

# Placenta Accreta Spectrum Novel Diagnostic Signs and Management

**Shahenda Ahmed Elsayed, Eman Mahfouz Hafez, Mohamed Sayed Bayoumi Abdallah \*, Alaa Eldin Abdelsalam Ahmed**

Department of Obstetrics and Gynecology, Faculty of Medicine, Zagazig University, Zagazig, Egypt

**\*Corresponding author:** [Mostafa Eid Radwan Abdelhamid](#)

## Abstract

Placenta accreta spectrum (PAS) is a potentially life-threatening pregnancy condition characterized by abnormal placental adherence and failure of normal placental separation at delivery. Classical imaging signs, such as placental lacunae, loss of the retroplacental clear zone, myometrial thinning, and an abnormal uterine–bladder interface, have long been used in clinical practice. However, these conventional markers may not always provide sufficient sensitivity or specificity, particularly in early gestation or in subtle cases. Recent research has focused on identifying novel imaging, biochemical, and clinical indicators that may improve diagnostic accuracy. Early and accurate diagnosis allows obstetricians to plan delivery in specialized centers equipped with multidisciplinary teams. Women with suspected or confirmed PAS should be managed in specialized referral centers with an experienced multidisciplinary team and appropriate resources for complex pelvic surgery and major obstetric hemorrhage.

**Keywords:** Placenta accreta spectrum; ultrasound; novel signs; magnetic resonance imaging; antenatal diagnosis; multidisciplinary management

## Introduction

Placenta accreta spectrum (PAS) is a potentially life-threatening pregnancy condition characterized by abnormal placental adherence and failure of normal placental separation at delivery. It is associated with substantial maternal morbidity, primarily due to severe obstetric hemorrhage, which may require massive blood transfusion, cesarean hysterectomy, and admission to intensive care. The morbidity associated with PAS may also include urinary tract injury and prolonged postoperative and psychosocial consequences. [1]

The incidence of PAS may be increasing. By pooled estimates, PAS now occurs in 0.17% (1 in 588) of pregnancies (95% CI 0.01% to 1.1%), compared to a much lower incidence in the 1970s and 1980s at 0.02% (1 in 4027) and 0.04% (1 in 2510), respectively. Accurate population-based statistics are hard to come by since PAS coding did not exist until the most recent ICD coding nomenclature and since disease definitions are evolving. The increasing rate of placenta accreta is likely attributable to a change in risk factors, most notably the increased rate of cesarean delivery. [2]

The exact etiology of PAS is unclear. Historically, it was proposed that PAS resulted from abnormal trophoblast invasion much like dysregulated proliferation of cancer cells; 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 dehiscence uterine scar. [3]

The most significant risk factor for PAS is placenta previa diagnosed in a patient with a history of cesarean delivery. 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 VEGF, results in proliferative transformation of the uterine arterioles and pelvic vessels early in pregnancy. [2]

Massive obstetric hemorrhage, need for hysterectomy, damage to adjacent organs such as the bladder, and preterm delivery are among the major complications associated with PAS. Early identification is therefore critical to optimize peripartum planning, reduce maternal complications, and improve neonatal outcomes. [4]

Traditional diagnosis of PAS relied heavily on clinical suspicion during delivery, often resulting in unexpected hemorrhage and emergency hysterectomy. Advances in imaging modalities particularly ultrasonography and magnetic resonance imaging have significantly improved antenatal detection rates. [5]

Classical imaging signs, such as placental lacunae, loss of the retroplacental clear zone, myometrial thinning and abnormal uterine–bladder interface, have long been used in clinical practice. However, these conventional markers may not always provide sufficient sensitivity or specificity, particularly in early gestation or in subtle cases. Consequently, recent research has focused on identifying novel imaging, biochemical, and clinical indicators that may improve diagnostic accuracy. These emerging signs are collectively referred to as “novel signs” of PAS and represent an evolving field in obstetric imaging and maternal–fetal medicine. [6]

### **Clinical Burden**

Transfusion at delivery occurs in about 50% of patients; intensive care unit (ICU) admission after delivery is common; and operative injury to the urinary tract occurs in 5–30% of cases. Cesarean hysterectomy, and consequent loss of fertility, has long been considered standard treatment in the United States. [7]

In some instances of PAS, delivery before fetal viability is needed to preserve maternal life, resulting in both termination of pregnancy and often loss of future fertility. [3]

Furthermore, morbidity continues beyond the immediate postpartum period. Patients with PAS experience higher rates of repeat hospitalization, need for additional surgeries, long-lasting psychosocial and emotional problems, and decreased quality of life. [8]

### **Etiology and Risk Factors**

PAS 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’s syndrome, prior endometrial ablation, multifetal pregnancy, and in vitro fertilization, with relative risks in the literature ranging on the order of 2–7 compared to baseline and persisting when adjusted for factors such as maternal age and prior cesarean delivery. [9]

### **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 based on increasing depth of perceived invasion within the myometrium. [2]

The usefulness of the historical classification has recently been challenged since its focus on progressive trophoblastic invasion seems contrary to observations from antenatal imaging, intraoperative findings, and targeted pathologic evaluation. In 2019, the International Federation of Gynecology and Obstetrics (FIGO) proposed a scheme of classification for the clinical diagnosis of PAS disorders. [10]

