Clinical Expert Series

Placenta Accreta Spectrum

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Placenta accreta spectrum (PAS) is one of the most dangerous conditions in pregnancy and is increasing in frequency. The risk of life-threatening bleeding is present throughout pregnancy but is particularly high at the time of delivery. Although the exact cause is unknown, the result is clear: Severe PAS distorts the uterus and surrounding anatomy and transforms the pelvis into an extremely high-flow vascular state. Screening for risk factors and assessing placental location by antenatal ultrasonography are essential for timely diagnosis. Further evaluation and confirmation of PAS are best performed in referral centers with expertise in antenatal imaging and surgical management of PAS. In the United States, cesarean hysterectomy with the placenta left in situ after delivery of the fetus is the most common treatment for PAS, but even in experienced referral centers, this treatment is often morbid, resulting in prolonged surgery, intraoperative injury to the urinary tract, blood transfusion, and admission to the intensive care unit. Postsurgical complications include high rates of posttraumatic stress disorder, pelvic pain, decreased quality of life, and depression. Team-based, patient-centered, evidence-based care from diagnosis to full recovery is needed to optimally manage this potentially deadly disorder. In a field that has relied mainly on expert opinion, more research is needed to explore alternative treatments and adjunctive surgical approaches to reduce blood loss and postoperative complications.

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chosocial and emotional problems, and decreased quality of life.⁶–⁸

INCIDENCE

The incidence of PAS may be increasing. By pooled estimates, PAS now occurs in 0.17% of pregnancies (1/588) [95% CI 0.01–1.1%]² compared with a much lower incidence in the 1970s and 1980s at 0.02% (1/4,027) and 0.04% (1/2,510), respectively.⁹,¹⁰ Accurate population-based statistics are hard to come by because PAS coding did not exist until the most recent International Classification of Diseases coding nomenclature¹¹ and because disease definitions are evolving.¹²–¹⁴ The increasing rate of PAS is likely attributable to a change in risk factors, most notably the increased rate of cesarean delivery.¹⁵–¹⁸

CAUSE AND RISK FACTORS

The exact cause of PAS is unclear. Historically, it was proposed that PAS resulted from abnormal trophoblast invasion much like dysregulated proliferation of cancer cells¹⁹,²⁰; however, newer models of PAS focus more on an inciting event of trophoblast attachment to an abnormal uterine wall and subsequent placental growth within a progressively remodeled and dehisced uterine scar.²¹–²³

The most significant risk factor for PAS is placenta previa diagnosed in a patient with a history of cesarean delivery.¹⁵,²⁴ In these patients, PAS likely develops because of embryo implantation in or near the area of the uterine scar. In PAS, trophoblasts implant into the myometrium directly with no intervening decidua. Abnormal angiogenic and growth factor signaling, including local abundance of vascular endothelial growth factor, results in proliferative transformation of the uterine arterioles and pelvic vessels early in pregnancy.²⁵,²⁶ Placenta accreta spectrum may also occur in other areas of uterine insult such as after myomectomy or in association with disorders of endometrial scarring or infertility. Very rarely, PAS occurs in patients with no known uterine instrumentation or other known risk factors.

Other risk factors include other uterine surgeries, Asherman syndrome, prior endometrial ablation, multifetal pregnancy, and in vitro fertilization, with relative risks in the literature ranging from 2–7 compared with baseline and persisting when adjusted for factors such as maternal age and prior cesarean delivery.²⁷–²⁹

CLASSIFICATION

Classification of PAS is evolving to reflect a newer understanding of the disease. According to historical schemas based on histopathologic assessment alone, abnormal trophoblast location in the myometrium was diagnosed as accreta, increta, or percreta according to increasing depth of perceived invasion within the myometrium.²⁰,³⁰–³² The usefulness of the historical classification has recently been challenged because its focus on progressive trophoblastic invasion seems contrary to observations from antenatal imaging, intraoperative findings, and targeted pathologic evaluation.²²,³³ In 2019, the International Federation of Gynecology and Obstetrics (FIGO) proposed a scheme of classification for the clinical diagnosis of PAS disorders.¹¹ In 2020, a panel of experts convened and published a document on classification and reporting of pathologic diagnosis of PAS disorders that roughly parallels the FIGO guidelines.¹⁴ These contemporary schemas, which are presented in Table 1, identify abnormal trophoblast attachment as the defining and inciting histopathologic characteristic of milder PAS (FIGO 1, PAS grade 1) but redefine progression of PAS to more severe forms (FIGO 2–3, PAS grades 2–3) based on the visible appearance and location of the placenta within a remodeled uterus and surrounding maternal structures.¹³,¹⁴ Regardless of the underlying pathophysiology, the result is clear: Severe PAS is characterized by significant distortion of the uterine and pelvic anatomy and impressive transformation of the placenta and pelvis into a potential source of massive hemorrhage.

DIAGNOSIS

The tools for diagnosis of PAS are imperfect, and many patients are not diagnosed until the time of delivery. When diagnosis is not made until delivery, management may occur in a hospital setting lacking necessary resources, which can result in worse outcomes.³⁴,³⁵ Investigation of promising biomarkers for PAS is underway,³⁶,³⁷ but broadly available and clinically useful blood or urine tests to predict PAS do not currently exist. It is important to note that a patient’s prior risk should not be dismissed on the basis of a reassuring ultrasound study. Consequently, risk-factor assessment and ultrasonography should be the foundation of PAS screening and diagnosis. Magnetic resonance imaging (MRI) may be preferred for diagnosis in some institutions, but its routine use is limited by higher cost and limited availability of expertise in MRI interpretation for PAS.

