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# Placenta Accreta Spectrum Disorders: Current Perspectives on Epidemiology, Diagnosis, and Management

**Tarek Mohamed El-Behiedy, Khaled Fathy Helal, Mohamed Ahmed Mahmoud Wasfy, Maryam Salim Mohamed Alzahran**

**Obstetrics and Gynecology Department, Faculty of Medicine -Zagazig University**

***Corresponding author:** Maryam Salim Mohamed Alzahran

**Email:** alzhranymrym387@gmail.com,

**Abstract**

Placenta accreta spectrum (PAS) disorders represent life-threatening obstetric complications characterized by abnormal placental adherence to or invasion through the uterine myometrium and adjacent structures. First systematically described by Irving and Hertig in 1937, PAS has transformed from an exceptionally rare condition occurring in approximately 1 in 30,000 deliveries to a major public health concern with current incidence rates of 1 in 300-500 deliveries. This dramatic 10-fold increase over the past four decades directly correlates with rising global cesarean delivery rates, establishing PAS as a predominantly iatrogenic complication of modern obstetric practice. The condition encompasses a spectrum of severity: placenta accreta (Grade 1), where chorionic villi attach directly to myometrium without intervening decidua; placenta increta (Grade 2), involving invasion into myometrial depth; and placenta percreta (Grade 3), characterized by penetration through the uterine serosa with potential invasion of bladder or other pelvic organs. PAS is associated with severe maternal morbidity including massive hemorrhage requiring extensive blood transfusion, emergency hysterectomy resulting in fertility loss, urologic and bowel injuries, intensive care unit admission, and maternal mortality rates reaching 7% in some series. The combination of placenta previa with prior cesarean delivery constitutes the highest risk profile, with PAS occurrence escalating from 3% after one cesarean to 67% after five or more procedures. Despite advances in prenatal imaging and multidisciplinary management, population-based studies reveal that approximately 50% of cases remain undiagnosed before delivery, contributing to preventable maternal morbidity and mortality. This review synthesizes current evidence on PAS pathophysiology, epidemiology, standardized classification systems, prenatal diagnostic strategies, and evidence-based management approaches to optimize maternal and neonatal outcomes.

**Keywords:** Placenta accreta spectrum, abnormally invasive placenta, placenta previa, cesarean delivery, prenatal ultrasound diagnosis, magnetic resonance imaging, maternal hemorrhage, cesarean hysterectomy, conservative management, maternal morbidity, trophoblast invasion, FIGO classification

## Introduction

Placenta accreta spectrum (PAS) disorders represent one of the most serious complications in modern obstetrics, characterized by abnormal adherence and invasion of placental tissue into the uterine myometrium and potentially beyond. First described by Frederick C. Irving and Arthur T. Hertig in 1937, these conditions have evolved from rare clinical curiosities to increasingly common obstetric emergencies that pose significant risks to both maternal and neonatal health (1).

The terminology surrounding abnormal placentation has undergone substantial refinement over the past decades. In March 2018, the International Federation of Gynecology and Obstetrics (FIGO) introduced standardized terminology, adopting "Placenta Accreta Spectrum" to encompass all degrees of abnormal placental implantation. This spectrum includes placenta accreta (adherent placenta attached directly to the myometrium), placenta increta (placental invasion into the myometrium), and placenta percreta (placental invasion through the uterine serosa and potentially into adjacent organs) (2).

The global incidence of PAS has risen dramatically over recent decades, with current estimates ranging from 0.3% to 0.31% of all deliveries, representing an approximate tenfold increase since the early 20th century when incidence was estimated at one in 30,000 deliveries. This escalation correlates strongly with increasing cesarean section rates worldwide, which have risen from less than 10% to over 30% in many countries. Data from nationally representative databases reveal that PAS disorders have increased approximately 2% every three months among patients undergoing cesarean delivery, highlighting the urgent need for improved diagnostic and management strategies (3).

Placenta previa, defined as complete or partial covering of the internal cervical os by the placenta, affects 0.3% to 2% of pregnancies in the third trimester and serves as a major risk factor for PAS development. The combination of placenta previa with prior cesarean delivery creates a particularly high-risk scenario, with PAS occurring in 10-60% of such cases depending on the number of previous cesarean sections. Population-based studies from the United Kingdom and Nordic countries have shown that this combination accounts for 29-62% of all PAS cases, leaving a substantial proportion occurring in women with different risk profiles (4).

The clinical significance of PAS extends beyond maternal morbidity to encompass substantial healthcare costs, prolonged hospitalizations, and psychological impacts on affected families. Maternal complications include massive hemorrhage requiring blood transfusion, emergency hysterectomy resulting in permanent infertility, urinary tract injuries, disseminated intravascular coagulation (DIC), intensive care unit (ICU) admission, and in severe cases, maternal mortality rates approaching 7%. Neonatal outcomes are similarly affected, with increased risks of preterm delivery, low birth weight, respiratory distress syndrome, and neonatal intensive care unit (NICU) admission (5).

This comprehensive review aims to synthesize current knowledge regarding the epidemiology, pathophysiology, diagnosis, and management of PAS disorders, with particular emphasis on the relationship between placenta previa and PAS outcomes, emerging diagnostic modalities, and evidence-based management strategies to optimize maternal and neonatal outcomes.

**Epidemiology and Risk Factors**

The epidemiology of placenta accreta spectrum disorders has undergone dramatic transformation over the past century. Early 20th-century studies reported an estimated incidence of one in 30,000 deliveries in the United States. Contemporary publications from diverse geographical regions now report substantially higher rates, with recent estimates ranging from one in 533 to one in 321 births in populations with elevated cesarean section rates. This represents an approximate tenfold increase in prevalence, directly paralleling the global rise in cesarean delivery rates (6).