In 2020, a panel of experts convened and published a document on classification and reporting of pathological diagnosis of PAS disorders that roughly parallels the FIGO guidelines. 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 Grade 2–3) based on the visible appearance and location of the placenta within a remodeled uterus and surrounding maternal structures. Regardless of underlying pathophysiology, the end 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. [1]

| Pathology Classification (PAS) <sup>14</sup> | Description                                                                                                                             | Clinical Classification (FIGO) <sup>13</sup> | Description                                                                                                                                                                                                                                              | Historical Classification                                                         |
|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| <b>Normal</b>                                | Layer of decidualized endometrium separates placenta from myometrium                                                                    | <b>Normal</b>                                | Placenta able to be separated (spontaneously or manually) after delivery                                                                                                                                                                                 |                                                                                   |
| <b>Grade 1</b>                               | Areas of absent decidua between villi and myometrium; uniform myometrial thickness without thinning                                     | <b>Grade 1</b>                               | Adherent placenta, unable to manually develop a clean plane of separation between placenta and myometrium; often requires curettage                                                                                                                      | Placenta adherent<br>Placenta creta<br>Accreta                                    |
| <b>Grade 2</b>                               | Irregular placental-myometrial interface, without involvement of outer myometrium (<75% of myometrial thickness); intact uterine serosa | <b>Grade 2</b>                               | Abnormal macroscopic findings over placental bed: placental “bulge;” hypervascularity; “Dimple sign,” with uterus pulling in on gentle cord traction                                                                                                     | Increta                                                                           |
| <b>Grade 3</b>                               |                                                                                                                                         | <b>Grade 3</b>                               |                                                                                                                                                                                                                                                          |                                                                                   |
| <b>3A</b>                                    | Irregular placental-myometrial interface, placental involvement of outer myometrium (>75% thickness); intact uterine serosa             | <b>3a</b>                                    | Macroscopic findings over placental bed and placental tissue seen through surface of uterus without extension to other organ<br>Appearance of uterine “window” with base of placenta visible through extremely thin myometrium or single layer of serosa | Increta or percreta (for histological PAS 3A) and percreta (for Clinical FIGO 3a) |
| <b>3D</b>                                    | Deep myometrial invasion with disruption of serosal surface                                                                             | <b>3b</b>                                    | Involvement of urinary bladder – clear surgical plane cannot be identified between uterus and bladder                                                                                                                                                    | Percreta                                                                          |
| <b>3E</b>                                    | Extrauterine extension with placental invasion into, or fibroadipose tissue extension to, extrauterine structures                       | <b>3c</b>                                    | Involvement/invasion of other pelvic tissues or organs (may also include bladder)                                                                                                                                                                        | Percreta                                                                          |

\* Requires hysterectomy or partial hysterectomy specimen; findings from delivered placentas and curettings are considered separately from PAS and designated basal plate myometrial fibers (BPMF)

\*\* Does not require pathological specimen, as grades are assigned based on intraoperative findings

Table 1. Comparison of current and historical classification systems for placenta accreta spectrum based on contemporary expert consensus guidelines. Source: Jauniaux et al. [11].

## Pathophysiology

The pathogenesis of PAS is closely related to defects in the decidua basalis and abnormal trophoblastic invasion of the myometrium. Under normal conditions, the decidua acts as a barrier that limits the depth of placental invasion into the uterine wall. In PAS, this barrier is either absent or severely deficient, allowing placental villi to penetrate abnormally into the myometrium. The most widely accepted theory suggests that previous uterine trauma particularly cesarean delivery disrupts the endometrial–myometrial interface, creating areas where normal decidualization cannot occur in subsequent pregnancies. [12]

When implantation occurs over a cesarean scar or other uterine scar tissue, trophoblasts may directly invade the underlying myometrium. Depending on the depth of invasion, PAS is classified into three main subtypes: placenta accreta, where villi attach directly to the superficial myometrium; placenta increta, where villi invade deeply into the myometrium; and placenta percreta, where the placenta penetrates through the entire uterine wall and may invade adjacent organs such as the bladder. This pathological continuum explains the term “placenta accreta spectrum,” emphasizing that these entities represent varying degrees of the same disease process rather than completely separate conditions. [13]

Abnormal vascular remodeling also plays a key role in PAS pathophysiology. Increased angiogenesis, abnormal spiral artery remodeling, and extensive neovascularization are frequently observed in affected placentas. These vascular changes contribute to the development of characteristic imaging findings, including hypervascularity and turbulent blood flow at the placental–myometrial interface. Recent histopathological studies have demonstrated increased expression of angiogenic factors such as vascular endothelial growth factor

and placental growth factor in PAS tissues, supporting the role of abnormal vascular proliferation in disease progression. [14]

### **Novel Diagnostic Signs**

Placenta Accreta Spectrum (PAS) represents a group of obstetric disorders characterized by abnormal adherence or invasion of the placenta into the uterine wall. The condition encompasses placenta accreta, increta, and percreta, reflecting increasing depth of trophoblastic invasion into the myometrium and surrounding tissues. [15]

Over the past three decades, the global incidence of PAS has risen dramatically, largely paralleling the increase in cesarean section rates. Historically, placenta accreta was considered a rare obstetric complication; however, it is now recognized as one of the most serious causes of severe maternal morbidity and mortality worldwide. [1]

### **Advances in Ultrasonographic Diagnosis**

Ultrasonography remains the primary imaging modality for prenatal diagnosis of PAS due to its accessibility, safety, and high diagnostic performance. Conventional ultrasound markers such as placental lacunae, thinning of the myometrium, and disruption of the bladder line have been widely used in clinical practice. However, the recognition of additional, more subtle sonographic indicators has expanded the diagnostic capabilities of ultrasound in recent years. [16]

One of the most significant novel signs is the “rail sign,” which refers to the presence of parallel hypervascular channels at the uterine–bladder interface seen on color Doppler imaging. These vascular structures represent abnormal neovascularization extending from the placenta toward the bladder. The rail sign is particularly associated with severe forms of PAS, including placenta percreta, where invasion beyond the uterine serosa occurs. Studies suggest that this sign may help differentiate true invasive placentation from placenta previa without invasion. [17]