Assessment of Risk

For the clinician, diagnosis starts with understanding risk and developing an appropriate index of suspicion for PAS. Clinicians and ultrasonography units should screen for history of cesarean delivery and inquire about any other uterine surgeries. Unlike imaging, this step
does not require advanced expertise, yet it is probably
the most important aspect of screening for PAS because
it influences imaging interpretation considerably. For
instance, the presence of placental lacunae or subpla-
cental vascularity is significantly more concerning in a
patient with four prior cesarean deliveries compared
with the identical ultrasonographic findings in a patient
with no uterine surgery history. In the former, these

Table 1. Comparison of Current and Historical Classification Systems for Placenta Accreta Spectrum Based on Contemporary Expert Consensus Guidelines\textsuperscript{13,14}

<table>
<thead>
<tr>
<th>Pathology Classification\textsuperscript{*} (PAS)\textsuperscript{14}</th>
<th>Description</th>
<th>Clinical Classification\textsuperscript{†} (FIGO)\textsuperscript{13}</th>
<th>Description</th>
<th>Historical Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Layer of decidualized endometrium separates placenta from myometrium</td>
<td>Normal</td>
<td>Placenta able to be separated (spontaneously or manually) after delivery</td>
<td>Placenta adherent Placenta creta</td>
</tr>
<tr>
<td>Grade 1</td>
<td>Areas of absent decidua between villi and myometrium; uniform myometrial thickness without thinning</td>
<td>Grade 1</td>
<td>Adherent placenta, unable to manually develop a clean plane of separation between placenta and myometrium; often requires curettage</td>
<td>Increta</td>
</tr>
<tr>
<td>Grade 2</td>
<td>Irregular placenta-myometrium interface, without involvement of outer myometrium (less than 75% of myometrial thickness); intact uterine serosa</td>
<td>Grade 2</td>
<td>Abnormal macroscopic findings over placental bed: placental bulge; hypervascularity; dimple sign, with uterus pulling in on gentle cord traction</td>
<td>Increta</td>
</tr>
<tr>
<td>Grade 3</td>
<td></td>
<td>Grade 3</td>
<td>Macroscopic findings over placental bed and placental tissue seen through surface of uterus without extension to other organs Appearance of uterine window with base of placenta visible through extremely thin myometrium or single layer of serosa</td>
<td>Increta or percreta (for histologic placenta accreta spectrum 3A) and percreta (for clinical FIGO 3a)</td>
</tr>
<tr>
<td>3A</td>
<td>Irregular placenta-myometrium interface, placental involvement of outer myometrium (more than 75% thickness); intact uterine serosa</td>
<td>3a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D</td>
<td>Deep myometrial invasion with disruption of serosal surface</td>
<td>3b</td>
<td>Involvement of urinary bladder; clear surgical plane cannot be identified between uterus and bladder</td>
<td>Percreta</td>
</tr>
<tr>
<td>3E</td>
<td>Extraterine extension with placental invasion into, or fibroadipose tissue extension to, extraterine structures</td>
<td>3c</td>
<td>Involvement or invasion of other pelvic tissues or organs (may also include bladder)</td>
<td>Percreta</td>
</tr>
</tbody>
</table>

PAS, placenta accreta spectrum; FIGO, International Federation of Gynaecology and Obstetrics.
\textsuperscript{*}Requires hysterectomy or partial hysterectomy specimen; findings from delivered placentas and curettings are considered separately from PAS and designated basal plate myometrial fibers.
\textsuperscript{†}Does not require pathologic specimen because grades are assigned based on intraoperative findings.
findings could confirm the diagnosis; in the latter, the findings would likely be considered normal variations. Other risk factors mentioned previously are associated with PAS, albeit less strongly, and should prompt close evaluation for PAS signs.

Patients with risk factors for PAS should undergo systematic evaluation of the placenta at multiple times starting early in pregnancy. Evidence of PAS or cesarean scar ectopic pregnancy, particularly abnormal vascularity and low placental implantation, can be detected as early as the viability ultrasonogram at 6–10 weeks of gestation. In the second trimester, patients with any number of prior cesarean deliveries should have the placental location defined in relation to the cervix and the area of low transverse cesarean scar(s). The scarred area typically is located just above or at the level of the cervix in the second and third trimesters for patients with prior term low transverse cesarean delivery(ies), although scar location may be higher in cases of prior classical cesarean delivery. If the placenta is located well above and away from the level of the prior scar(s), the risk of PAS in the lower uterine segment is likely exceedingly low. Conversely, if the placenta overlies the anterior lower uterine segment (ie, forms a previa or is low lying and extends onto the area of prior hysterotomy), a thorough evaluation for ultrasonographic signs of PAS is recommended.

Ultrasoundography

In patients at risk, ultrasonography is the primary screening and diagnostic modality. The most important sign for PAS is placenta previa because it modifies the risk for disease and morbidity most strikingly. When previa is present in patients with prior cesarean delivery, the risk of PAS is considerable and increases with the number of prior cesarean deliveries (3%, 11%, 40%, 61%, and 67%, for the first, second, third, fourth, and fifth or more cesarean delivery, respectively). The Society for Maternal-Fetal Medicine (SMFM) convened a task force to define the most important ultrasound signs related to PAS. Descriptions of these markers are found in Appendix 1, available online at http://links.lww.com/AOG/D194. The most common signs are a loss of the normal hypoechoic “clear” zone between the placenta and myometrium, myometrial thinning (less than 1 mm), placental lacunae, subplacental hypervascularity, and bridging vessels, although these and other signs of PAS are surprisingly common in unaffected pregnancies. Additional signs include placental bulging, bladder wall interruption, exophytic mass, and uterovesical hypervascularity. Investigations continue in the search for new, potentially more helpful signs. Transvaginal imaging with sweeps of the lower uterine segment can be invaluable to evaluate the lower uterine segment in higher resolution. No individual sign is highly predictive of PAS, so a combination of findings and a patient’s a priori risk help to determine the overall suspicion.

Models to predict the risk of PAS on the basis of the number and character of ultrasonographic signs have been proposed, but they are not yet adequately validated in external cohorts. Predictive models to date suffer from imprecision and unsatisfactory rates of false-negative results (missed diagnoses). It is important to note that the absence of ultrasound findings for PAS does not rule out the diagnosis in patients with previa and clinical risk factors.

Magnetic Resonance Imaging

The role of MRI in PAS diagnosis is less well defined. MRI may provide helpful information in select cases and in institutions with special expertise in interpreting placental MRI. In high-risk cohorts, MRI may be equivalent to ultrasonography in diagnostic accuracy. However, caution is warranted in interpreting these data because MRI research for PAS is typically performed in busy referral centers and only in patients who have very high suspicion for PAS based on ultrasonography.

