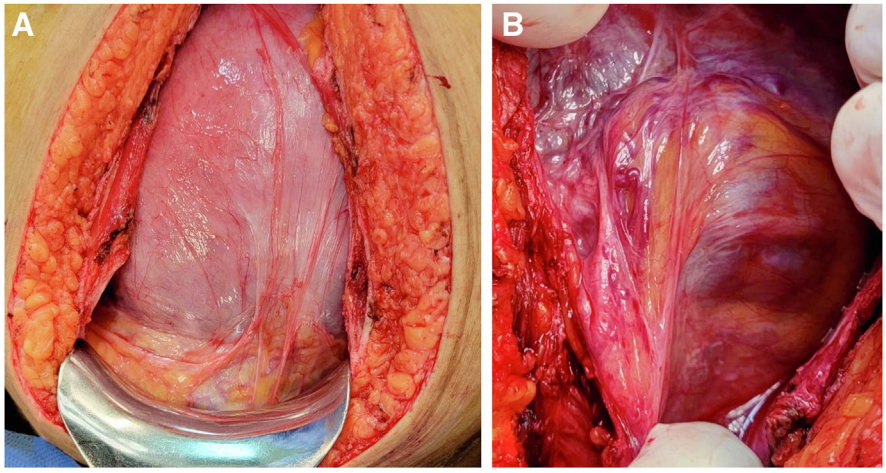
Patients with a history of multiple lower-segment CDs will often have a lower anterior uterine wall largely consisting of fibrotic scar tissue.[23] Physiologically, the lower uterine segment (LUS) contains fewer myofibers and more elastic connective tissue than the upper segment[28,29] and, thus, is more vulnerable to the development of scar defect and myometrial disruption at the surgical site than the upper segment.[30,31] In large cesarean scar defects (CSDs), there is often an absence of reepithelialization to the endometrium during the secretory phase.[32] In these cases, the residual myometrial thickness (RMT) is often <2 mm[33,34] with permanent loss of the spiral arteries, the junctional zone between the endometrium and superficial myometrium, and most of the length of the radial arteries.[35,36] This allows extravillous trophoblastic cells to migrate close to the uterine serosa and reach the large arterial branches of the uterine artery, a situation that never occurs in an anatomically normal, unscarred uterine wall. It is now clear that implantation of the blastocyst in a CD scar, can develop into a, cesarean scar ectopic pregnancy (CSEP), and that an ongoing CSEP is the precursor of accreta placentation.[37,38] There are limited data on the outcome of CSEP,[35,39] as most patients experience a miscarriage in the first trimester of pregnancy[40] or as most pregnancies are surgically terminated.[41] For those CSEPs that continue into the second and third trimesters of pregnancy, the outcome can be a low-lying placenta or placenta previa, a placenta previa accreta, or rarely a complete uterine rupture.[35] It is likely that the amount of definitive placental tissues developing inside the scar defect and the corresponding RMT at the beginning of pregnancy modulates the incidence of different types of complications.[35,42]

The incidence of CSDs increases with the number of previous CDs and is more common with retroverted uteruses.[33,34,43] Moreover, the development of a CSD may vary according to the hysterotomy closure technique, suture material used, and type of CD (ie, elective vs emergency). Overall, systematic reviews and meta-analyses of randomized control trials (RCTs) comparing single-layer myometrial closure with double-layer myometrial closure have found a similar incidence of CSD, suggesting that the type of uterine closure has little influence on uterine scarification after CD.[44−46] More recent RCTs have shown that double-layer unlocked sutures are associated with thicker RMT[47,48] and higher healing ratio[47] than single-layer locked sutures. There is currently no prospective data on the size and location of a CSD between pregnancies and the risks of abnormal placentation in subsequent pregnancies. A small retrospective case-control study found that the use of a monofilament suture for hysterotomy closure reduces the risk of having a placenta previa[49] and that the use of a continuous suture is associated with a higher risk of PAS than the use of interrupted sutures.[50] A recent prospective study reported a higher incidence of CSDs after elective CD than after emergent CD and a thicker RMT when emergent CD was performed at a cervical dilatation of <4 cm.[51] These data could explain why elective CD have been associated with a relatively higher incidence of PAS in subsequent pregnancies than emergency CDs.[52,53]

Pelvic adhesions

Most long-term complications related to CD are related to the development of postoperative adhesions (Figure 1).