A further emerging marker is the “placental bulge sign,” characterized by abnormal outward contouring of the uterus due to placental tissue extending beyond the normal uterine shape. This sign can be visualized on both grayscale ultrasound and MRI and indicates significant myometrial invasion. Unlike traditional markers, which primarily evaluate the placental–myometrial interface, the placental bulge reflects the overall structural distortion of the uterus caused by invasive placentation. [18]

Another recently described Doppler sign is the presence of “subplacental hypervascular zones,” characterized by dense clusters of chaotic vascular signals beneath the placenta. These zones reflect extensive neovascularization and may precede more obvious structural changes. Early identification of such vascular abnormalities may allow earlier detection of PAS during the second trimester. [19]

The non-tapered placental edge refers to an atypical sonographic appearance in which the placental margin appears rounded, thickened, or bulbous rather than gradually thinning toward the membranes. Under normal conditions, the placental edge demonstrates a tapered configuration, reflecting orderly villous attachment and progressive reduction in placental thickness at the periphery. [20]

In PAS, abnormal placental invasion may alter the normal placental contour, resulting in a blunt or non-tapered placental edge on sagittal ultrasound. This finding represents a wide amount of trophoblast at the placental margin and may support the diagnosis of PAS when associated with other sonographic abnormalities. [21]

Small placental lacunae have recently been described as a novel sonographic marker of placenta accreta spectrum (PAS). They are defined as one or more hypoechoic areas within the placental parenchyma measuring <1 cm in diameter, in contrast to the larger and more irregular placental lacunae traditionally considered a classic sign of PAS. The presence of small lacunae may reflect early or subtle abnormalities of placental–myometrial development and may be particularly useful in detecting less extensive forms of abnormal placentation, including placenta accreta. [20]

Placental separation signs describe abnormalities in the expected sonographic indicators of normal placental detachment and interface formation between the placenta and uterine wall. In physiologic implantation, a distinct hypoechoic retroplacental clear zone represents decidual tissue that facilitates eventual placental separation after delivery. In PAS, defective decidualization leads to partial or complete absence of this separation plane. [20]

### **Magnetic Resonance Imaging and Emerging Radiologic Signs**

While ultrasound remains the first-line modality for PAS diagnosis, magnetic resonance imaging (MRI) plays an important complementary role, particularly in complex cases or when posterior placentation limits ultrasound visualization. MRI provides superior soft-tissue contrast and a larger field of view, allowing better assessment of placental invasion into surrounding structures. [22]

Several novel MRI signs have been described in recent years. One of the most notable is the “dark intraplacental bands sign,” which refers to irregular hypointense bands within the placenta on T2-weighted images. These bands are thought to represent areas of fibrin deposition and abnormal vascular channels. Their presence has been strongly correlated with invasive placentation, particularly placenta increta and percreta. [23]

Another emerging MRI feature is the “focal uterine bulge sign,” which corresponds to localized distortion of the uterine contour due to placental invasion. Unlike generalized uterine enlargement, this focal bulge appears as a discrete protrusion of placental tissue beyond the expected uterine boundary. This sign is particularly useful in identifying placenta percreta with potential invasion into the bladder or surrounding pelvic structures. [24]

The “placental heterogeneity sign” has also been proposed as a marker of PAS. On MRI, affected placentas may demonstrate heterogeneous signal intensity due to a mixture of vascular spaces, fibrin deposition, and hemorrhage. Although placental heterogeneity can occur in other conditions, when combined with additional imaging markers it significantly increases the suspicion for PAS. [20]

### **Emerging Biomarkers**

Beyond imaging findings, researchers have begun exploring biochemical markers that may aid in the early detection of PAS. Several circulating proteins involved in placental development and angiogenesis have shown potential diagnostic value. Elevated levels of maternal serum alpha-fetoprotein (AFP) have been reported in pregnancies complicated by PAS, possibly due to increased placental permeability or disruption of the maternal–fetal interface. [25]

Placental growth factor (PlGF) and soluble fms-like tyrosine kinase-1 (sFlt-1), both key regulators of angiogenesis, have also been investigated as potential biomarkers. Abnormal levels of these proteins may reflect altered vascular development associated with invasive placentation. Although current evidence remains limited, these biomarkers may eventually complement imaging studies in identifying high-risk pregnancies. [26]

Recent studies have investigated circulating cell-free fetal DNA (cffDNA) and cell-free microRNAs (miRNAs) as potential non-invasive biomarkers for the early detection of placenta accreta spectrum (PAS). Elevated maternal serum cffDNA has been associated with PAS; however, its diagnostic performance as a standalone marker appears limited, suggesting that it may be more useful when combined with clinical and imaging parameters. Similarly, specific circulating miRNAs, including miR-26a-5p, miR-17-5p, and miR-101-3p, have shown promising diagnostic potential during first-trimester screening. Nevertheless, these molecular biomarkers require validation in larger and independent cohorts before they can be incorporated into routine clinical practice. [27,28].

### **Clinical Implications of Novel Diagnostic Signs**

The identification of novel signs of PAS has important implications for clinical practice. Early and accurate diagnosis allows obstetricians to plan delivery in specialized centers equipped with multidisciplinary teams, including maternal–fetal medicine specialists, anesthesiologists, interventional radiologists, and experienced surgeons. Planned cesarean hysterectomy at an appropriate gestational age remains the standard management for most severe cases of PAS. [23]

Antenatal diagnosis of placenta accreta spectrum (PAS) allows appropriate counseling and coordinated multidisciplinary planning before delivery, including optimization of maternal hemoglobin and preparation for potential massive hemorrhage with blood products and cell salvage. Planned delivery in an experienced multidisciplinary center may reduce emergency surgery and transfusion-related morbidity. In selected women, conservative or expectant management may be considered as an alternative to hysterectomy; however, its use remains individualized and requires careful patient selection and counselling regarding potential complications. [29,13].