Geographic and demographic variations in PAS incidence reflect differences in obstetric practices, healthcare access, and population characteristics. Studies from the Middle East, including Egypt and Saudi Arabia, have documented varying prevalence rates influenced by cultural factors affecting family size, acceptance of cesarean delivery, and access to prenatal diagnostic services. The prevalence of PAS varies among different populations according to the distribution of associated risk factors, making accurate prevalence estimation challenging without standardized diagnostic criteria and reporting mechanisms (7).

**Primary Risk Factors**

**Prior Cesarean Delivery**

Previous cesarean section represents the single most significant modifiable risk factor for PAS development. The risk escalates dramatically with increasing numbers of prior cesarean deliveries. A large multicenter United States study demonstrated that among women with placenta previa, the risk of PAS was 3% after one cesarean delivery, 11% after two, 40% after three, 61% after four, and 67% after five or more cesarean deliveries. This linear relationship between the number of uterine scars and PAS risk underscores the importance of judicious use of primary cesarean delivery and promotion of vaginal birth after cesarean (VBAC) when appropriate (8).

The mechanism by which prior cesarean delivery predisposes to PAS involves iatrogenic disruption of the endometrium-myometrial interface, leading to impaired decidualization at the scar site. This deficient decidual layer fails to regulate trophoblastic invasion adequately, enabling abnormally deep placental infiltration. The extent of deciduo-myometrial damage correlates with the depth of placental invasion, with full-thickness surgical scars showing stronger associations with invasive placentation (increta/percreta) compared to superficial endometrial injuries that more commonly result in adherent placentation (accreta) (9).

**Placenta Previa**

Placenta previa, defined as placental implantation over or within 2 cm of the internal cervical os, constitutes another major risk factor for PAS. Approximately half of all PAS cases occur in association with placenta previa. The risk of developing previa increases progressively with higher numbers of previous cesarean deliveries, with reported rates of 1% after one cesarean, 2.8% after three cesareans, and 3.7% after five or more cesarean deliveries. When placenta previa coexists with a history of cesarean delivery, particularly when the placenta implants over the previous hysterotomy scar (anterior placenta previa), the risk of PAS reaches its zenith (10).

The lower uterine segment possesses inherent vulnerability to abnormal placentation due to its relatively thin musculature and less robust decidual development compared to the fundus. Additionally, the biomechanical stress of previous uterine incisions concentrated in this region creates focal areas of scarring and impaired vascular remodeling that predispose to both previa and accreta pathology (11).

**Advanced Maternal Age**

Maternal age represents an independent risk factor for both placenta previa and PAS development. The incidence of placenta previa increases from less than 1% in women under 20 years to approximately 2% after age 35 years and 5% after age 40 years, representing a ninefold increase. Similarly, PAS risk escalates with advancing maternal age, although this relationship may be partially confounded by higher parity and increased probability of previous uterine procedures in older women. The biological basis for age-related risk may involve altered hormonal environments, cumulative endometrial damage, or age-related changes in uterine vasculature and decidual function (12).

**Multiparity**

High parity independently increases PAS risk, likely through cumulative endometrial trauma from repeated pregnancies and deliveries. Each pregnancy induces structural and functional changes to the endometrium and myometrium, including progressive thinning of the uterine wall, altered vascular patterns, and potential microtrauma even in the absence of surgical intervention. Studies have documented significant associations between multiparity (≥3 previous births) and PAS development, with effect sizes that persist after adjustment for confounding variables including maternal age and cesarean delivery history (13).

**Other Uterine Procedures**

Various gynecologic and obstetric procedures beyond cesarean delivery contribute to PAS risk through endometrial disruption. Manual removal of the placenta, uterine curettage for miscarriage management or endometrial sampling, myomectomy, endometrial ablation, and uterine artery embolization all create potential sites of deficient decidualization. The location and extent of resulting scarring determines subsequent risk, with transmural injuries carrying higher risk than superficial procedures. Additionally, conditions like endometritis may impair endometrial regeneration and healing, further compromising the decidual barrier against excessive trophoblastic invasion (14).

**Assisted Reproductive Technology**

In vitro fertilization (IVF) has emerged as an independent risk factor for PAS, with mechanisms extending beyond the increased multiple gestation rates associated with assisted reproduction. The characteristic hormonal milieu during embryo transfer, including supraphysiologic estrogen levels from ovarian stimulation, may enhance trophoblastic invasion through the endometrium. Alternatively, the relatively thin, less robustly decidualized endometrium often present during frozen embryo transfer cycles may provide inadequate resistance to trophoblastic penetration. Studies suggest IVF confers approximately 2-4 fold increased PAS risk, although precise estimates vary based on specific protocols and patient populations (15).

**Cesarean Scar Pregnancy**

Cesarean scar pregnancy, defined as gestational sac implantation into a previous hysterotomy scar, represents a unique risk factor with the potential to evolve into clinically significant PAS. Not all scar pregnancies progress to PAS, but identifying those at highest risk remains challenging. Recent ultrasound markers, including the cross-over sign (COS), show promise for risk stratification. Systematic reviews indicate that cesarean scar pregnancies with detectable fetal cardiac activity face substantially higher risk of first- and second-trimester maternal complications, with approximately

three-quarters of pregnancies reaching the third trimester developing PAS. Management strategies for cesarean scar pregnancy must balance the risks of expectant management against the morbidity of early pregnancy termination (16).