The most common MRI features associated with PAS are abnormal uterine bulging, dark intraplacental bands on T2-weighted imaging, disruption of the uteroplacental zone, disorganized placental vasculature, and heterogeneous placental signal intensity. On MRI, placenta previa and placental bulging are the most reproducible signs, although they are often present in nonaccreta cases. Use of MRI for diagnosis may be preferred in some institutions, and its use is under active investigation in PAS research centers, but clinicians should not presume that MRI will be a helpful adjunct to ultrasonography in every setting. Expertise in the diagnosis of PAS varies by institution, and, similar to ultrasonography, the diagnostic accuracy of MRI is likely worse outside of experienced referral centers. Given its cost and uncertain utility, we believe that MRI should be used only when it is likely to offer important clinical information about the disease character or location beyond what ultrasonography can provide.

Antenatal Staging and Morbidity Prediction: The Future of Placenta Accreta Spectrum Diagnosis?

Detecting PAS is an important first step of diagnosis, but it is not the whole story. Placenta accreta spectrum
investigators and surgeons are further interested in questions of location and extent (or topography) of PAS. This is important work; the surgical teams preparing for management of PAS need better predictive models for morbidity and better staging paradigms for PAS. Antenatal staging paradigms exist, but few have been validated outside of the facilities from which they originate.\textsuperscript{52}

On a fundamental level, members of the PAS diagnostics team should be able to provide answers to key questions that will be helpful to the surgical team. How certain are we that this patient has PAS? Where is the placenta located in the uterus and pelvis? Where can surgical difficulty be anticipated? Answering these questions helps to formulate the right team, the right time to deliver, and the right approach to treatment. An ideal staging paradigm therefore would incorporate the history with easily identifiable imaging signs into a model to accurately predict PAS morbidity and surgical expectations rather than simply the presence of PAS.

In summary, even at highly specialized referral centers, PAS diagnosis is difficult and imperfect. When approaching the challenge of screening and diagnosis, clinicians should maintain a high index of suspicion and a low threshold for referral to specialty centers with PAS expertise.

**SYSTEM PREPAREDNESS**

System preparedness may be more important than an individual clinician’s experience or skill in ensuring safe and effective care for patients with known or suspected PAS. Preparing a health system, hospital, and clinical team for PAS care is challenging because of the relatively low incidence, high level of expertise required, and extraordinary number of hospital-based resources needed. Leading international organizations have provided guidelines for the management of PAS, including lists of resources and services necessary to plan and manage cases of PAS.\textsuperscript{5,53,54} Furthermore, the American College of Obstetricians and Gynecologists (ACOG) and SMFM endorse a practice of referral to specialized centers and regionalization of care for PAS,\textsuperscript{5,55} but health care professional surveys and state-level data suggest that referral to higher levels of care has not yet become universal practice.\textsuperscript{56–58}

Unfortunately, the rate of missed diagnosis of PAS remains high (up to 50%).\textsuperscript{59,60} All facilities offering obstetric care should therefore prepare an action plan for unexpected cases and routinely engage in comprehensive self-assessment to determine whether routine PAS care should be performed locally (see the Assessment of Resources for Placenta Accreta Spectrum section) or referred to more experienced centers. To improve readiness, preparation, and response to cases of PAS, SMFM developed checklists (found at https://www.smfm.org/checklists-and-safety-bundles) that can be used for self-assessment. These checklists also specifically address unexpected cases of PAS and can assist institutions that may be underresourced to manage unexpected cases of PAS.

**Assessment of Resources for Placenta Accreta Spectrum**

A first step for hospitals providing obstetric care is to determine whether they have the resources and expertise to manage planned cases of PAS. At minimum, ACOG and SMFM state that hospitals planning to manage patients with “suspected accreta or placenta previa with prior uterine surgery” should have the available resources of a Maternal Level of Care III (subspecialty) or higher facility.\textsuperscript{55} Specifically, hospitals should have immediate 24-hour access to the following: 1) blood bank services with ability for massive transfusion; 2) neonatal and adult intensive care facilities; and 3) obstetric and surgical expertise in managing complex maternal and obstetric complications such as PAS. Admittedly, not enough is known about quality metrics and case volumes to make recommendations about what constitutes a minimum level of expertise required for PAS care. However, if the relationship between case volume and quality metrics in PAS mirrors that in other surgeries, low-volume surgeons and low-volume facilities are likely to experience worse outcomes compared with high-volume surgeons and centers.\textsuperscript{51,62}

Determining what constitutes adequate expertise for PAS management is therefore a critical knowledge gap in the field. This and other high-priority items are noted in Box 1.

**Optimizing Care and Preparing for Placenta Accreta Spectrum**

Hospitals and teams serving as PAS referral centers should work systematically to ensure optimization of PAS care. Placenta accreta spectrum referral centers should have a designated interdisciplinary team committed to case review, iterative team learning, and a culture of continuous quality improvement. An effective interdisciplinary PAS team is characterized by the following: 1) coordination by a program champion or champions; 2) membership from maternal–fetal medicine, obstetrics, gynecologic surgery, anesthesia, critical care, interventional radiology, and neonatology; 3) ability to quickly mobilize an experienced surgical team at all times; 4) interdisciplinary treatment planning meetings or
formalized communication; and 5) standardized evidence-based approaches to PAS diagnosis, staging, and management.

Conversely, obstetric hospitals and teams with lesser resources or experience should establish pathways and partnerships for referral to higher levels of care. Referral should occur as early as possible: at the time of diagnosis or when there is uncertainty about the diagnosis. This allows early confirmation or re-evaluation of the diagnosis, ideally before 26–32 weeks of gestation, and care coordination and case planning in the facility that is most appropriate for the level of concern. Referral at the time of delivery in unexpected cases is also possible and preferable in some circumstances (Fig. 1).