Moreover, early detection enables better neonatal outcomes by allowing planned preterm delivery under controlled conditions rather than emergency delivery during hemorrhagic complications. Thus, the recognition of novel imaging and biochemical markers may significantly improve both maternal and neonatal prognoses. [30]

### **Diagnosis and Management**

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. Investigation of promising biomarkers for PAS is underway, but broadly available and clinically useful blood or urine tests to predict PAS are not currently available. [31]

Importantly, a patient's a priori risk should not be dismissed based on a reassuring ultrasound study. Consequently, risk factor assessment and ultrasound 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. [26]

### **Assessment of Risk**

For the clinician, diagnosis starts with understanding risk and developing an appropriate index of suspicion for PAS. Clinicians and ultrasound units should screen for history of cesarean delivery and inquire about any other uterine surgeries. Unlike imaging, this step does not require advanced expertise; and yet, it is probably the most important aspect of screening for PAS since it influences imaging interpretation considerably. [21]

For instance, the presence of placental lacunae or subplacental vascularity is significantly more concerning in a patient with four prior cesarean deliveries compared to the identical sonographic findings in a patient with no uterine surgery history. In the former, these findings could confirm the diagnosis; in the latter, the findings would likely be considered normal variations. Other risk factors mentioned above 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. [32]

The scarred area is typically located just above or at the level of the cervix in the second and third trimester for patients with prior term low-transverse cesarean(s), 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 (i.e. forms a previa or is low-lying and extends into the area of prior hysterotomy) a thorough evaluation for sonographic signs of PAS is recommended. [33]

### **Ultrasound**

In patients at risk, ultrasound is the primary screening and diagnostic modality. The most important sign for PAS is placenta previa, as this modifies the risk for disease and morbidity most strikingly. When previa is present in patients with prior cesarean, 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, respectively). SMFM convened a task force to define the most important ultrasound signs related to PAS. [34]

The most common signs are loss of the normal hypoechoic zone between the placenta and myometrium or "clear zone", 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. [35]

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 helps to determine the overall suspicion. [31]

Models to predict the risk of PAS based on the number and character of sonographic signs have been proposed, but these are not yet adequately validated in external cohorts. Predictive models to date suffer from imprecision and unsatisfactory rates of false-negative results (missed diagnoses). Importantly, the absence of ultrasound findings for PAS does not rule out the diagnosis in patients with previa and clinical risk factors. [36]

### **Magnetic Resonance Imaging**

The role of magnetic resonance imaging (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 ultrasound in diagnostic accuracy. [37]

However, caution is warranted in interpreting these data since MRI research for PAS is typically performed in busy referral centers and only in patients who have very high suspicion for PAS based on ultrasound. 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. [38]

On MRI, placenta previa and placental bulging are the most reproducible signs, although these are often present in non-accreta 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 ultrasound in every setting. [39]

Expertise in the diagnosis of PAS varies by institution and, similar to ultrasound, 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 ultrasound can provide. [37]

### **Antenatal Staging and Morbidity Prediction**

Detecting PAS is an important first step of diagnosis, but it is not the whole story. PAS investigators and surgeons are further interested in questions of location and extent (or topography) of PAS as well. This is important work, as 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. [40]

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. [41]

### **Systems 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 due to the relatively low incidence, high level of expertise required, and extraordinary number of hospital-based resources needed. [33]

Leading international organizations have provided guidelines for management of PAS including lists of resources and services necessary to plan and manage cases of PAS. Further, the American College of Obstetricians & Gynecologists (ACOG) with the Society for Maternal-Fetal Medicine (SMFM) endorse a practice of referral to specialized centers and regionalization of care for PAS, but health care professional surveys and state-level data suggest that referral to higher levels of care has not yet become universal practice. [34]

Unfortunately, the rate of missed diagnosis of PAS remains high (up to 50%). All facilities offering obstetric care should therefore prepare an action plan for unexpected cases, and routinely engage in comprehensive self-assessment to determine if routine PAS care should be performed locally (see section Assessment of Resources for PAS) or referred to more experienced centers. To improve readiness, preparation, and response to cases of PAS, the SMFM developed checklists which can be used for self-assessment. These checklists also specifically address unexpected cases of PAS and can assist institutions that may be under-resourced to manage unexpected cases of PAS. [42]

### **Assessment of Resources for PAS**

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. [35]

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 like 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, then low-volume surgeons and low-volume facilities are likely to experience worse outcomes compared to high-volume surgeons and centers. Determining what constitutes ‘adequate expertise’ for PAS management is therefore a critical knowledge gap in the field. [30]

### **Optimizing Care and Preparing for PAS**

Women with suspected or confirmed PAS should be managed in specialized referral centers with an experienced multidisciplinary team and appropriate resources for complex pelvic surgery and major obstetric hemorrhage. Effective PAS care requires coordinated involvement of maternal–fetal medicine specialists, obstetricians, anesthesiologists, surgeons experienced in complex pelvic procedures, radiologists, urologists, neonatologists, interventional radiologists, and transfusion specialists. Regular multidisciplinary case review, standardized protocols, clear communication, and immediate access to blood products and critical care facilities are essential components of a high-quality PAS service. Management within such specialized centers facilitates individualized antenatal planning and coordinated perioperative care, with the aim of reducing maternal morbidity and improving outcomes. [13]

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 for early confirmation or reevaluation of the diagnosis, ideally prior to 26–32 weeks gestation, and care coordination and case planning in the facility that is the most appropriate for the level of concern. Referral at the time of delivery in unexpected cases is also possible and preferable in some circumstances. [25]

Management of unexpected and intraoperative placenta accreta spectrum cases outside PAS specialty centers is shown in Figure 1.