FIGURE 1
Intraoperative views at 37 weeks showing multiple adhesions between the bladder and uterine



A, Thin adhesions. **B,** Thick adhesions.

CD, cesarean delivery.

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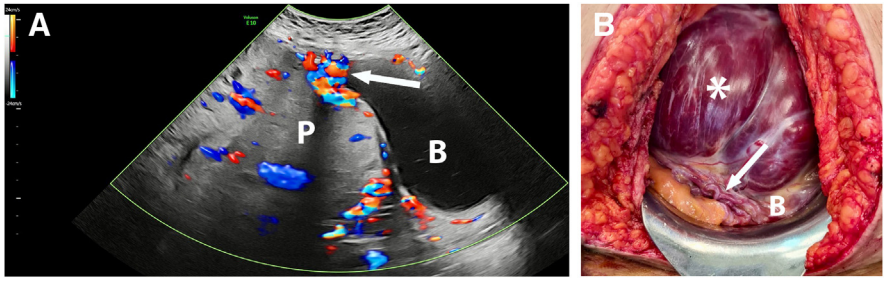
These include emergency operations for small bowel obstruction, chronic abdominal and pelvic pain, and secondary infertility.[54,55] Adhesions are fibrous, bandlike structures that form between 2 different anatomic surfaces.[54] Postsurgical pelvic adhesions, particularly of the vesicouterine pouch, are present in more than a third of patients with a history of 1 or 2 previous CDs.[56] With each cumulative CD, adhesions increase in frequency, become thicker and denser, and involve larger areas.[54] Postoperative wound infection increases the likelihood of adhesions developing in the anterior pelvic compartment,[56] and there is a possible association between skin scar thickness and severity of pelvic and abdominal adhesions.[57]

Adhesion formation may be influenced by double-layer closure of the uterine incision and closure of the peritoneum. Of note, 2 RCTs of primary CD showed that closure or nonclosure of the peritoneum did not lead to marked differences in the adhesion rate at a repeat CD.[58,59] In contrast, a prospective cohort study of first repeat CD found that a single-layer uterine closure is associated with a 7-fold increase in bladder adhesions but not of other pelvic or abdominal adhesions.[60]

FIGURE 2
Preoperative and intraoperative views at 36 weeks of a placenta previa Perinatal assessment of a placenta previa after 4 prior CDs 4 previous CDs



A, Large vessels (*arrow*) at the top of the bladder (B) on longitudinal transabdominal CDI view showing a placenta (P) previa covering the cervix. **B,** Vascular anastomosis (*arrow*) between the top of the bladder and uterine wall and an extended disruption (*asterisk*) of the anterior uterine wall through which the placental basal plate can be seen. A focal area of placenta increta was found under the vascular anastomoses.

CD, cesarean delivery; *CDI*, Color Doppler Imaging.

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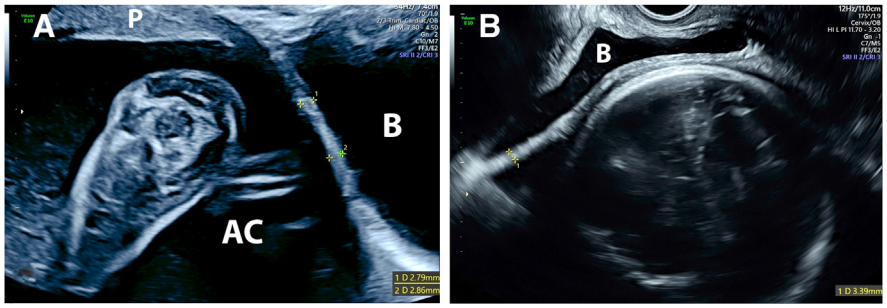
The complex cesarean delivery vs placenta accreta spectrum

The group of pregnant patients with the highest risk of complications during CD are those with a history of ≥2 previous CDs who present in the current pregnancy with an anterior placenta previa and require an emergent procedure for premature labor and/or antenatal bleeding.[61,62] Moreover, these patients are likely to present with thick and dense adhesions in the LUS, bladder, and rectus sheath,[54] increased vascularization under the placental bed,[35] and large areas of myometrial dehiscence.[63–67]