**Racial and Ethnic Factors**

The role of race and ethnicity in PAS epidemiology remains controversial, with conflicting evidence from various populations. Some studies report increased risk among Black and Asian women, while others find no significant racial differences after adjustment for socioeconomic factors and healthcare access. These inconsistencies may reflect complex interactions between genetic susceptibility, environmental exposures, healthcare disparities, and differences in obstetric practices across racial and ethnic groups. Further research using standardized diagnostic criteria and adequate adjustment for confounding variables is needed to clarify racial and ethnic contributions to PAS risk (17).

**Pathophysiology**

**Decidual Deficiency Theory**

The prevailing hypothesis for PAS pathogenesis centers on defective decidualization at sites of previous uterine injury, most commonly cesarean delivery scars. The decidua basalis normally regulates trophoblastic invasion through multiple mechanisms, including production of protease inhibitors, expression of cell adhesion molecules, and secretion of immune modulators that limit trophoblast penetration to the superficial endometrium. Disruption of this decidual-myometrial interface, whether through surgical trauma, inflammation, or other insults, removes these regulatory mechanisms and permits uncontrolled infiltration of extravillous trophoblast through the myometrial depth (18).

Evidence supporting the decidual deficiency theory derives from multiple sources. Histopathologic examination of PAS specimens consistently demonstrates absent or markedly attenuated decidual tissue between placental villi and myometrium. Ectopic pregnancies implanting in locations physiologically devoid of decidua, such as the fallopian tube or abdominal cavity, invariably exhibit aggressive invasion of muscular and serosal layers analogous to placenta percreta. Furthermore, the extent of trophoblastic penetration correlates with the degree of deciduo-myometrial damage, with superficial injuries more commonly associated with adherent placentation and full-thickness scars predisposing to invasive forms (19).

**Vascular Remodeling Abnormalities**

Normal placentation requires extensive remodeling of maternal spiral arteries by invading extravillous trophoblast cells. This physiologic process transforms high-resistance, muscular spiral arterioles into low-resistance, dilated uteroplacental vessels capable of accommodating the 10-fold increase in blood flow required for fetal growth. In PAS, this vascular remodeling extends abnormally deep into the myometrium, affecting large arteries below the normal physiologic limit at the endometrial-myometrial junction. These deeply remodeled vessels remain dilated and lose their normal vasoreactive properties throughout pregnancy (20).

Additionally, PAS cases demonstrate aberrant neovascularization within and around the placental bed, particularly evident in the lower uterine segment of patients with invasive placentation. Ultrasound imaging and direct surgical observation reveal hypervascular placental beds with tortuous, dilated vessels and increased blood flow. This abnormal vasculature likely represents a combination of pathologic angiogenesis stimulated by hypoxic placental tissue and the persistence of abnormally dilated spiral arteries failing to undergo postpartum involution. The clinical significance of this hypervascularity manifests as the massive, often uncontrollable hemorrhage characteristic of PAS when surgical separation is attempted (21).

**Scar Dehiscence and Uterine Window**

Progressive thinning and eventual dehiscence of lower uterine segment cesarean scars contributes to PAS pathophysiology, particularly in the third trimester. Biomechanical stress from the growing fetus, uterine contractions, and myometrial distension all promote gradual scar disruption. In some cases, placental tissue becomes visible directly beneath the uterine serosa through areas of complete dehiscence, creating a "uterine window." This phenomenon must be distinguished from true placenta percreta, as uterine windows may occur with otherwise normal placentation and do not necessarily warrant cesarean hysterectomy. The key differentiating feature is that surrounding myometrium appears normal in uterine windows, whereas true percreta displays characteristic vascular changes and myometrial disruption extending beyond the dehiscence site (22).

**Molecular and Immunologic Mechanisms**

Emerging research has identified molecular alterations in PAS placentas that may contribute to pathologic invasion. Studies demonstrate dysregulated expression of matrix metalloproteinases (MMPs) and their tissue inhibitors (TIMPs), with increased protease activity facilitating excessive extracellular matrix degradation and trophoblast penetration. Alterations in cell adhesion molecules, including integrins and cadherins, may impair normal trophoblast-decidual interactions that limit invasion depth. Additionally, abnormal expression of angiogenic factors such as vascular endothelial growth factor (VEGF) and placental growth factor (PlGF) likely contributes to the aberrant vascularization characteristic of PAS (23).

Immunologic factors also play roles in PAS pathogenesis. The maternal-fetal interface normally exhibits carefully orchestrated immune tolerance mechanisms, including specialized decidual natural killer (NK) cells and T-regulatory cells that prevent maternal immune rejection of fetal tissues while maintaining surveillance against excessive trophoblast invasion. Disruption of this delicate immunologic balance, potentially through decidual injury or altered cytokine environments, may permit pathologic placental invasion. Furthermore, expression patterns of human leukocyte antigens (HLA) and killer cell immunoglobulin-like receptors (KIRs) on trophoblast and decidual cells may influence invasion propensity (24).

**Hormonal Influences**

The hormonal environment during implantation and early placentation may modulate PAS risk, particularly in pregnancies achieved through assisted reproductive technology. Supraphysiologic estrogen levels resulting from controlled ovarian hyperstimulation could enhance trophoblastic invasion through multiple mechanisms, including upregulation of proteases, stimulation of angiogenesis, and modulation of immune responses. Conversely, relatively low progesterone levels or altered progesterone receptor expression in subfertility populations might compromise decidual development and function. The precise hormonal contributions to PAS pathogenesis remain incompletely understood and warrant further investigation (25).