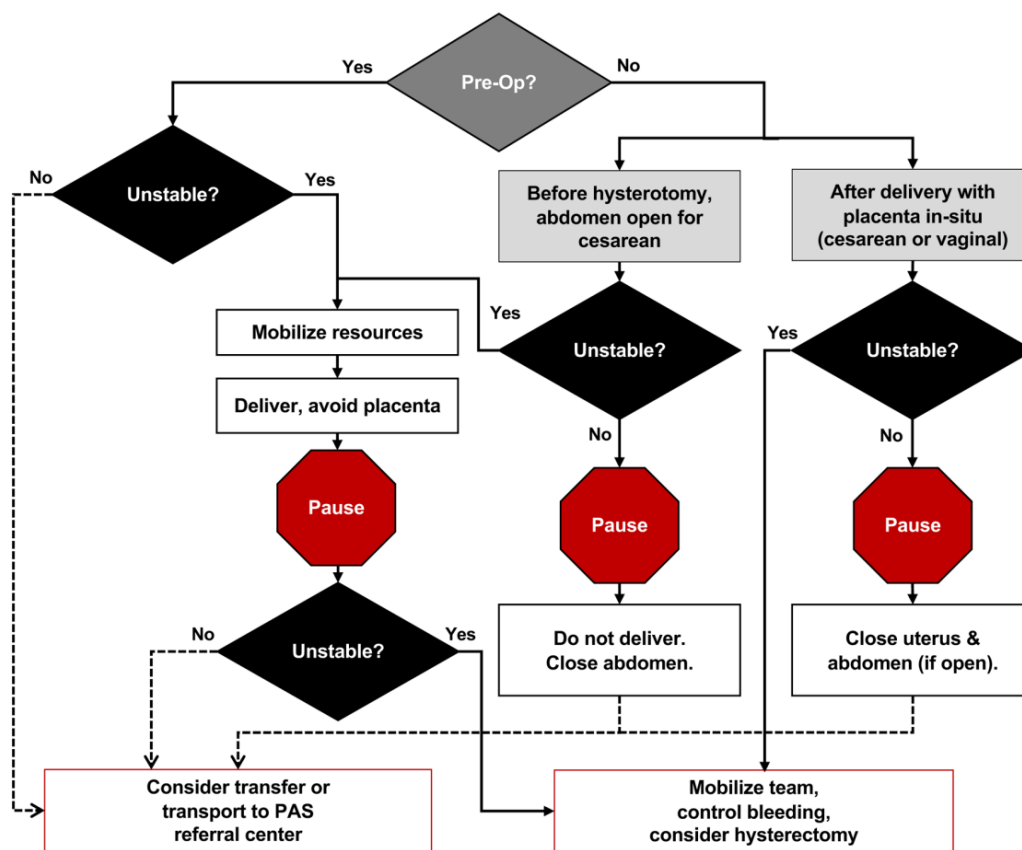


Figure 1. Managing unexpected and intraoperative placenta accreta spectrum cases outside of PAS specialty centers. Source: Imafuku et al. [24].

### Antenatal Diagnosis and Risk Stratification

Effective management of PAS begins with accurate prenatal diagnosis, which allows transition from emergency obstetrics to controlled surgical planning. Ultrasound remains the primary diagnostic modality, with magnetic resonance imaging serving as an adjunct in complex or posterior placentation. Identification of PAS risk depends on both imaging findings and clinical history, particularly placenta previa in the presence of previous cesarean delivery or uterine surgery. [15]

Antenatal diagnosis enables classification into suspected accreta, increta, or percreta, although definitive staging often occurs intraoperatively. Risk stratification also considers placental location, degree of bladder involvement, vascularity, and maternal comorbidities. Early recognition facilitates referral to tertiary care centers equipped with blood bank resources, advanced anesthesia capability, and experienced surgical teams. Counseling during the antenatal period is essential, addressing risks of hemorrhage, hysterectomy, fertility loss, preterm delivery, and potential adjacent organ injury. Timing of hospitalization, administration of corticosteroids for fetal lung maturation, and preparation for planned delivery are guided by individualized risk assessment. Antenatal planning significantly reduces maternal morbidity compared with undiagnosed cases presenting in labor or during attempted manual placental removal. [15]

### Multidisciplinary Care and Delivery Planning

Central to PAS management is coordinated multidisciplinary care. Planned delivery should occur in centers capable of managing massive obstetric hemorrhage and complex pelvic surgery. Preoperative meetings align surgical roles, anesthesia plans, transfusion strategies, neonatal preparedness, and contingency protocols. Blood products must be readily available, frequently requiring activation of massive transfusion pathways. Delivery

timing typically balances fetal maturity against risk of spontaneous bleeding, with elective delivery commonly scheduled between 34–36 weeks' gestation in stable patients. [15]

Preoperative optimization includes correction of anemia, thromboembolism risk assessment, and detailed surgical mapping using imaging studies. Multidisciplinary simulation and checklist-based preparation have been shown to reduce operative time and complications. Communication among team members is critical, particularly regarding anticipated surgical difficulty and possible need for urologic or vascular intervention. The structured approach transforms PAS management into a controlled surgical procedure rather than an obstetric emergency, significantly improving maternal outcomes. [10]

### **Surgical Management: Cesarean Hysterectomy**

Cesarean hysterectomy with the placenta left in situ remains the gold standard management for most cases of PAS, particularly when invasion is extensive. The fundamental principle is avoidance of placental disruption, as attempts at removal can trigger life-threatening hemorrhage. Following fetal delivery through an incision away from the placenta, the umbilical cord is ligated without placental manipulation. [6]