Not all ongoing CSEPs develop into true PAS; however, they are surgically challenging at delivery because of a placenta previa under a scarred, thinned partially disrupted LUS that may involve part of the cervix. Not all cases of complex CDs are PAS; however, they may initially look similar on imaging and at laparotomy.[63–65] Non-accreta placenta previa with major LUS remodelling may require either similar treatment, including scar resection and repair, or cesarean hysterectomy if the LUS is too damaged for repair.[65] The difference between the difficult CD for placenta previa and PAS is that, in true PAS, there is an area of excessive fibrinoid deposition at the uteroplacental interface that makes these 2 tissues inseparable, as though they are glued together.[68] In the setting of placentation over a CSD without PAS, the placenta separates at

FIGURE 3
Ultrasound imaging views of LUS remodeling after multiple CDs



A, Longitudinal transabdominal view of the LUS at 28 weeks of gestation in a patient with 3 previous CDs showing an anterior high placenta (P). The upper half of the uterobladder interface has a thickness of <3 mm with no visible myometrium. **B,** Transvaginal view of the LUS at 32 weeks of gestation in a patient with 2 previous CDs showing the fetal head bulging toward the bladder (B).

AC, amniotic cavity; *CD*, cesarean delivery; *LUS*, lower uterine segment.

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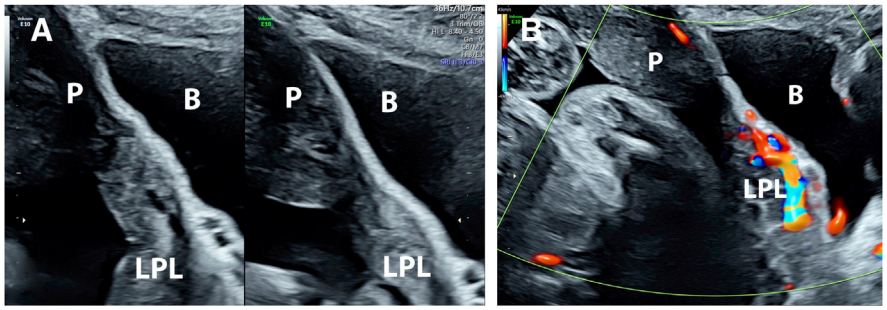
birth, leaving a thin, distended LUS wall in the region of the previous defect.[63–67]

In addition, a large CSD is the first step in the development of LUS dehiscence or myometrial disruption in subsequent pregnancies, independent of the placental position. Cases of large dehiscence develop progressively as pregnancy advances and the uterus distends, leaving a thin layer of scarred tissue covered with serosa at the end of the third trimester of pregnancy through which the fetal presentation or the placental basal plate may become visible at laparotomy (Figure 2).[64] This can explain why there is a poor correlation between first-trimester RMT and third-trimester LUS thickness in women with a previous CD.[69]

Surgical techniques have been recently described to avoid a hysterectomy in cases presenting with a large dehiscence of the LUS (Figures 3-5)[70] or to remove the dehisced area to improve the outcome in subsequent pregnancies[71] in areas of PAS limited to the upper part of the LUS (Figure 2).[67,72] However, these techniques require advanced surgical expertise, which may not be available in all centers or in an emergency. After multiple CDs, these thin bulging areas may extend down to the cervix and leave insufficient healthy myometrium for anatomic restoration of the lower segment after delivery (Figure 6) and lack the requisite contractility and elasticity to contract sufficiently to stop bleeding. Thus, the surgeon must recognize and exercise sound judgment about when to abandon the approach of resection and repair and default to cesarean hysterectomy, even with absent histopathology-confirmed PAS.[67]

FIGURE 4
Bladder-uterine fusion after multiple CDs



A, Longitudinal transabdominal view of the LUS at 32 weeks of gestation in a patient with 4 previous CDs presenting with a bilobate placenta (P) and the edge of the lower placental lobe (LPL) at <2 cm from the internal os of the cervix. Under gentle abdominal pressure with the ultrasound probe, the top of the bladder remains at the same level compared with the uterine wall. The uterobladder interface is echogenic and rigid as a result of the fusion of the bladder and LUS serosa and secondary fibrosis. **B,** CDI mapping of the subplacental circulation showing enlarged large vessels under the LPL.