**Clinical Presentation and Diagnosis**

The clinical presentation of PAS varies considerably depending on gestational age at diagnosis, degree of placental invasion, and presence of complications. Many cases remain asymptomatic until delivery, with diagnosis made through routine prenatal imaging. However, women may present with antepartum vaginal bleeding, particularly when PAS coexists with placenta previa. Such bleeding episodes typically occur in the late second or third trimester and may range from minimal spotting to massive hemorrhage requiring emergency delivery. The classic presentation of placenta previa—painless vaginal bleeding with a soft, non-tender uterus and reassuring fetal status—should always prompt consideration of possible underlying PAS (26).

At the time of delivery, whether by scheduled cesarean or emergent operative intervention, PAS manifests as failure of normal placental separation after delivery of the neonate. Attempted manual removal of an adherent or invasive placenta invariably triggers torrential bleeding from the exposed placental bed, where deficient myometrium cannot contract adequately to achieve hemostasis. This scenario represents an obstetric emergency requiring immediate aggressive management. In cases of placenta percreta with bladder invasion, patients may report hematuria or lower abdominal pain. Rare cases of spontaneous uterine rupture in the antepartum period have been reported with extensive myometrial invasion (27).

**Ultrasound Diagnosis**

Transvaginal and transabdominal ultrasonography constitute the primary screening and diagnostic modalities for PAS, with sensitivity and specificity exceeding 90% in experienced hands. Systematic evaluation should be performed in all women with risk factors, particularly those with placenta previa and prior cesarean delivery. The optimal timing for screening remains debated, but most experts recommend initial evaluation during routine second-trimester anatomic survey (18-22 weeks), with follow-up examinations in the third trimester (28-32 weeks) to assess progression and facilitate delivery planning (28).

**Grayscale Ultrasound Findings**

Several grayscale sonographic features suggest PAS. Loss or irregularity of the retroplacental "clear zone" the hypoechoic band normally visible between the placental basal plate and myometrium represents one of the most consistent and reliable signs. This finding reflects absence of the normal decidual layer and direct apposition of placental tissue to myometrium. Abnormal placental lacunae, appearing as irregular anechoic spaces within the placenta often containing turbulent flow visible on grayscale imaging, constitute another key diagnostic feature. These lacunae are graded using the Finberg classification, with Grade 3 lacunae (numerous large, irregular spaces) showing strongest association with PAS (29).

Additional grayscale findings include myometrial thinning (< 1 mm or undetectable), bladder wall interruption (loss of the hyperechoic line between uterine serosa and bladder), placental bulge (deviation of uterine serosa away from expected contour), and focal exophytic placental mass extending through the uterine serosa into the bladder or other organs. No single finding definitively establishes PAS diagnosis, but the presence of multiple features substantially increases diagnostic confidence (30).

**Color and Power Doppler Assessment**

Doppler evaluation provides complementary information regarding the abnormal vascularity characteristic of PAS. Uterovesical hypervascularity, defined as striking amounts of color Doppler signal between the myometrium and posterior bladder wall, indicates numerous tortuous vessels with multidirectional flow and aliasing artifact in this region. Subplacental hypervascularity similarly demonstrates increased vascularity within the placental bed. Bridging vessels, appearing to extend from the placenta through the myometrium and beyond the serosa into the bladder or other structures, represent a particularly specific finding often running perpendicular to myometrial fibers. Finally, placental lacunae feeder vessels show high-velocity blood flow from myometrial vessels into placental lacunae, producing turbulence at the entry point (31).

**Three-Dimensional Ultrasound**

Three-dimensional (3D) power Doppler ultrasonography offers potential advantages over two-dimensional imaging by allowing comprehensive visualization of placental vascular architecture and spatial relationships between the placenta, uterus, and adjacent organs. Studies investigating 3D techniques report promising diagnostic performance, though whether 3D imaging improves outcomes beyond skilled 2D evaluation remains uncertain. The primary utility of 3D ultrasound may lie in cases where 2D findings are equivocal or for training purposes to enhance provider familiarity with PAS sonographic features (32).

**Magnetic Resonance Imaging**

Magnetic resonance imaging (MRI) serves as a complementary diagnostic tool in select cases, though it has not demonstrated clear superiority over ultrasound for PAS diagnosis. MRI achieves sensitivity and specificity comparable to ultrasound in most studies. The primary indications for MRI include posterior placentation (where ultrasound visualization may be limited), high maternal body mass index precluding adequate ultrasound assessment, and evaluation of potential parametrial or bladder invasion to guide surgical planning. MRI offers the advantage of depicting the entire pelvis and can be evaluated offline by multiple reviewers. However, higher cost, limited availability, and longer acquisition times compared to ultrasound restrict its routine use (33).

**MRI Findings**

MRI features suggestive of PAS include uterine bulging, heterogeneous signal intensity within the placenta, dark intraplacental bands on T2-weighted images, loss of the normal hypointense myometrial zone between the placenta and uterine serosa, abnormal placental vascularity, and direct visualization of placental tissue extending through the uterine serosa or into the bladder. Standardized MRI descriptors analogous to the ultrasound criteria have been proposed to improve consistency in reporting and interpretation. T2-weighted sequences provide optimal anatomic detail, while T1-weighted images assist in detecting hemorrhage. Gadolinium contrast administration should be avoided during pregnancy when possible, though post-delivery MRI with contrast may aid in characterizing retained placental tissue in conservatively managed cases (34).

**Biochemical Markers**

Multiple potential biomarkers for PAS have been investigated, though none has achieved sufficient diagnostic performance for clinical implementation. First-trimester studies have shown decreased levels of human chorionic gonadotropin (hCG) and free beta-subunit (β-hCG) with increased pregnancy-associated plasma protein A (PAPP-A) in women who subsequently develop PAS. Mid-trimester evaluations demonstrate elevated β-hCG and alpha-fetoprotein (AFP) levels in PAS cases. More recently, proteomic analyses have identified distinct plasma protein profiles in PAS pregnancies, with dysregulation of approximately 50 proteins involved in inflammation, vascular remodeling, and extracellular matrix regulation (35).