Hysterectomy is then performed with the placenta undisturbed within the uterus. Surgical technique often involves a midline abdominal incision for optimal exposure, careful bladder dissection, and early vascular control. Experienced surgeons may employ stepwise devascularization or internal iliac artery ligation to reduce blood loss. In cases of placenta percreta with bladder involvement, partial cystectomy or urologic reconstruction may be required. Blood loss during cesarean hysterectomy can be substantial, necessitating rapid transfusion and meticulous hemostasis. Despite its radical nature, planned cesarean hysterectomy has demonstrated lower morbidity compared with emergent procedures following failed placental separation. [15]

### **Conservative and Uterus-Preserving Approaches**

Although hysterectomy remains standard, conservative management strategies have been explored in carefully selected patients desiring fertility preservation or when hysterectomy poses excessive risk. Conservative approaches include leaving the placenta in situ with delayed resorption, partial myometrial resection with uterine reconstruction, or focal placental excision. Expectant management relies on gradual placental involution over weeks to months, monitored through imaging and clinical assessment. However, risks include delayed hemorrhage, infection, sepsis, and need for secondary hysterectomy. Methotrexate therapy has historically been proposed to accelerate placental regression, though evidence supporting its benefit remains limited and controversial. Conservative surgery may be feasible in focal accreta without deep invasion, but success depends heavily on surgical expertise and patient selection. Women undergoing uterus-preserving treatment require prolonged follow-up and counseling regarding recurrence risk in subsequent pregnancies. Thus, conservative management remains individualized rather than routine practice. [15]

Devascularization is an important component of some uterus-preserving surgical techniques for PAS and aims to reduce blood flow to the placental implantation site before placental or myometrial resection. Depending on the surgical approach and extent of invasion, vascular control may include bilateral uterine artery ligation, ligation of cervical vessels, internal iliac artery occlusion or ligation, and selective control of newly developed vesicouterine vessels. This is usually followed by removal of the invaded uterine segment and placenta, with direct hemostatic suturing and reconstruction of the uterine wall. Such techniques may facilitate uterine preservation and reduce intraoperative bleeding in appropriately selected patients, although their use requires considerable surgical expertise and should be individualized according to the topography of PAS. [43].

### **Role of Interventional Radiology**

Interventional radiology has increasingly contributed to PAS management as an adjunct to surgical treatment. Techniques such as prophylactic balloon occlusion of the internal iliac or uterine arteries aim to reduce intraoperative blood loss by temporarily limiting pelvic perfusion. Uterine artery embolization may also be used postoperatively to control persistent bleeding. While some studies report reduced transfusion requirements, evidence remains mixed, and procedural risks include vascular injury, thrombosis, and ischemic complications. The effectiveness of balloon occlusion may vary depending on collateral circulation and degree of placental invasion. Consequently, interventional radiology is best considered a supportive modality rather

than a replacement for definitive surgical management. Careful patient selection and availability of experienced interventional teams are essential for safe implementation. [10]

### **Anesthetic and Hemorrhage Management Strategies**

Anesthetic management plays a crucial role in optimizing outcomes during PAS surgery. General anesthesia is frequently preferred due to anticipated prolonged surgery and potential for massive hemorrhage, although regional techniques may be used selectively in stable cases. Advanced hemodynamic monitoring, large-bore intravenous access, and rapid transfusion systems are standard preparations. [4]

Massive transfusion protocols emphasize balanced resuscitation with packed red blood cells, plasma, platelets, and fibrinogen replacement to prevent coagulopathy. Adjunctive therapies include tranexamic acid administration and point-of-care coagulation monitoring such as thromboelastography. Maintaining normothermia and correcting metabolic abnormalities are critical components of hemorrhage control. Early recognition of bleeding and proactive resuscitation reduce the risk of disseminated intravascular coagulation and organ failure. Anesthesia teams must coordinate closely with surgeons to anticipate periods of major blood loss and adjust resuscitative measures accordingly. [22]

### **Postoperative Care and Complication Management**

Postoperative management focuses on stabilization, monitoring for complications, and recovery following major surgery. Many patients require intensive care unit admission for hemodynamic observation and transfusion support. Common postoperative complications include infection, thromboembolism, urinary tract injury, and delayed hemorrhage. Bladder injury is particularly relevant in placenta percreta cases, necessitating prolonged catheterization and urologic follow-up. Early mobilization, thromboprophylaxis, and antibiotic stewardship form essential components of postoperative care. Psychological support is equally important, especially for women undergoing unplanned fertility loss through hysterectomy. Multidisciplinary follow-up ensures recovery of physical and emotional health while addressing long-term reproductive counseling and contraception planning. [6]

### **Neonatal Considerations**

Neonatal outcomes in PAS are largely influenced by prematurity resulting from planned early delivery. Coordination with neonatology teams allows preparation for respiratory support, thermal regulation, and feeding assistance in preterm infants. Administration of antenatal corticosteroids and magnesium sulfate for neuroprotection is commonly incorporated into delivery planning. Despite prematurity-related risks, planned delivery generally improves neonatal outcomes compared with emergency deliveries associated with uncontrolled maternal hemorrhage. Neonatal teams play an integral role in balancing maternal safety with fetal maturity when determining optimal timing of delivery. [4]

### **Conclusion**

Effective management of PAS begins with accurate prenatal diagnosis, which allows transition from emergency obstetrics to controlled surgical planning. No individual sign is highly predictive of PAS, so a combination of findings and a patient's a priori risk helps to determine the overall suspicion. Central to PAS management is coordinated multidisciplinary care. Planned delivery should occur in centers capable of managing massive obstetric hemorrhage and complex pelvic surgery.