COORDINATED ANTENATAL MANAGEMENT

Antenatal Care

Comprehensive antenatal care for patients with suspected PAS begins with detailed risk stratification for tailored counseling and goals-of-care discussion. Identification of any PAS risk by either obstetric history or routine imaging warrants additional dedicated discussion of uterine procedural history and plan for timely obstetric imaging focused on PAS severity assessment as described in the diagnosis section. Personalized counseling for PAS needs to be both practical and emotionally supportive, taking into account the best estimate of a priori risk from a thorough risk-factor assessment, predicted severity of disease incorporating current clinical factors and imaging findings, and potential for morbidity, including possible threat to future fertility. Although risk stratification may evolve over serial imaging studies in the pregnancy, the conversation that first introduces the possibility of PAS needs to emphasize where a patient can turn for reliable information. Finding information is as easy as accessing the internet; however, the range and intensity of information relating to PAS can be overwhelming. For the vast majority of pregnant patients, the possibility of mortality is unexpected, so discussing the concept of PAS, its associated threat to health, and medical management options during pregnancy is important as soon as the a priori risk is determined to be high or the diagnosis is suspected.

From a practical standpoint, once clinically significant PAS is suspected, the essential components of antenatal care include proactively mitigating hemorrhage risk, arranging the timing and location of delivery, and coordinating the multidisciplinary team. If adequate resources and expertise are not available locally, referral to a center with PAS expertise is strongly advised. The predominant risk with a PAS diagnosis is obstetric hemorrhage, making timely assessment of hematologic parameters and iron stores a necessity. Laboratory screening for anemia at 24–28 weeks of gestation and treatment for hemoglobin levels less than 10.5 g/dL or serum ferritin levels lower than 30 ng/dL, which is recommended in all pregnancies, is critical in this population. Optimizing hemoglobin before delivery may require high-concentration iron replacement with intravenous iron formulations. Treatment thresholds specific to PAS for hemoglobin or serum ferritin have not been established, but given safety and efficacy data, late second or early third trimester administration of intravenous iron rather than oral iron is reasonable for any degree of anemia or iron deficiency. For patients with unique circumstances (eg, refusal of blood products, complex antibodies), additional considerations may be warranted, including perioperative erythropoietin, intraoperative cell salvage, or acute normovolemic hemodilution.

Anticipation of blood loss and plans for intraoperative management should be discussed in coordination with anesthesiologists familiar with obstetric hemorrhage and resuscitation. Early consultations with anesthesiologists and surgical specialists who can provide expert review and knowledgeable predictions of what the patient and family may anticipate around the time of delivery are fundamental to prepare both the patient and the care team. Neonatal expectations must be discussed as well given that most PAS deliveries will occur preterm (ie, before 37 weeks of gestation). Antenatal corticosteroid administration may be indicated when a preterm delivery is planned.

In addition to planning intended delivery scenarios, the team needs to establish contingency plans for how and where the pregnant patient can seek appropriate care in the case of complications such as antenatal hemorrhage or early labor signs. Consideration of inpatient admission is individualized, balancing both clinical factors and availability of resources in close proximity to the patient’s home. Throughout the pregnancy, effective and frequent communication between the pregnant patient and the multidisciplinary team should be prioritized.

Delivery Timing

Delivery timing recommendations are driven by expert opinion and are strongly influenced by data from pregnant patients with placenta previa. International professional organizations, including ACOG and SMFM, advocate for delivery of patients with suspected or confirmed PAS at 34 0/7–35 6/7 weeks of gestation in the absence of bleeding or labor. Later
delivery near term may be safe in selected cases, including those without placenta previa, but it is unclear what combination of other reassuring factors (eg, history of term birth, long cervical length, or less severe disease) might contribute to robust risk stratification for later delivery. A systematic inquiry of high-volume centers reported wide variation in scheduled delivery timing for PAS, without directly associated alterations in outcomes for the pregnant patients. Additional studies are needed to validate proposed expert recommendation for delivery between 34 0/7 and 35 6/7 weeks of gestation.

Preoperative Preparation
There are several additional aspects of immediate preoperative preparation to consider. Preoperative checklists can assist in preparation for these complex surgical cases in the days leading up to delivery. If not already obtained, consultations with the appropriate services are needed. A blood type and antibody screen should be obtained, and, if complex antibodies are present, special preparations and consultation with the blood bank should be performed well in advance of surgery.

On the day of surgery, preparing for the possibility of significant resuscitative efforts and massive transfusion is warranted. At minimum, this includes obtaining adequate intravenous access for fluid and blood resuscitation with multiple large-bore intravenous catheters and use of direct invasive arterial monitoring. In addition, PAS teams should consider the use of cell salvage and rapid infusion.

Fig. 1. Managing unexpected and intraoperative cases of placenta accreta spectrum (PAS) outside of PAS specialty centers. Real-time discovery of previously undiagnosed PAS is possible at any center that provides obstetric care, presenting an urgent need for complex clinical decision making. Opportunities for transfer to a PAS referral center may be present before delivery of the neonate, after delivery of the neonate but before placental delivery (particularly if the placenta was not disrupted at hysterotomy), and after attempted removal of the placenta but before initiation of hysterectomy. Ongoing assessment of the stability of the pregnant patient and the fetus is needed throughout the process of considering potential transfer.

devices to expedite transfusion of blood products. Because risk of rapid bleeding is difficult to predict, we bring a cooler to the operating room with multiple units of packed red cells, fresh-frozen plasma, and platelets to be ready for rapid transfusion when needed.69

Coordination with an anesthesiologist accustomed to PAS care or managing massive obstetric hemorrhage, rapid large-volume transfusion, and invasive hemodynamic monitoring is crucially important.68 Often, this is a person or team with subspecialty training in obstetric anesthesia. The optimal approach to anesthesia for PAS surgery is unknown and differs according to the intention of initial surgical treatment. Although general endotracheal anesthesia is often chosen, many referral centers use neuraxial analgesia for either all of the case or part of the case up until the time of delivery.70

The optimal operating theater for PAS surgery in each hospital varies depending on local resources and preferences, proximity to blood bank and neonatal intensive care unit, the goals of treatment (see Delivery and Treatment section), and the urgency of the case. Many referral centers perform PAS surgery in the main operating room, where key equipment and surgical consultants are most readily available. In other centers, the hybrid operating room71 or labor and delivery operating rooms are appropriate for PAS surgery.