Despite these promising preliminary findings, substantial challenges impede translation of biomarker research into clinical practice. Considerable overlap exists between biomarker levels in affected and unaffected pregnancies, limiting sensitivity and specificity. Biomarker concentrations vary with gestational age at sampling, necessitating gestational age-specific reference ranges. Furthermore, most studies have employed retrospective case-control designs in relatively small, high-risk populations, potentially overestimating diagnostic performance. Future research combining multiple biomarkers with clinical risk factors and imaging findings through machine learning algorithms may eventually enable effective serological screening analogous to current approaches for aneuploidy and preeclampsia (36).

**Intraoperative Diagnosis**

Regardless of prenatal imaging findings, definitive PAS confirmation requires intraoperative assessment. A systematic stepwise approach has been proposed to standardize clinical diagnosis at the time of cesarean delivery. Upon entering the abdomen, the surgical team should first perform thorough inspection of the external uterine surface and pelvis for signs of placental invasion, including bluish-purple discoloration overlying the placental bed, evident uterine bulging or distortion, prominent vascularity, or frank placental tissue visible through the serosa or invading adjacent organs. Identification of these features confirms PAS and should prompt immediate implementation of appropriate management protocols (37).

If external findings are equivocal, the uterine incision should be made in a location avoiding the placenta when possible. After neonatal delivery, gentle controlled cord traction may be attempted while observing for the "dimple sign"—inward pulling of the uterine wall in the direction of traction without placental separation, indicating abnormal adherence. If this sign is present or if significant hemorrhage begins with minimal manipulation, further attempts at placental removal should be abandoned and cesarean hysterectomy or conservative management pursued as planned. Importantly, digital exploration to manually separate the placenta must be avoided, as this maneuver precipitates uncontrollable hemorrhage from the deficient myometrium unable to contract adequately for hemostasis (38).

**FIGO Classification System**

The International Federation of Gynecology and Obstetrics (FIGO) has established a standardized classification system integrating clinical and histopathologic criteria to categorize placental adherence and invasion. Grade 1 (abnormally adherent placenta/placenta accreta) encompasses cases where placental villi attach directly to superficial myometrium without intervening decidua but do not invade deeply. Grade 2 (abnormally invasive placenta/placenta increta) describes villous penetration into myometrial muscle fibers. Grade 3 (abnormally invasive placenta/placenta percreta) includes three subcategories: Grade 3a (invasion limited to uterine serosa), Grade 3b (bladder invasion), and Grade 3c (invasion of other pelvic tissues or organs). This classification system facilitates standardized reporting, enables meaningful comparison across studies, and guides management decisions (39).

**Management Strategies**

**Prenatal Planning and Multidisciplinary Care**

Optimal outcomes in PAS cases require meticulous prenatal planning coordinated by a multidisciplinary team (MDT) with expertise in complex obstetric hemorrhage management. The hallmark of centers of excellence for PAS care includes availability of experienced obstetricians, anesthesiologists, neonatologists, interventional radiologists, urologists, vascular surgeons, gynecologic oncologists, and blood bank personnel. This team should be available 24 hours daily to ensure rapid response capability for emergency deliveries. Prenatal consultations should establish clear communication channels, review imaging findings collaboratively, discuss potential complications, obtain informed consent for various interventions including hysterectomy, and develop individualized delivery plans (40).

Evidence consistently demonstrates that planned delivery in tertiary centers with experienced MDTs significantly reduces maternal morbidity and mortality compared to undiagnosed cases delivered in community settings. Studies report 40-50% rates of severe maternal morbidity in PAS cases overall, but centers with specialized protocols achieve substantially improved outcomes. Maternal mortality rates have declined from historical levels approaching 7% to approximately 0.05% in contemporary series from expert centers, primarily through early diagnosis, careful planning, and standardized management protocols (41).

**Timing of Delivery**

Determining optimal delivery timing involves balancing maternal risks of antepartum hemorrhage or emergency delivery against neonatal risks of prematurity. No universal consensus exists regarding ideal gestational age for scheduled delivery. Various expert groups have proposed elective delivery ranging from 34 to 38 weeks, reflecting the lack of high-quality evidence guiding this decision. A reasonable individualized approach considers the woman's specific risk profile, including history of preterm delivery, antepartum bleeding episodes, and PAS severity (42).

For women without previous preterm birth who remain stable without vaginal bleeding, preterm contractions, or preterm premature rupture of membranes (PPROM), expectant management until 36-37 weeks appears safe and allows for greater fetal maturation. Conversely, women with prior preterm delivery, multiple bleeding episodes, single significant hemorrhage, or PPROM should undergo planned delivery at approximately 34 weeks after administration of antenatal corticosteroids for fetal lung maturation. Emergency delivery may become necessary at any gestational age if maternal or fetal compromise develops. Regardless of planned timing, all women with diagnosed PAS should receive antenatal corticosteroids according to gestational age-specific guidelines (43).

**Surgical Approach: Cesarean Hysterectomy**

Cesarean hysterectomy remains the definitive management for PAS and is considered the gold standard approach in most cases. This procedure involves delivering the infant through a uterine incision placed to avoid placental transection when possible, then proceeding immediately to hysterectomy without attempting placental removal. Several technical considerations optimize outcomes in this challenging operation (44).