AC, amniotic cavity; *CD*, cesarean delivery; *CDI*, Color Doppler Imaging; *LUS*, lower uterine segment.

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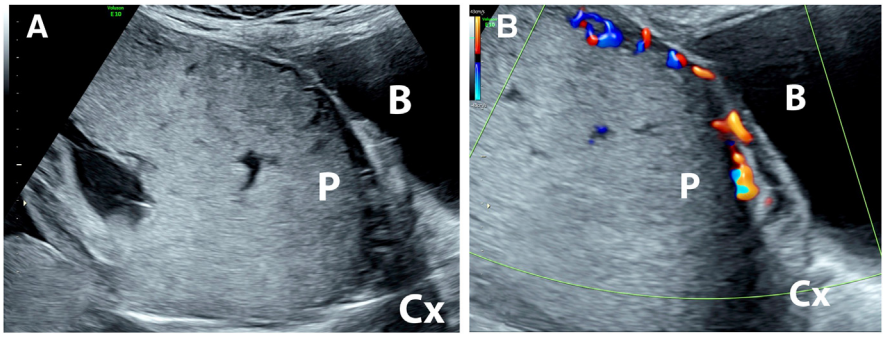
The role of imaging

With increased awareness of an association between a previous CD and placenta previa accreta, many patients at risk are now also screened for PAS.[5] Prenatal identification of patients at high risk of PAS at birth reduces maternal hemorrhagic morbidity.[73] Most studies have focused on individual imaging markers or determining the sensitivity and specificity of antenatal screening for PAS. In contrast, few studies have gone a step further to evaluate the role of ultrasound and magnetic resonance imaging (MRI) in identifying imaging signs that indicate anatomic changes that can affect the risk of intraoperative complications in subsequent CDs.[74] Overall, imaging has been underused for the preoperative evaluation of the surgical risks and can lead to an under- or overestimation of the risk of intraoperative difficulty. Table 1 presents an ultrasound imaging protocol that may contribute to surgical planning.

Abnormalities of uterine contour, including the loss of the clear zone, myometrial thinning, and a bulgelike appearance of the LUS on ultrasound (Figure 6), are commonly used in the antenatal evaluation of patients at risk of PAS (Figures 5 and 6).[75,76] There is no difference in the distribution of these signs between a regular placenta previa and a placenta previa accreta because these sonographic findings are secondary to LUS scarification and remodeling

FIGURE 5
Placenta previa non-accreta with minor remodeling of the LUS



A, Longitudinal transabdominal view of the LUS at 28 weeks of gestation in a patient with 2 previous CDs presenting with a placenta previa covering the internal os of the cervix. **A,** the upper part of the LUS is thin but the lower part appears anatomically normal; **B,** CDI mapping of the subplacental circulation shows no increase in vascularity.

B, bladder; *CD*, cesarean delivery; *CDI*, Color Doppler imaging; *Cx*, cervix; *LUS*, lower uterine segment; *P*, placenta.

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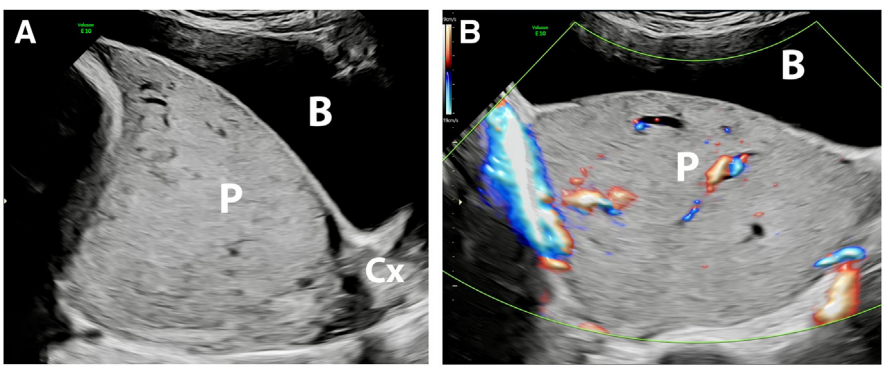
rather than to accreta placentation and, therefore, may not differentiate between difficult CD because of extended LUS scarification and PAS.[65,67] There is currently no standardized ultrasound criterion for the diagnosis and extension of LUS remodeling, and there is no prospective data on the role of MRI in evaluating the surgical complexity of a CD beyond the association of imaging findings with estimated blood loss at delivery.