Patient positioning in the operating room depends on the surgical approach. In general, positioning should allow adequate surgical exposure for a large laparotomy; sufficient space for rapid intubation and multiple intravenous and arterial lines; leftward tilt until the fetus is delivered; and access to the perineum to periodically assess blood loss from below, allow vaginal procedures or assistance, and perform cystoscopy and stent placement if indicated.72 Depending on the surgical plan, some centers routinely use preoperative or intraoperative cystoscopy to delineate the position of the bladder and ureters, and prophylactic ureteral stent placement has been associated with reduced incidence of genitourinary injury in patients with PAS undergoing hysterectomy.73

DELIVERY AND TREATMENT

High-quality comparative data are lacking to determine the best treatments for patients with PAS at the time of delivery, and this lack of evidence contributes to wide variation in both clinical practice and surgical outcomes. In the absence of data, surgeons rely on collective local experience to determine treatment approach. The optimal surgical approach for a patient with PAS depends on multiple factors that vary substantially between patients and between centers. These include, but are not limited to, individual disease characteristics, gestational age at the time of delivery, surgical team experience, and institutional resources. In addition, the preferences and values of the patient should inform plans. Dozens of approaches have been described in the literature, but none is clearly superior. These strategies can be condensed into four groups: 1) cesarean hysterectomy after delivery of the newborn with the placenta left in situ; 2) conservative (or expectant) in situ management of the placenta; 3) planned delayed hysterectomy weeks after in situ management; and 4) partial myometrial resection and uterine reconstruction.

The treatment options for PAS discovered very early in gestation or cesarean scar ectopic pregnancy, which is now recognized as a precursor to PAS, are not discussed here in detail, although these are conditions for which PAS diagnostic and surgical teams are increasingly asked to contribute opinions on treatment.39,74 If diagnosis is made before viability, gravid hysterectomy with placenta and fetus left in situ is a rare but reasonable option for patients with PAS.

Cesarean Hysterectomy

Cesarean hysterectomy, removal of the uterus with the placenta left in situ after delivery of the newborn, is the most common approach practiced in the United States, and hysterectomy is typically the most appropriate approach for PAS with active hemorrhage and hemodynamic instability.5 Hysterectomy is also the default backup plan or salvage approach when other treatment strategies fail. In the absence of very severe disease (FIGO 3b or 3c or PAS grade 3E, see Table 1) and in the hands of an experienced surgical team, some experts believe that this approach reduces the risk of the worst outcomes compared with alternative approaches.

Cesarean hysterectomy performed in the setting of PAS is technically complex and hazardous, and it should ideally be performed by a surgical team with PAS experience. Patients with PAS are particularly vulnerable to bleeding for several reasons related to their underlying pathophysiology. First, the architecture designed to generate a high-flow low-resistance circuit to support the growing fetus creates a precarious surgical field, with rapid blood loss ensuing from even minor disruption of placental tissue, uterine tissue, or uterine vasculature. Second, the third trimester gravid uterus is 30-fold to 40-fold larger in size compared with a nongravid uterus, with a significant decrease in collagen concentration and increase in
water concentration. A 10-fold increase in blood flow, as high as 17% of cardiac output or 700 mL/min, makes any surgical misstep an inciting event for life-threatening hemorrhage. The result is uterine tissue that is soft, edematous, and vascular, requiring dramatic adaptation of tissue handling compared with a nonpregnant hysterectomy. Placenta accreta spectrum surgeons must be comfortable operating in the retroperitoneum near the pelvic side wall because most cases involve altered anatomy, including a widened and distorted lower uterine segment, often with aberrant locations of the uterine arteries and ureters and a distorted bladder. Further complexity results from the presence of abdominopelvic adhesive disease related to prior uterine surgery or abdominal surgery.

Although there is tremendous practice variability regarding surgical approaches, several techniques have been proposed by experts at high-volume centers to reduce intraoperative morbidity. A vertical midline incision for abdominal entry is generally recommended to allow adequate exposure of the uterus and pelvic dissection in the setting of the gravid uterus. Delivery should be through a hysterotomy well away from the placental site to avoid placental disruption. This is best accomplished by first mapping the placental location with a sterile intraoperative ultrasonogram directly on the uterine surface and performing the uterine incision away from the placental site. Some centers routinely enter the uterus using serial clamping to devascularize an area for entry or hysterotomy extension with a stapler device. During hysterectomy, stepwise devascularization of the uterus beginning at the utero-ovarian pedicles allows progressive mobility of the postgravid uterus and a reduction in collateral blood supply and reserves the most difficult dissection for last. The difficult areas of dissection are also those with the highest vascularity, including bladder and lateral isolation of vascular pedicles, so approaching them last allows expedited specimen amputation if bleeding is encountered.

Electrodissection is used throughout the case, and many centers use vessel sealing devices. Of note, each of the currently marketed vessel sealing devices reports a maximum vessel diameter for efficacy at 7 mm, which may be exceeded by the size of vascular pedicles in PAS. Thus, a combination of sealing device and traditional suture ligation techniques is typically used. Placement of an EEA Sizer device or Breisky retractor within the vagina may assist in identification of the top of the vagina given that tactile determination of the transition from cervix to vagina is much more challenging with a pregnancy-remodeled cervix, particularly if also altered by placenta previa.

**Conservative In Situ Management**

Conservative in situ management (or expectant management) is practiced commonly in some parts of the world, both as a potential way of preserving the uterus for future pregnancy and as a potential way to reduce surgical morbidity. In this technique, the newborn is delivered by cesarean away from the placenta. The cord is trimmed short and tied off near the cord insertion. The nonadherent portions of the placenta may be trimmed away, or the entire placenta may be left in situ undisturbed. The uterine incision is then closed. If no immediate bleeding complications arise intraoperatively during the initial period of observation, the abdomen is closed, and expectant management continues until there is complete resorption of the placenta or until an indication to abandon conservative management occurs.

Conservative management may reduce the risk of major surgical morbidity and bleeding, although the absolute number of cases described in the literature remains quite low. Nonrandomized and observational studies of conservative management, including the recent PACCRETA (Placenta Accreta) study from France, have found reductions of up to 70% in the odds of transfusion, blood loss, and operative injury to the urinary tract or colon compared with immediate hysterectomy. Conservative management was also successful in avoiding hysterectomy in most cases (78–94%).