**Surgical Access**

Adequate surgical exposure is paramount given the potential for massive hemorrhage and need for pelvic dissection in difficult anatomic planes. Many surgeons prefer vertical skin incisions extending from the umbilicus toward the pubis, providing excellent access to the entire pelvis and enabling rapid extension if necessary. However, large transverse incisions, including modified Maylard incisions with division of the rectus muscles, offer acceptable alternatives with faster healing and superior cosmetic outcomes. The choice should be individualized based on surgeon preference, patient body habitus, placental location, anticipated complexity, and gestational age (45).

**Uterine Incision**

Intraoperative ultrasound performed in sterile fashion can guide hysterotomy placement to avoid placental transection. In cases of anterior placenta previa with suspected accreta, a fundal or high vertical incision may be necessary. After infant delivery, the uterine incision should be closed rapidly, leaving the placenta completely undisturbed and in situ. Any attempt at placental removal, whether manual or with instruments, risks catastrophic hemorrhage and should be strictly avoided. The closed uterus containing the placenta then facilitates the subsequent hysterectomy by providing a firm, defined structure for dissection (46).

**Type of Hysterectomy**

Total hysterectomy with removal of the cervix is typically required when PAS accompanies complete placenta previa, as the lower uterine segment and cervix frequently harbor invasive placental tissue. Subtotal (supracervical) hysterectomy may be considered in rare cases where the accreta area is confined to the fundus or upper uterine segment, though such cases are uncommon. The decision should be made based on intraoperative findings and surgeon assessment of cervical involvement (47).

**Management of Complications**

Urinary tract injuries occur in approximately 29% of cesarean hysterectomies performed for PAS, with 76% involving bladder lacerations, 17% ureteral injuries, and 5% genitourinary fistulas. Meticulous surgical technique with careful bladder dissection, liberal use of intraoperative cystoscopy, and availability of urologic consultation minimize these risks. Other potential complications include bowel injury, vascular injury, and nerve damage, though these occur less frequently than urologic injuries. Intraoperative cell salvage and massive transfusion protocols should be implemented, as blood loss frequently exceeds 2000 mL and transfusion requirements may surpass 10 units of red blood cells (48).

**Delayed Hysterectomy**

Delayed or interval hysterectomy represents an alternative radical approach in select circumstances. This strategy involves delivering the infant, closing the uterus with placenta in situ, and closing the abdomen, then scheduling planned hysterectomy 3-12 weeks postpartum after uterine involution and reduction in vascularity. Theoretical advantages include easier surgical planes, decreased blood loss, and reduced injury to adjacent structures. Two primary scenarios warrant consideration of delayed hysterectomy: 1) unsuspected highly invasive PAS diagnosed at laparotomy when the surgeon lacks experience managing complex cases and both mother and infant are stable, permitting stabilization and transfer to a center of excellence; and 2) elective cases where initial surgery focuses on maternal-neonatal stabilization with subsequent definitive surgery after optimization (49).

Limited data regarding delayed hysterectomy outcomes preclude firm conclusions about its safety and efficacy compared to immediate hysterectomy. Potential disadvantages include persistent bleeding risk during the interval period, ongoing infection risk, need for multiple operations, and patient anxiety. Further research is needed to define optimal patient selection criteria and timing for interval hysterectomy (50).

**Conservative Management**

Fertility-sparing conservative management, defined as any approach avoiding hysterectomy, may be considered in carefully selected cases for women desiring future childbearing or in settings where cultural or social factors make permanent sterility unacceptable. The fundamental principle of conservative management involves delivering the infant via cesarean section, ligating the umbilical cord close to its placental insertion, and leaving the entire placenta in situ without any attempt at removal. The expectation is that placental tissue will gradually undergo devascularization, degeneration, and eventual resorption or expulsion over subsequent weeks to months (51).

**Outcomes and Complications**

Conservative management success rates, defined as uterine preservation, range from 78-80% in published series. However, this approach carries substantial risks. Severe maternal complications occur in approximately 6% of conservatively managed cases, including sepsis, uterine necrosis, delayed postpartum hemorrhage requiring emergency surgery, uterine rupture in subsequent pregnancies, vesicouterine fistula, pulmonary edema, renal failure, venous thromboembolism, and rarely maternal death. The time course for placental resorption or expulsion varies considerably, with median duration of approximately 13.5 weeks but ranging from 4 weeks to 9-12 months in individual cases (52).

**Adjunctive Measures**

Various adjunctive interventions have been employed with conservative management, including methotrexate administration, uterine artery embolization, prophylactic balloon catheter placement, and uterine compression sutures. However, evidence regarding efficacy of these measures remains limited and conflicting. Importantly, methotrexate use has been associated with maternal death in the largest case series and is explicitly discouraged by international consensus guidelines, as term placental tissue exhibits minimal proliferative activity and thus fails to respond to antiproliferative agents. Uterine artery embolization has been linked to severe complications including uterine necrosis. Most experts recommend against routine use of adjunctive measures, with conservative management consisting simply of leaving the placenta in situ with close postoperative monitoring, prophylactic antibiotics, and serial ultrasound assessments (53).

**Patient Selection and Counseling**

Appropriate patient selection is critical for conservative management. Ideal candidates include women with strong desire for fertility preservation, focal adherent (rather than deeply invasive) placentation, hemodynamic stability at delivery, absence of active bleeding, and willingness to accept risks including prolonged follow-up, potential need for delayed

hysterectomy, and uncertain time course for placental resolution. Comprehensive counseling must address all potential complications, the possibility of failure necessitating emergency hysterectomy, unknown effects on subsequent pregnancies, and recurrence risk in future gestations. Women should understand that while subsequent fertility rates approach 89% among those attempting pregnancy, PAS recurrence risk reaches 29% in subsequent pregnancies (54).