Placentation in the LUS is associated with physiological vascular changes that may increase morbidity in patients with a history of CD. In placenta previa, the changes in subplacental vasculature in the early second trimester of pregnancy are similar in ongoing CSEP and low-implanted controls next to a CSD.[35] In CSEPs that progress to PAS, the development of placental tissue in proximity of large diameter arteries of the outer uterine wall leads to a further increase in the uteroplacental circulation.[36] The definition of what constitutes subplacental or uterovesical "hypervascularity" in the second half of pregnancy remains elusive.[77] When combined with changes in the intervillous circulation, that is, placental lacunae with large feeder vessels (Figure 7), these signs increased the odds of cesarean hysterectomy and massive transfusion (Table 1), independent of the presence of PAS at delivery.[64] Moreover, small accreta areas can affect the entire LUS circulation,[36] parametrial circulation, and existing arterial anastomoses with the bladder (Figure 2). The prenatal evaluation of the size and vascular mapping of the suspected accreta area may help the surgical team in planning the procedure, but there is currently no prospective data on this approach.

Thick and dense adhesions (Figure 1) require extensive dissection, which, when combined with LUS dehiscence, bulging, and hypervascularization in a patient presenting with an anterior placenta previa, constitute the most complex grade of CD with and without part of the placenta being accreta. A new transabdominal sonographic sign has recently been described that could detect intra-abdominal adhesions in pregnant patients undergoing repeat CD.[78–80] This sign evaluates the sliding of the uterus under the inner part of the rectus fascia during deep breathing, and its absence (sliding-negative) predicts severe intra-abdominal adhesions. When validated, this sign could be useful in identifying patients who are at risk of complex CDs related to an extended abdominopelvic adhesive disease.

TVS has been underused in the management of abnormal placentation probably because it is not used in routine obstetrical ultrasound practice. However, TVS is essential to the differential diagnosis of a low-lying placenta or placenta previa[81] and indispensable for the examination of patients with high body mass index. Moreover, TVS is pivotal to the follow-up of patients diagnosed with a placenta previa at the midgestation scan with and without ultrasound signs suggestive of PAS and may contribute to both prenatal

FIGURE 6
Placenta previa non-accreta with major remodeling of the LUS



A, Longitudinal transabdominal views of the LUS at 36 weeks of gestation in a patient with 4 previous CDs presenting with a placenta previa covering the internal os of the cervix and showing a LUS thickness of <1 mm with bulging of the placenta toward the bladder; **B,** Transverse transabdominal view with CDI mapping of the subplacental and lateral uterine circulations showing no increase in vascularity.

B, bladder; *CD*, cesarean delivery; *CDI*, Color Doppler Imaging; *Cx*, cervix; *LUS*, lower uterine segment; *P*, placenta.

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TABLE 1
Ultrasound imaging protocol for the preoperative assessment of patients with a history of multiple CDs

Ultrasound signs	Likely pathology	Surgical risks[62,64]
Thin (<3 mm) LUS myometrium with bulging of the fetal presentation toward the bladder, but with at least 1−2 cm of healthy myometrium between the LUS and the bladder (Figure 3)	CD scar with LUS disruption and dehiscence ("uterine window")	Bladder injury. May require focal resection and repair of the LUS
Anterior placenta previa covering the entire LUS, within 2 cm of healthy myometrium, but not reaching the internal os, with a myometrial thickness of >1 mm. No additional abnormal placentation sign (Figure 4)	Low-lying placenta	Bladder injury and uterine atonia with bleeding from the placental bed with need for the use of a tamponade balloon
Placenta previa covering the cervix with a myometrial thickness of >1 mm. No additional abnormal placentation sign (Figure 5)	Placenta previa	Bladder injury and uterine atonia with bleeding from the placental bed, need for transfusion and placement of a tamponade balloon and/or compressive suture
Anterior placenta previa reaching or covering the cervix with myometrial thinning (<1 mm) and placental bulge toward the bladder and/or parametria. No additional abnormal placentation sign (Figure 6)	Placenta previa with cesarean scar defect	Bladder injury and need for transfusion and hysterectomy if extended scarification of the LUS, with inability to effectively reapproximate hysterotomy edge and repair
Anterior placenta previa reaching or covering the cervix with myometrial thinning (<1 mm), placental bulge toward the bladder and/or parametria, and increased uteroplacental, paracervical, intraplacental (multiple lacunae), and pelvic vascularity (Figure 7)	High probability of placenta previa accreta	Bladder injury, need for massive transfusion (>10 RBC units) and emergent hysterectomy