### **References**

1. Einerson, B. D., Gilner, J. B., & Zuckerwise, L. C. (2023). Placenta Accreta Spectrum. *Obstetrics and Gynecology*, 142(1), 31–50. <https://doi.org/10.1097/AOG.0000000000005229>
2. Liu, X., Wang, Y., Wu, Y., Zeng, J., Yuan, X., Tong, C., & Qi, H. (2021). What we know about placenta accreta spectrum (PAS). *European Journal of Obstetrics, Gynecology, and Reproductive Biology*, 259, 81–89. <https://doi.org/10.1016/j.ejogrb.2021.02.001>
3. Bloomfield, V., Rogers, S., & Leyland, N. (2020). Placenta accreta spectrum. *Canadian Medical Association Journal*, 192(34), E980. <https://doi.org/10.1503/cmaj.200304>

4. Silveira, C., Kirby, A., Melov, S. J., & Nayyar, R. (2022). Placenta accreta spectrum: We can do better. *The Australian & New Zealand Journal of Obstetrics & Gynaecology*, 62(3), 376–382. <https://doi.org/10.1111/ajo.13471>
5. Salmanian, B., Einerson, B. D., Carusi, D. A., Shainker, S. A., Nieto-Calvache, A. J. (2022). Timing of delivery for placenta accreta spectrum: the Pan-American Society for the Placenta Accreta Spectrum experience. *American Journal of Obstetrics & Gynecology MFM*, 4(6), 100718. <https://doi.org/10.1016/j.ajogmf.2022.100718>
6. Kayem, G., Seco, A., Beucher, G., Dupont, C., Branger, B. (2021). Clinical profiles of placenta accreta spectrum: the PACCRETA population-based study. *BJOG: An International Journal of Obstetrics and Gynaecology*, 128(10), 1646–1655. <https://doi.org/10.1111/1471-0528.16647>
7. Carusi, D. A., Fox, K. A., Lyell, D. J., Perlman, N. C., Aalipour, S., (2020). Placenta accreta spectrum without placenta previa. *Obstetrics and Gynecology*, 136(3), 458–465. <https://doi.org/10.1097/AOG.0000000000003970>
8. Morlando, M., & Collins, S. (2020). Placenta accreta spectrum disorders: challenges, risks, and management strategies. *International Journal of Women's Health*, 12, 1033–1045. <https://doi.org/10.2147/IJWH.S224191>
9. Twickler, D. M., Yule, C. S., & Spong, C. Y. (2021). Predicting placenta accreta spectrum: validation of the placenta accreta index. *Journal of Ultrasound in Medicine*, 40(12), 2789. <https://doi.org/10.1002/jum.15663>
10. Donovan, B. M., & Shainker, S. A. (2021). Placenta Accreta Spectrum. *NeoReviews*, 22(11), e722–e733. <https://doi.org/10.1542/neo.22-11-e722>
11. Lizárraga-Verdugo, E., Beltrán-Ontiveros, S. A., Gutiérrez-Grijalva, E. P., Montoya-Moreno, M. (2024). The underlying molecular mechanisms of the placenta accreta spectrum: a narrative review. *International Journal of Molecular Sciences*, 25(17), 9722.
12. Mohamed Siraj, S. H., Tan, K. H., & Wright, A. M. (2023). Conservative surgical approach towards placenta accreta spectrum disorders for uterine preservation. *BMC Pregnancy and Childbirth*, 23(1), 28.
13. Matsuzaki, S., Mandelbaum, R. S., Sangara, R. N., McCarthy, L. E., Vestal, N. L., Klar, M., Matsushima, K., Amaya, R., Ouzounian, J. G., & Matsuo, K. (2021). Trends, characteristics, and outcomes of placenta accreta spectrum: a national study in the United States. *American Journal of Obstetrics and Gynecology*, 225(5), 534.e1-534.e38. <https://doi.org/10.1016/j.ajog.2021.04.233>
14. Jauniaux, Eric, Kingdom, J. C., & Silver, R. M. (2021). A comparison of recent guidelines in the diagnosis and management of placenta accreta spectrum disorders. *Best Practice & Research. Clinical Obstetrics & Gynaecology*, 72, 102–116. <https://doi.org/10.1016/j.bpobgyn.2020.06.007>
15. Markfeld Erol, F., Häußler, J. A., Medl, M., Juhasz-Boess, I., & Kunze, M. (2024). Placenta accreta spectrum (PAS): diagnosis, clinical presentation, therapeutic approaches, and clinical outcomes. *Medicina (Kaunas, Lithuania)*, 60(7). <https://doi.org/10.3390/medicina60071180>
16. Arakaza, A., Zou, L., & Zhu, J. (2023). Placenta accreta spectrum diagnosis challenges and controversies in current obstetrics: a review. *International Journal of Women's Health*, 635-654.
17. Reale, S. C., & Farber, M. K. (2022). Management of patients with suspected placenta accreta spectrum. *BJA Education*, 22(2), 43–51. <https://doi.org/10.1016/j.bjae.2021.10.002>
18. Nieto-Calvache, A. J., Palacios-Jaraquemada, J. M., Hussein, A. M., Jauniaux, E., Milani Coutinho, C., & Rijken, M. (2024). Management of placenta accreta spectrum in low- and middle-income countries. *Best Practice & Research. Clinical Obstetrics & Gynaecology*, 94, 102475. <https://doi.org/10.1016/j.bpobgyn.2024.102475>
19. Pegu, B., Thiagaraju, C., Nayak, D., & Subbaiah, M. (2021). Placenta accreta spectrum-a catastrophic situation in obstetrics. *Obstetrics & Gynecology Science*, 64(3), 239–247. <https://doi.org/10.5468/ogs.20345>