**Local Resection**

Local surgical resection techniques, involving removal of the myometrial segment containing adherent or invasive placental tissue with reconstruction of the uterine defect, represent emerging fertility-preserving approaches. Multiple variations have been described, including triple P procedure (perioperative placental localization followed by pelvic devascularization), wedge resection with uterine reconstruction, placental attachment site resection, and others. Terminology and technical details vary considerably across reports, complicating interpretation of available evidence (55).

The International Society for Abnormally Invasive Placenta (IS-AIP) defines appropriate candidates for local resection as cases with focal disease affecting less than 50% of the anterior uterine surface, absence of parametrial or cervical invasion, and availability of surgical expertise. When properly selected cases undergo resection by experienced surgeons, outcomes may include reduced blood loss and lower morbidity compared to hysterectomy, while preserving fertility. However, substantial limitations in current evidence preclude definitive recommendations. Most published series are small, retrospective, and subject to significant selection bias. Standardized outcome reporting and prospective comparative studies are urgently needed to establish the role of local resection in PAS management algorithms (56).

**Interventional Radiology Procedures**

Prophylactic balloon catheter placement in the internal iliac or common iliac arteries, performed by interventional radiologists prior to cesarean delivery, has been proposed to facilitate rapid vascular occlusion and hemorrhage control if massive bleeding occurs. Theoretical advantages include immediate reduction in pelvic blood flow upon balloon inflation, potentially decreasing surgical blood loss and transfusion requirements. However, evidence regarding efficacy remains mixed and controversial (57).

Several randomized trials and meta-analyses have failed to demonstrate consistent benefits of prophylactic balloon catheter placement in PAS cases. Some studies report modest reductions in blood loss, while others show no significant differences and even suggest possible harm through delays in definitive management or vascular complications. Additional concerns include substantial cost, fetal radiation exposure, risk of arterial injury or thrombosis, and potential for ischemic complications including buttock claudication or neurologic injury. Current evidence does not support routine prophylactic balloon catheter use, though individual cases with extensive pelvic involvement or difficult vascular access might benefit from selective application (58).

Postoperative uterine artery embolization may play a role in managing persistent hemorrhage after conservative management or local resection procedures. However, this intervention carries risks including infection, uterine necrosis, and fertility impairment, and should be reserved for cases where benefits clearly outweigh risks (59).

**Anesthetic Considerations**

Anesthetic management profoundly influences maternal outcomes in PAS cases. For scheduled cesarean deliveries without emergency indications, neuraxial anesthesia (spinal, epidural, or combined spinal-epidural) is generally preferred. Regional techniques offer several advantages including reduced blood loss compared to general anesthesia, avoidance of airway instrumentation and mechanical ventilation, maintenance of maternal consciousness for immediate neonatal bonding, and superior postoperative pain control. Additionally, neuraxial anesthesia avoids the uterine relaxation induced by volatile anesthetic agents during general anesthesia, which can exacerbate postpartum hemorrhage (60).

Nonetheless, general anesthesia remains necessary in certain scenarios, including emergency deliveries requiring immediate intervention, hemodynamically unstable patients, coagulopathy precluding neuraxial techniques, and patient preference or contraindications to regional anesthesia. For cases beginning with neuraxial anesthesia where hysterectomy becomes necessary, conversion to general anesthesia allows deeper sedation for the extended operative duration. Close collaboration between obstetric and anesthesia teams facilitates smooth transitions between anesthetic techniques as clinical circumstances evolve (61).

Critical anesthetic components for PAS cases include large-bore intravenous access (typically two 16- or 18-gauge catheters), arterial line placement for continuous blood pressure monitoring and serial blood gas analysis, consideration of central venous access for massive transfusion, normothermia maintenance to prevent coagulopathy, and implementation of institutional massive transfusion protocols. Tranexamic acid administration should be considered based on emerging evidence of efficacy in obstetric hemorrhage. Communication with blood bank personnel before surgery ensures adequate blood product availability, including packed red blood cells, fresh frozen plasma, platelets, and cryoprecipitate in ratios appropriate for massive transfusion (62).

**Blood Product Management**

Massive transfusion, defined as replacement of one or more blood volumes within 24 hours or transfusion of 10 or more units of red blood cells, occurs frequently in PAS cases. Traditional component therapy with sequential administration of packed red blood cells followed by plasma and platelets based on laboratory values has been superseded by balanced resuscitation protocols using predetermined ratios of blood components. Evidence from trauma and military medicine demonstrates that early, aggressive administration of plasma and platelets in approximately 1:1:1 ratio with red blood cells improves outcomes by preventing dilutional coagulopathy and maintaining hemostatic capacity (63).

Obstetric massive transfusion protocols adapted from trauma algorithms should be activated early when significant hemorrhage is anticipated or occurs. Point-of-care testing including thromboelastography (TEG) or rotational thromboelastometry (ROTEM) enables rapid assessment of coagulation status and targeted correction of specific deficiencies. Fibrinogen replacement with cryoprecipitate or fibrinogen concentrate is particularly important, as obstetric hemorrhage characteristically depletes fibrinogen levels. Target fibrinogen levels of at least 2 g/L (200 mg/dL) should be maintained. Additional hemostatic adjuncts may include recombinant activated factor VII (rFVIIa) in refractory cases, though evidence supporting its use remains limited and safety concerns exist (64).