There are several concerns with conservative management, including the risk of emergent reoperation attributable to a complication of retained placenta and the need for prolonged and complex follow-up. In one study, endometritis occurred in 11% of those undergoing conservative management, and the chance of hospital readmission was much higher (29% vs 3.4%). In some cases, endometritis can be successfully managed with antibiotic treatment without surgery. In addition, in many patients who require repeat operation or hysterectomy, the surgery is not emergent and can be scheduled when an indication arises such as ongoing severe pain or persistent bleeding. However, some patients undergoing conservative management will require prompt or emergent treatment for life-threatening bleeding or severe uterine infection with sepsis.

In the United States, unique barriers to conservative management exist. Patients living far from the hospital face logistical and cost barriers. Local clinicians may be unwilling to manage the perceived risks of retained PAS far from access to a referral
center. Insurance coverage may end before completion of placental resorption or fail to adequately cover the cost of additional care. In addition, not all pregnant patients with PAS are eligible; up to one third develop predelivery or intraoperative bleeding. Other patients may not be willing to accept the burden of prolonged follow-up and the uncertainty of conservative management.

In addition, a healthy skepticism among U.S. clinicians remains about whether the promising outcomes of conservative management studies can be reproduced. Selection bias almost certainly exists in uncontrolled studies of conservative management, likely resulting in more favorable outcomes. Patients undergoing conservative management had fewer antenatal complications, were more likely to have a nonemergent delivery on their planned surgical date, and were less likely to be hemorrhaging during or before delivery. An inherent problem in prior studies of conservative management is the lack of histopathologic confirmation after delivery. Use of standardized definitions of disease staging and statistical methods controlling for differences in baseline characteristics may reduce the risk of selection bias, but these methods cannot eliminate bias.

Planned Delayed Hysterectomy

One proposed approach to minimize the risks associated with both immediate hysterectomy and conservative management is performing an interval hysterectomy weeks after delivery. This allows definitive treatment of PAS while potentially mitigating risks of immediate hysterectomy, particularly in cases of severe PAS. Before the delivery of the newborn by cesarean, a systematic evaluation of the abdomen and pelvis is performed by the surgical team to document the extent of disease. This assessment includes evaluation of the remodeled uterus, bladder, parametria, adhesive disease, and other pelvic organ involvement. If the surgical team agrees that immediate hysterectomy can be carried out in a reasonably safe manner, it is performed instead of delayed hysterectomy. If the surgical team elects delayed hysterectomy, the newborn is delivered and another systematic evaluation of the abdomen and pelvis is performed by the surgical team to document the extent of disease. This assessment includes evaluation of the remodeled uterus, bladder, parametria, adhesive disease, and other pelvic organ involvement. If the surgical team agrees that immediate hysterectomy can be carried out in a reasonably safe manner, it is performed instead of delayed hysterectomy. If the surgical team elects delayed hysterectomy, the newborn is delivered and another systematic evaluation of the abdomen and pelvis is performed to ensure the integrity of the hysterotomy and absence of clinically significant vaginal bleeding, which would be a contraindication to delayed management. The value of adjunctive procedures for delayed hysterectomy, including femoral access, ureteral catheter placement, resuscitative endovascular balloon occlusion of the aorta, pelvic artery embolization, and postoperative antibiotics, remains open for investigation.

Delayed hysterectomy remains an investigational approach, although data from small studies show lower estimated blood loss (750–850 mL vs 2,000–3,000 mL), lower transfusion volumes, and fewer transfusions of more than 4 units (14% vs 55%) compared with immediate hysterectomy. Because this strategy requires two planned surgeries and possibly multiple hospitalizations, it is associated with longer total surgical times and longer postoperative lengths of stay. Rates of surgical and postoperative complications are similar to rates in those undergoing immediate hysterectomy. The most common complications reported across studies of delayed hysterectomy were infection of the urinary tract and surgical site.

Partial Myometrial Resection and Uterine Reconstruction

Single-surgery partial myometrial resection and reconstruction of the uterus is a treatment approach in some areas of the world. This strategy involves en bloc resection of the placenta and attached myometrium in well-selected cases, followed by repair and reconstruction of the remaining uterus and cervix. This strategy is typically performed during the same surgery as cesarean delivery. Important to the success of this approach is experience in determining at the time of surgery whether to attempt resection or proceed directly to hysterectomy on the basis of individual patient characteristics. These factors include sufficient viable myometrial tissue surrounding the affected area, degree of hypervascularity, and location and severity of pelvic adhesive disease. Knowing when to use this approach is a nuanced skill that comes only with experience. Some investigators couple resection and repair with pelvic devascularization procedures, compression suturing, incorporating the cervix into the closure, or tourniquet placement to reduce blood loss during uterine repair and reconstruction.

This approach has not been commonly used (or at least has not been widely reported) in the United States. The SMFM and ACOG state that this approach should be “rare and considered individually.” Patients considering this approach should understand that resection may not be possible or may result in significant bleeding that would require hysterectomy. There are questions about the generalizability of the data describing resection and reconstruction. Reports of success most often come from uncontrolled case series at single centers, sometimes with unclear selection criteria. Resection and reconstruction may be useful in select patients.

Before this technique is used more broadly,
prospective research is needed to define the best candidates and to compare outcomes with other approaches.

There are major unresolved questions about future pregnancies after uterine preservation. Patients undergoing uterine reconstruction after severe PAS are left with a considerably deformed and scarred uterus that may, in future pregnancies, place them at considerable risk of adverse outcomes, including recurrent PAS, uterine rupture, and preterm birth. The few case series addressing these questions are not definitive to rule out significant harm.95

**Intrapartum Diagnosis of Placenta Accreta Spectrum**

Intrapartum identification of PAS presents a unique situation in which teams may face an urgent need for complex clinical decision making. For patients undergoing cesarean delivery, evaluation of the uterus before hysterotomy may show evidence of PAS such as bulging and an abnormally vascular lower uterine segment or extrusion of placenta through a serosal defect (Fig. 2). Recognizing signs of PAS before delivery allows careful assessment of resources and meticulous planning of hysterotomy well away from the placental location. The period after delivery, either vaginally or by cesarean, is another critical time for the assessment of expected placental separation. Failure of spontaneous separation, or an absent plane between the placenta and uterine wall on manual examination, is an important sign of PAS and should prompt assessment and mobilization of resources for management of PAS.