20. Skupski, D. W., Duzyj, C. M., Scholl, J., Perez-Delboy, A., Ruhstaller, K. (2022). Evaluation of classic and novel ultrasound signs of placenta accreta spectrum. *Ultrasound in Obstetrics & Gynecology*, 59(4), 465–473. <https://doi.org/10.1002/uog.24804>
21. Jauniaux, E., D'Antonio, F., Bhide, A., Prefumo, F., Silver, R. M. (2023). Modified Delphi study of ultrasound signs associated with placenta accreta spectrum. *Ultrasound in Obstetrics & Gynecology*, 61(4), 518–525. <https://doi.org/10.1002/uog.26155>
22. Jauniaux, Eric, Fox, K. A., Einerson, B., Hussein, A. M., Hecht, J. L., & Silver, R. M. (2023). Perinatal assessment of complex cesarean delivery: beyond placenta accreta spectrum. *American Journal of Obstetrics and Gynecology*, 229(2), 129–139. <https://doi.org/10.1016/j.ajog.2023.02.021>
23. Kapoor, H., Hanaoka, M., Dawkins, A., & Khurana, A. (2021). Review of MRI imaging for placenta accreta spectrum: Pathophysiologic insights, imaging signs, and recent developments. *Placenta*, 104, 31–39. <https://doi.org/10.1016/j.placenta.2020.11.004>
24. Imafuku, H., Tanimura, K., Shi, Y., Uchida, A., Deguchi, M., & Terai, Y. (2021). Clinical factors associated with a placenta accreta spectrum. *Placenta*, 112, 180–184. <https://doi.org/10.1016/j.placenta.2021.08.001>
25. Einerson, B. D., Comstock, J., Silver, R. M., Branch, D. W., Woodward, P. J., & Kennedy, A. (2020). Placenta accreta spectrum disorder: uterine dehiscence, not placental invasion. *Obstetrics and Gynecology*, 135(5), 1104–1111. <https://doi.org/10.1097/AOG.0000000000003793>
26. Wu, X., Yang, H., Yu, X., Zeng, J., Qiao, J., Qi, H., & Xu, H. (2023). The prenatal diagnostic indicators of placenta accreta spectrum disorders. *Heliyon*, 9(5), e16241. <https://doi.org/10.1016/j.heliyon.2023.e16241>
27. Palacios-Jaraquemada, José Miguel, Fiorillo, A., Hamer, J., Martínez, M., & Bruno, C. (2022). Placenta accreta spectrum: a hysterectomy can be prevented in almost 80% of cases using a resective-reconstructive technique. *The Journal of Maternal-Fetal & Neonatal Medicine*, 35(2), 275–282. <https://doi.org/10.1080/14767058.2020.1716715>
28. Bhide, A. (2023). Routine screening for placenta accreta spectrum. *Best Practice & Research. Clinical Obstetrics & Gynaecology*, 90, 102392. <https://doi.org/10.1016/j.bpobgyn.2023.102392>
29. Ogawa, K., Jwa, S. C., Morisaki, N., & Sago, H. (2022). Risk factors and clinical outcomes for placenta accreta spectrum with or without placenta previa. *Archives of Gynecology and Obstetrics*, 305(3), 607–615. <https://doi.org/10.1007/s00404-021-06189-2>
30. Timofeeva, A. V., Fedorov, I. S., Suhova, Y. V., Tarasova, A. M., Ezhova, L. S., Zabelina, T. M.,... & Sukhikh, G. T. (2024). Diagnostic role of cell-free miRNAs in identifying placenta accreta spectrum during first-trimester screening. *International Journal of Molecular Sciences*, 25(2), 871.
31. Poljak, B., Khairudin, D., Wyn Jones, N., & Agten, A. K. (2023). Placenta accreta spectrum: diagnosis and management. *Obstetrics, Gynaecology & Reproductive Medicine*, 33(8), 232–238. <https://doi.org/10.1016/j.ogrm.2023.05.004>
32. Aryananda, R. A., Nieto-Calvache, A. J., Duvekot, J. J., Aditiawarman, A., & Rijken, M. J. (2023). Management of Unexpected Placenta Accreta Spectrum Cases in Resource-Poor Settings. *AJOG Global Reports*, 100191. <https://doi.org/10.1016/j.xagr.2023.100191>
33. Hessami, K., Salmanian, B., Einerson, B. D., Carusi, D. A. (2022). Clinical Correlates of Placenta Accreta Spectrum Disorder Depending on the Presence or Absence of Placenta Previa: A Systematic Review and Meta-analysis. *Obstetrics and Gynecology*, 140(4), 599–606. <https://doi.org/10.1097/AOG.0000000000004923>.
34. Salmanian, B., Fox, K. A., Arian, S. E., Erfani, H., Clark, S. L., Aagaard, K. M. (2020). In vitro fertilization as an independent risk factor for placenta accreta spectrum. *American Journal of Obstetrics and Gynecology*, 223(4), 568.e1-568.e5. <https://doi.org/10.1016/j.ajog.2020.04.026>

35. Palacios-Jaraquemada, José M, Basanta, N., Nieto-Calvache, Á., & Aryananda, R. A. (2022). Comprehensive surgical staging for placenta accreta spectrum. *The Journal of Maternal-Fetal & Neonatal Medicine*, 35(26), 10660–10666. <https://doi.org/10.1080/14767058.2022.2154572>
36. Baldwin, H. J., Nippita, T. A., Torvaldsen, S., Ibiebele, I., Ford, J. B., & Patterson, J. A. (2020). Outcomes of subsequent births after placenta accreta spectrum. *Obstetrics and Gynecology*, 136(4), 745–755. <https://doi.org/10.1097/AOG.0000000000004051>