**Maternal and Neonatal Outcomes**

**Maternal Morbidity**

Placenta accreta spectrum disorders are associated with substantial maternal morbidity even with optimal management. Reported rates of severe maternal morbidity (SMM) range from 40-60% in most series, though substantial variation exists based on definitions, case severity, and institutional expertise. The most common complications include massive hemorrhage requiring transfusion (occurring in >90% of cases), hysterectomy (60-90%), urologic injury (15-30%), intensive care unit admission (20-50%), disseminated intravascular coagulation (10-20%), acute kidney injury (5-15%), prolonged hospitalization (median 6-8 days), and sepsis (5-10%) (65).

The presence of placenta previa significantly influences maternal outcomes in PAS cases. Women with PAS and concurrent placenta previa experience higher rates of hemorrhage, increased transfusion requirements, greater likelihood of emergency hysterectomy, and elevated risks of urologic and vascular injuries compared to those with PAS without previa. These differences likely reflect the anatomic challenges of operating in the lower uterine segment with its proximity to bladder and ureters, combined with the attenuated and poorly contractile nature of lower segment myometrium that impairs hemostasis. Additionally, complete placenta previa often necessitates total hysterectomy due to cervical involvement, whereas some non-previa cases may be amenable to local resection or conservative management (66).

**Maternal Mortality**

Historical maternal mortality rates from PAS approached 7-10%, though contemporary series from specialized centers report substantially lower rates of 0.05-1%. This dramatic improvement reflects multiple factors including increased prenatal diagnosis rates allowing for planned deliveries in tertiary centers, availability of multidisciplinary expert teams, refined surgical techniques, improved blood product management, and better critical care. Nevertheless, PAS remains a leading cause of pregnancy-related mortality in developed countries and represents an even greater threat in resource-limited settings where access to advanced surgical care, blood products, and intensive care may be restricted (67).

**Neonatal Outcomes**

Neonatal outcomes in PAS pregnancies are primarily influenced by gestational age at delivery rather than PAS per se. Preterm birth occurs in approximately 30-60% of PAS cases, driven by both scheduled early deliveries to minimize

maternal risks and emergency deliveries necessitated by hemorrhage or other complications. Consequently, neonates born to mothers with PAS experience increased rates of low birth weight, respiratory distress syndrome, neonatal intensive care unit admission, and other prematurity-related morbidities compared to term deliveries (68).

Studies comparing neonatal outcomes between PAS cases with and without placenta previa demonstrate mixed results. Some reports indicate higher preterm delivery rates and lower birth weights in previa cases, possibly reflecting earlier scheduled deliveries to minimize maternal bleeding risk. However, when matched for gestational age at delivery, neonatal outcomes appear similar between previa and non-previa PAS cases. One-minute Apgar scores tend to be slightly lower in previa PAS cases in some series, though five-minute scores typically normalize. Long-term neurodevelopmental outcomes have not been systematically studied but would be expected to correlate with degree of prematurity rather than PAS diagnosis itself (69).

**Psychological Impact**

The psychological impact of PAS on affected women and their families deserves greater recognition. Diagnosis of a life-threatening pregnancy complication naturally generates anxiety, fear, and distress. Women undergoing hysterectomy experience grief over permanent loss of fertility, particularly those who had desired additional children or who place strong cultural or personal value on childbearing capacity. The potential for severe hemorrhage, intensive care admission, prolonged hospitalization, and separation from the newborn infant compounds psychological stress. Some women develop symptoms of post-traumatic stress disorder (PTSD) following traumatic deliveries complicated by massive hemorrhage or other severe complications (70).

Conversely, women who undergo successful conservative management face different psychological challenges, including anxiety during the prolonged period of placental resorption, fear of complications requiring emergency surgery, and uncertainty about effects on future fertility. Healthcare providers should incorporate psychological screening and support into comprehensive PAS care, offering access to mental health professionals, peer support groups, and resources for processing the emotional aspects of these challenging diagnoses (71).

**Subsequent Pregnancy Outcomes**

Women who preserve fertility through conservative management or local resection face important questions regarding subsequent pregnancy outcomes and recurrence risk. Available data, though limited by small sample sizes and potential reporting bias, suggest that approximately 70-89% of women attempting pregnancy after conservative management conceive successfully. However, PAS recurrence rates in subsequent pregnancies range from 17-29%, substantially higher than baseline population risk. These pregnancies require intensive surveillance with early ultrasound evaluation to detect recurrent abnormal placentation, and delivery planning should occur in specialized centers with PAS expertise (72).

Additional concerns in subsequent pregnancies include risks of uterine rupture at sites of previous resection or in uteri with retained placental tissue, potential effects of residual trophoblastic tissue on fertility and implantation, and psychological impacts of pregnancy after traumatic prior delivery. Comprehensive preconception counseling should address these issues, review recurrence risks, discuss surveillance strategies, and ensure women make informed decisions about future childbearing (73).

**Conclusion**

Early prenatal diagnosis through systematic ultrasound screening of high-risk women, combined with delivery planning by multidisciplinary teams in specialized centers, significantly improves maternal and neonatal outcomes. While cesarean hysterectomy remains the definitive management approach, carefully selected cases may be candidates for fertility-preserving strategies including conservative management or local resection, though these approaches carry substantial risks requiring comprehensive patient counseling. Future research priorities include development of effective biomarkers for early detection, refinement of surgical techniques to minimize morbidity, standardized outcome reporting to enable meaningful comparison across studies, and investigation of preventive strategies to reduce the burden of this potentially catastrophic condition. As cesarean delivery rates continue to rise globally, the obstetric community must prioritize judicious use of primary cesarean section, promotion of vaginal birth after cesarean when appropriate, and continued innovation in diagnostic and therapeutic approaches to optimize outcomes for women affected by placenta accreta spectrum disorders.

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