CD, cesarean delivery; *LUS*, lower uterine segment; *RBC*, red blood cells.

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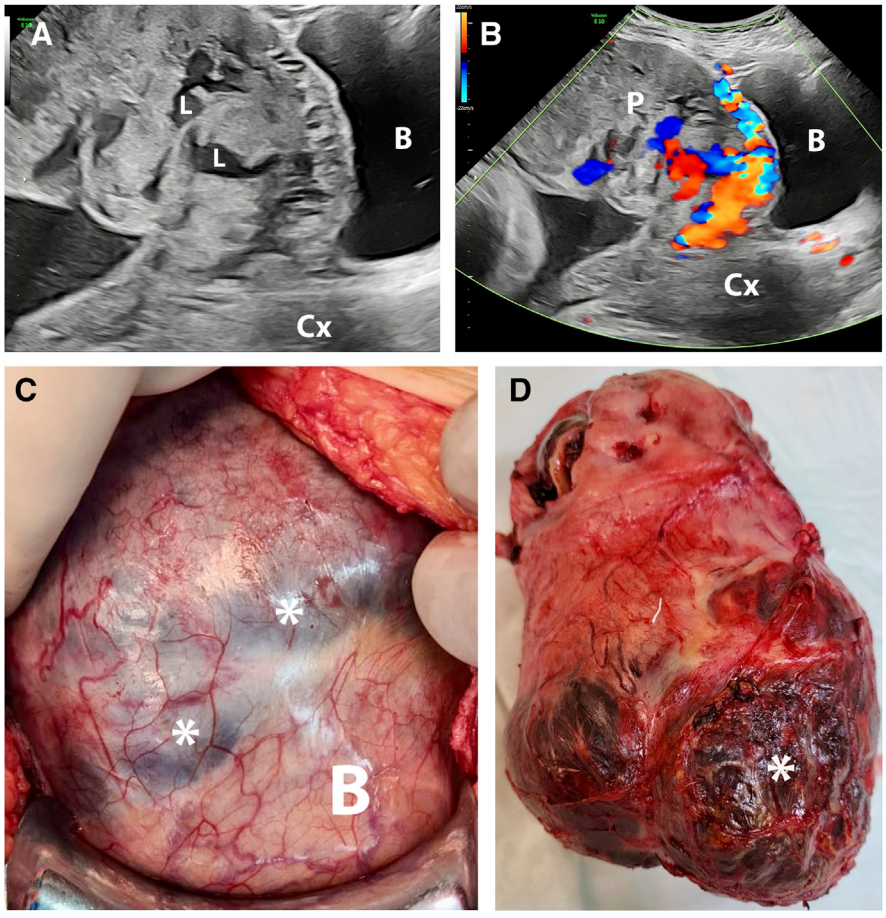
management and prediction of surgical outcomes (Table 1), particularly when the cervix is involved.[7,77,82] For example, a short cervical length (<3 cm) and a placenta with a thick edge (>1 cm) on TVS increase the odds of MOH and emergent cesarean hysterectomy in patients presenting with a complete placenta previa in the third trimester of pregnancy.[83–85]

The role of intraoperative description and histopathology

Histopathology of hysterectomy specimens contributes little to the management of the individual patient, as surgery necessarily occurs before histopathology is available. The prenatal ultrasound identification of a low-lying placenta or placenta previa is standardized.[81] In contrast, PAS is a clinicohistopathologic diagnosis, and thus, prenatal imaging can only screen or identify patients with a high probability of the condition at birth.[77] As many patients with a history of multiple previous CDs presenting with a placenta previa will also have extended uterine remodeling, the photographic recording of intraoperative findings and detailed histopathologic examination are essential steps to obtain accurate epidemiologic data, to improve the quality of prenatal imaging and evaluate the outcome of different management strategies.