When an obstetric team encounters undiagnosed PAS, optimal management depends on the specific situation (Fig. 1). In cases of fetal or maternal instability, rapid delivery may be necessary; however, definitive management of PAS with hysterectomy or alternative strategy is not absolutely or immediately required once stabilization has occurred. In fact, a finding of PAS at laparotomy in an otherwise stable patient is an opportunity to pause and assess whether proceeding with delivery is in the patient’s best interest. Often, when a center lacks resources or expertise, transport before delivery is the best course of action. Another time point for assessment is after delivery. If PAS is encountered after delivery of the newborn, closing the uterus and abdomen with the placenta in situ may be safer than attempting hysterectomy in low-resource settings. The same is true for PAS suspected after vaginal delivery, for which failure of placental separation necessitates surgical planning. Depending on the resources and expertise of a facility, this is a time to decide whether transport to a higher level of care is preferable and feasible to proceeding with delivery or hysterectomy. This decision is ideally based on prior and ongoing assessment of system resources and expertise, as well as an established relationship and action plan for transitioning care to a designated referral center. Throughout, continued assessment of a patient’s hemodynamic stability and provision of life-saving and resuscitative care such as volume repletion, blood product transfusion, and antifibrinolytic agents are paramount.

**ENDOVASCULAR APPROACHES TO REDUCE BLOOD LOSS**

Even with advanced surgical expertise and optimal preoperative planning in experienced referral centers, rapid life-threatening hemorrhage during delivery and treatment for PAS can occur. The distinct challenge for PAS management comes from the proliferative neovasculature, which can arise from essentially anywhere in the pelvis, including internal iliac, external iliac, and possibly aortic or ovarian vessels. These vessels are hypertrophied and have a very high flow rate.26,96 Anticipating the potential for a large intraoperative blood loss, some centers collaborate with interventional radiologists to pursue endovascular approaches to reduce blood loss, including balloon occlusion and embolization. There is tremendous heterogeneity in reported studies, resulting in severely limited generalizability and limited opportunity to assess comparative efficacy.

Endovascular approaches may be beneficial in some scenarios. For immediate hysterectomy, endovascular adjunctive procedures may simplify dissection by “drying” the surgical field.97 Similarly, diminishing blood supply to the uterus and placenta may hasten involution for either immediate or delayed hysterectomy or conservative management.85

**Balloon Occlusion**

Balloon occlusion can be applied at multiple levels, from distal to proximal including placement in uterine arteries, internal iliac arteries, common iliac arteries, or the distal abdominal aorta (Fig. 3). Small case reports, case series, and retrospective cohort studies yield mixed results for balloon occlusion.98,99 A randomized controlled trial of internal iliac artery occlusion balloons reported no improvement in blood loss volume or need for hysterectomy.100 A meta-analysis suggests that endovascular intervention may result in less blood loss compared with no endovascular intervention, particularly if occlusion is done at the level of the abdominal aorta,101 but data are largely from
uncontrolled studies with highly varied inclusion criteria, indications for use, and techniques for balloon inflation. Ultimately, more prospective research is needed to confirm and define benefits of balloon occlusion.

Serious complications of balloon occlusion are primarily vascular and result from balloon migration, balloon rupture, vessel intimal injury or pseudoaneurysm, claudication from downstream ischemia, and arterial thrombosis. Arterial thrombosis occurs in 9–15% of those undergoing internal iliac artery or abdominal aorta occlusion. Extended inflation time may result in complications such as limb ischemia, necrosis, or multiorgan dysfunction syndrome. Radiation exposure is another significant concern before delivery attributable to fluoroscopy exposure at balloon placement, which is generally higher for more distal placement.

**Prophylactic Multivessel Embolization**

Given concerns about the complication rates and uncertain efficacy of balloon occlusion, some centers alternatively opt for prophylactic embolization. A promising approach includes targeted multivessel embolization after delivery of the newborn to reduce

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**Fig. 2. Appearance of severe placenta accreta spectrum (PAS).** Visual correlation with patient outcomes at each stage of diagnosis and management is important for honing skills of PAS recognition, developing classification schemes predictive of clinical morbidity, and iterative learning for the multidisciplinary PAS care team. All images and photographs in this figure are from the same patient. **A.** Representative antenatal ultrasound images (29 weeks of gestation) show complete placenta previa with placental bulging toward the bladder, loss of retroplacental clear zone, myometrial thinning, and extreme uterovesical hypervascularity with bridging vessels visible by color Doppler (right). **B.** Taken at the time of abdominal entry for scheduled cesarean delivery at 35 weeks of gestation, this photograph demonstrates obvious massive dehiscence of the previous cesarean scar, with a large portion of the placental base visible through a thin translucent layer of uterine serosa. **C.** The placental edge was mapped with intraoperative ultrasonography to create a hysterotomy well away from the placental edge. The neonate was delivered, avoiding placental disruption, and the hysterotomy was closed. Reduction in uterine volume with neonatal delivery allowed full pelvic anatomy assessment, and a clear surgical plane could not be identified between the bladder and uterus. The patient was deemed to be a candidate for delayed interval hysterectomy. **D.** These photographs, taken at the time of completion laparotomy 40 days later, demonstrate the degree of tissue involution and reduction in vasculature that is the primary impetus for the delayed hysterectomy approach.

average blood loss while drastically reducing the potential for nontarget ischemia that can result from aortic or internal iliac balloon occlusion.\textsuperscript{86,108} Similar to most balloon occlusion data, prophylactic embolization data are retrospective, but the reported reduction in blood loss and transfusion rates sparks interest for a prospective study.

**POSTPARTUM CARE**

**Short-Term Postpartum Care**

After initial treatment for PAS, patients require attention to specialized needs, often including critical care, in addition to routine postpartum care. Anticipation of critical care needs depends on clear communication between the obstetric team and critical care team(s). This process can start early with antenatal consults at PAS diagnosis and should allow coordinated multidisciplinary daily care, including the obstetrician, even in critical care units that traditionally place care under the full responsibility of the intensivist. The patient with PAS needs the intensivist’s expertise in standard measures to reduce the effects of post-intensive care syndrome,\textsuperscript{109,110} as well as the obstetrician’s expertise in achieving attainable elements of the normal postpartum experience.
The simple act of normalization can go a long way toward healing from a highly atypical birth experience inherent in PAS disease. Routine postpartum elements can be brought to the patient in any unit such as early initiation of lactation support and creative attempts to bring the birthing parent and newborn together. This may come in the form of video connections between maternal and neonatal hospital locations, methods of keeping the recovering birthing parent involved in the care progress of the (often premature) neonate, or nursing-supervised visits to the neonatal unit once the birthing parent is stabilized.

Patients with PAS have unique needs beyond postpartum care. Those needs inevitably bridge multiple medical disciplines, making them unfamiliar to health care professionals at the bedside. It is the responsibility of the core PAS team to clearly communicate expectations to nurses, house staff, consultants, physical therapists, case managers, patients, and their support people. Postoperative milestones such as pain levels, urinary function, foley catheter removal, epidural discontinuation, expectations for bleeding, understanding of intraoperative events, and return of appetite are just some examples of care elements that may fall outside the standard postpartum and postoperative course and must be preemptively addressed through education and counseling. Small reminders and consistent communication to the full care team can avoid missteps such as routine nursing assessments for fundal height or postpartum evaluations that may interpret excessive posthysterectomy vaginal bleeding as normal lochia.

**Long-Term Post–Placenta Accreta Spectrum Care**

A common thread of the PAS experience is the extreme and unexpected nature of the experience, particularly compared with pregnancy expectations before diagnosis. Thus, it is misguided to consider the work and care provision of the PAS team to be complete once the birthing parent and their neonate are safely discharged from the hospital after delivery. Regardless of innate resilience, this circumstance sets up patients and families for emotional distress, fear, feelings of loss, and varying degrees of trauma. Furthermore, the cognitive, psychiatric, and physical effects of post-intensive care syndrome can persist for weeks or months after hospital discharge.

Formal development of an integrated care pathway has been proposed to address these serious unmet needs. Patients and families affected by PAS may find helpful the provision of educational materials, standardized planning and recovery protocols, and ready access to PAS specialist review in all stages of the experience from diagnosis through postdelivery recovery and what has been called living beyond PAS. The engagement of a nurse navigator, peer support networks, or a core team serving as the primary contact for the patient and family can also address the long-term processing required for this major physical and emotional transition. Consistent presence can bring peace of mind at a broad level and can expedite connecting the patient to the right member of a large care team at any point in their PAS experience.

Long-awaited research is emerging to explore the unique challenges to recovery for the growing population of patients with PAS and their families. Several recent qualitative research studies have extracted themes from the lived experience from those affected by PAS. These first-hand accounts are invaluable for framing future goals to better support patients with PAS in their short-term and long-term recovery. It is important to note that the existing medical literature represents only a fraction of the demographic affected by PAS disease, leaving much work to be done to address varying cultural implications, economic effects, and support needs where large gaps remain in PAS care provision (Box 1).

**CONCLUSION**

Placenta accreta spectrum is a condition that places patients at high risk of hemorrhage, surgical complications, and even death. Therefore, the care of patients with PAS is best accomplished at centers with ample experience and resources to manage the breadth of both physical and psychosocial needs attendant to a PAS diagnosis. Clinical risk assessment, mainly a history of uterine surgery, in addition to a detailed ultrasound assessment of the placenta in patients at risk, is the first-line diagnostic approach. In prenatally diagnosed cases, cesarean hysterectomy is the most common and definitive approach. Considering conservative or alternative management approaches depends on the expertise and resources of the institution, the severity of PAS, and the patient’s preferences. Any institution that offers obstetric care must anticipate the potential for encountering undiagnosed PAS and have a pathway for escalation to a higher level of care.

An intrapartum diagnosis of PAS is often associated with increased bleeding, and in cases in which stabilization can occur, transfer to an experienced PAS center may be the best option.
Box 1. Suggested Innovations, Knowledge Gaps, and Research Priorities for the Future of Placenta Accreta Spectrum Care

Contemporary innovations
- Characteristics of placenta accreta spectrum referral centers:
  - Coordination by a program champion or champions
  - Membership from all involved specialties
  - Capability for 24/7 mobilization of placenta accreta spectrum surgical team
  - Interdisciplinary treatment planning meetings or formalized communication
- Standardized evidence-based approaches to placenta accreta spectrum diagnosis, staging, and management
- Standardized intraoperative staging and pathologic classification based on visible appearance of the placenta, remodeled uterus, and surrounding maternal structures
- Peer support networks and care navigators

Urgent clinical needs
- Externally validated antenatal staging schemes correlated to clinical outcomes
- Integrative risk assessment combining a priori risk, primarily from prior uterine surgery, with imaging
- Identification of best treatments for placenta accreta spectrum and cesarean scar ectopic pregnancy before viability (gravid hysterec- tomy, dilation and evacuation, resection)
- Techniques for improving uterine scar integrity to prevent placenta accreta spectrum, cesarean scar ectopic pregnancy, and other scar morbidities
- Approaches and infrastructure to mitigate antenatal anxiety and postnatal trauma
- Structured systems for education of new clinicians who provide placenta accreta spectrum care (diagnosis, management, and surgery)

Key Research Gaps
Further advances in the field of placenta accreta spectrum will require prospective systematic assessment in the following areas:
- Systems
  - Objective core outcome sets and quality metrics
  - Defining case volume and competency for placenta accreta spectrum expertise
  - Regionalization of placenta accreta spectrum care
- Diagnosis
  - Staging that predicts morbidity (not just disease presence)
  - Biomarker development
  - First trimester identification
- Antenatal
  - Individualized delivery timing
  - Define patient-centered outcomes

Delivery and treatment
- Comparative, randomized studies of alternative treatments
- Evaluation of surgical adjuncts
  - Ureteral stents
  - Uterotonics
- Anesthesia approaches (general, neuraxial, combined)

Adjuncts to Surgery
- Randomized trials comparing endovascular intervention modalities, focusing on both efficacy and harm

After delivery
- Interventions to improve psychological and patient-centered outcomes

Although understanding of the pathophysiology, ideal diagnostic tools, and optimal treatment approach is growing, much remains to be discovered. Future directions for PAS investigation are vast and include the following: how to designate and build a PAS referral center; optimal surgical approach and techniques; person-centered outcomes related to experience, psychosocial effects, and strategies to mitigate trauma; and improved diagnosis through discovery of biomarkers for PAS.

REFERENCES

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