Clinical classification systems[86–88] are prone to confirmation bias, with the surgeon more likely to "confirm" what has been reported on prenatal imaging, and pathologists may upgrade or downgrade their diagnosis based on what the surgeon has reported.[64] In particular, this situation affects the differential diagnosis between placenta previa and placenta previa accreta in

FIGURE 7
Placenta previa with LUS remodelling and utero-placental vascular changes



A, Longitudinal view of the LUS at 35 weeks of gestation in a patient with 4 previous CDs presenting with a placenta (P) previa partially covering the internal os of the cervix (Cx) with large lacunae (L) and bulging of the placenta toward the bladder (B). **B,** CDI mapping showing the increased subplacental vascularity with feeder vessels entering the lacunae (L). **C,** Intraoperative view showing the area of focal uterine disruption and dehiscence above the bladder insertion (*asterisk*). **D,** Hysterectomy specimen showing the placental basal plate protruding through the LUS (*asterisk*) after dissection of the uterine serosa.

CD, cesarean delivery; *CDI*, Color Doppler Imaging; *LUS*, lower uterine segment.

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patients with an LUS remodeled by multiple previous CDs. Both groups of patients will present with loss of the clear zone, myometrial thinning, and a bulgelike appearance of the LUS on prenatal imaging and thick and dense pelvic adhesions and large dehiscence of the LUS at laparotomy.[65,67] These cases have been increasingly reported as placenta percreta with large retrospective cohort studies reporting an incidence of >50% of percreta but with little or no detail on the histopathologic criteria used to confirm the clinical diagnosis.[89,90] In these cases, the villous tissue is almost always contained within a thin shell of thin fibrous myometrium and serosa, and it is the surgical manipulation and dissection that lead to shell disruption and, therefore, a false diagnosis of placenta percreta.[64]

Newer grading systems, such as those developed by the International Federation of Gynecology and Obstetrics[91] and the Society for Pediatric Pathology,[92] aim to (1) differentiate superficial types of PAS (placenta creta or adherent) from other causes of retention, such as subacute abruption or accessory lobes, by requiring histologic examination of the delivered placenta, surgical excision, or gravid hysterectomy specimen; (2) recognize that the deep types of PAS that were previously described as "invasive" (increta or percreta) represent uterine remodeling rather than true tumorlike invasion so that surgical risk is determined by the location and extent of LUS remodeling and hypervascularization and adhesions rather than any intrinsic property of the placenta. As such, the increta or percreta terminology is replaced by grade 3 for all cases where the uterine wall under the placenta is thinned by >75% and qualified as to the degree of preoperative or intraoperative surgical disruption of the LUS.[92]

Management and training

The pathophysiological changes described above make placental delivery hazardous and surgical resection technically difficult, especially when located low within the pelvis, whether the placenta is accreta or not. In Table 2, we propose a new classification from which to record the preoperative level of surgical difficulty for CD, based on patient obstetrical history and prenatal findings, and the resources required, and on existing guidelines for the management of anomalies of placentation.[7,93,94] The level ranges from an elective CD for which all general obstetrician-gynecologists should be adequately trained, to one in which fetal malpresentation because of a large LUS fibroid may require a second senior operator, and to a placenta previa covering the internal os with or without an accreta area, which requires specialized multidisciplinary team (MDT) management. Because of the wide variation in expertise in both high-income countries and low- to middle-income countries (LMIC), this classification needs to be evaluated prospectively in different setups.

The role of the multidisciplinary team

An MDT is relatively a novel concept that was developed to address the

TABLE 2
Classification of the level of surgical difficulty at elective CD

Classifications	Resources required[93–95]
Level I Standard CD - Malpresentation breech, transverse lie, or unstable lie - Multiple pregnancy - Posterior low-lying placenta or marginal placenta previa - Repeat CDs of ≤3 with no suspected placental anomaly - Vasa previa absent in other operations - Maternal infection (primary genital herpes or HIV) - Maternal diabetes mellitus with polyhydramnios fetal macrosomia - Fetal anomalies likely to obstruct the labor (hydrocephaly or tumor) - Previous major shoulder dystocia or third- and fourth-degree perineal tears - Maternal request	Obstetrics and gynecology surgeon and qualified assistant (resident, trainee, or surgical assistant)
Level II Specialist CD - Anterior low-lying placenta or marginal placenta previa in nulliparous patients - LUS fibroids obstructing low transverse hysterotomy, especially with malpresentation - Very premature CD (<28 wk) for severe FGR requiring a classical CD - Repeat CD of ≥4 - Repeat CD with ultrasound or MRI evidence of major LUS remodeling - Repeat CD for patients with history of prior major abdominal surgery, such as for bladder or bowel disorders, uterine reconstruction (repair of didelphys or multiple myomectomies), or abdominal trauma - CD in a patient with renal transplant in the pelvic fossa	1–2 senior obstetrics and gynecology surgeons Blood products immediately available if anterior placenta previa is present Urology or abdominal surgeon available as required
Level III MDT CD - Placenta previa covering the cervix in patients with previous CDs - Anterior low-lying placenta or placenta previa with ultrasound or MRI evidence of major LUS remodeling (Table 1) - Low-lying placenta or placenta previa with imaging signs indicating a high probability of PAS (Table 1)	2 senior obstetrics and gynecology surgeons Blood products immediately available 2 senior anesthesiologists Urology surgeon available

CD, cesarean delivery; *FGR*, fetal growth restriction; *LUS*, lower uterine segment; *MRI*, magnetic resonance imaging; *MTD*, multidisciplinary team; *PAS*, placenta accreta spectrum.

Jauniaux. Complex cesarean sections. Am J Obstet Gynecol 2023.

management of complex CDs associated with PAS. Patients at high risk of PAS diagnosed prenatally and managed by an MDT are less likely to require large-volume blood transfusion and reoperation for bleeding complications compared with patients managed by standard obstetrical care,[95] even in cases of unexpected PAS.[96] Data on blood transfusion volume, surgery duration, and the overall perinatal outcome may be biased by the experience of the operating team but are certainly useful to show improvement in the management of complex CDs, as the team becomes more experienced. If it is possible to accurately identify these complex cases not associated with PAS, it is likely worthwhile to care for those patients with an MDT. Of course, cost-benefit must be shown in prospective studies.

Training the next generation

The lack of experience and inadequate surgical techniques are the most frequent problems associated with maternal deaths in PAS.[97] Although there may not be evidence of accreta placentation in many of these cases, validated methods of assessment are required to assure the surgical competency of future obstetrical specialists in performing complex CDs. The Objective Structured Assessment of Technical Skills (OSATS) tool has been used to assess the capacity of an obstetrician to perform a CD. Trainee feedback suggests that the effectiveness of the tool diminishes as the seniority of the trainee increases, with technical competence assessed less effectively in more complex procedures.[98] Training progression is associated with a reduction in procedure time and estimated blood loss at CD, which are both surrogate markers of competence recorded in a surgical logbook and should be used with the OSATS tool to provide a more comprehensive assessment of overall competence.[99]

The experience of a local hospital in Colombia was recently published, in which the authors described the influence of an interinstitutional collaboration with a PAS expert group in Argentina through virtual channels after a brief face-to-face training program.[100,101] This expert group supervised surgical techniques and supplied remote assistance. The hospital observed

marked improvements in clinical outcomes and quality of care and, thus, concluded that this method of training could be an appropriate alternative to improve the surgical experience and clinical outcomes of PAS, especially in LMIC. In addition, educational films and on-line learning can be integrated into the training programs, providing accessible, relevant, and sustainable training tools for global audiences.[102]

Conclusion

CD is one of the most frequently performed major surgical procedures worldwide. Although CD is often routine, it sometimes is a complex surgical procedure, even in the absence of PAS. The risks of all complications increase with the number of previous CDs. To improve the outcomes for complex CDs, we need a more systematic approach to the imaging evaluation of increased pelvic vascularity, uterine dehiscence, and adhesions, and we need to establish expert MDTs with training posts to allow the next generation of obstetrician-gynecologists to acquire the necessary skills to manage complex CDs (Videos 1 and 2). ■

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