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When the placenta won't let go – placenta accreta spectrum

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INTRODUCTION

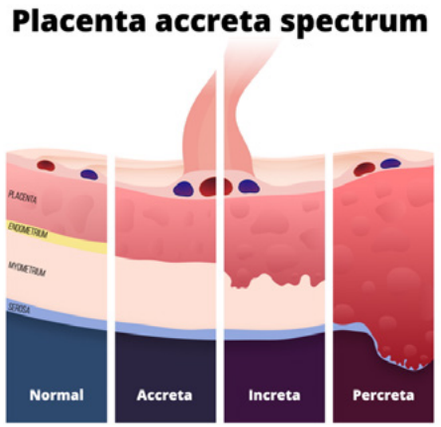
Placenta accreta spectrum (PAS) is a rare complication of pregnancy associated with significant morbidity and mortality; however, the incidence is increasing worldwide. Managing PAS represents one of the most complex challenges in modern obstetric and anaesthesia practice, demanding meticulous preparation and seamless collaboration across different specialties. As Benjamin Franklin aptly observed, "By failing to prepare, you are preparing to fail." This principle holds true in the management of PAS, where success is predicated on early recognition, comprehensive planning and a multidisciplinary approach.

TERMINOLOGY

The histopathologic term "placenta accreta" was first described by obstetrician Frederick Irving and pathologist Arthur Hertig in 1937 at the Boston Lying-In Hospital.[1] They described cases of "abnormal adherence of the afterbirth in whole or in parts to the underlying uterine wall." In many of their patients, attempts to remove the adherent placenta resulted in catastrophic haemorrhage, often requiring emergency hysterectomy. Luke et al then described the concept of PAS disorders in 1966 as including both abnormally adherent and invasive placentas.[2]

Three categories are now considered under the spectrum,[3] shown in Figure 1.[4]

Figure 1. Illustration of PAS categories



Placenta *accreta* (PA) – the most common, where the placental villi penetrate only to the surface of the myometrium. Placenta *increta* (PI) – where the placental villi invade the myometrium. Placenta *percreta* (PP) – where the villi invade beyond the myometrium to the uterine serosa and potentially involves adjacent organs, such as the bladder.

PATHOPHYSIOLOGY

PAS is associated with an increased risk of postpartum haemorrhage (PPH) caused by the abnormal separation of the placenta from the uterine wall. Several theories have been proposed for the mechanisms by which PAS occurs. The current most accepted hypothesis is that PAS occurs in the setting of abnormal decidualisation.[5] A healthy-formed decidua normally regulates trophoblast invasion. A defect of the endometrial-myometrial interface, which may occur in the setting of a uterine scar from a previous caesarean delivery, leads to failure of normal decidualisation. This allows abnormal deep placental anchoring villi and trophoblast infiltration into and through the myometrium.

The development of PAS has been linked to iatrogenic interference of the endometrial-myometrial interface from uterine entry procedures such as caesarean section or myomectomy. PAS can be associated with more superficial damage, as may be caused by curettage, manual removal of the placenta or postpartum endometritis.[6] It is thought that even microscopic defects, as may occur in conditions such as adenomyosis, fibroids, bicornuate uterus and myotonic dystrophy, can lead to abnormal villous tissue adhesion or invasion. These conditions may be the underlying cause of PAS in primiparous women.

RISK FACTORS

Four major independent risk factors have been identified for the development of PAS.[7]

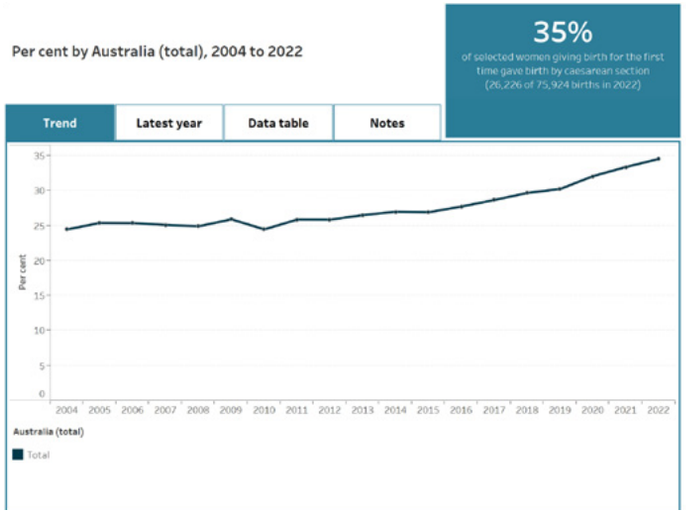
Table 1. Independent risk factors for placenta accreta spectrum (PAS)

Prior caesarean section
Advanced maternal age
Antenatal diagnosis of placenta praevia
Multiple birth

EPIDEMIOLOGY

The reported incidence of PAS in Australia and New Zealand is approximately 44.2 per 100,000 women,[7] or 1 in 2262 births. The incidence is increasing in Australia due to an increase in caesarean section rates and increasing maternal age. Caesarean section rates for primiparous women in Australia have increased from around 25% in 2004 to almost 35% in 2022 (see Figure 2).[8] This is consistent with trends from our institution, where there are increasing rates of both caesarean sections and PAS. The risk of PAS also increases after each subsequent caesarean delivery.[9] Mortality associated with PAS has been reported as high as 6-10% in older studies.[10] Modern management with early diagnosis and multidisciplinary care has reduced mortality rates to approximately 0.05%.[11]

Figure 2. National core maternity indicators – caesarean section rates



DIAGNOSIS AND IMAGING

The definitive diagnosis of PAS can only be made during surgery and subsequent histopathological confirmation. Antenatal diagnosis, however, is crucial to minimise associated maternal morbidity and mortality. Early recognition of PAS in the antenatal period allows appropriate planning for delivery in a tertiary centre, under the care of a specialised multidisciplinary team.[12]

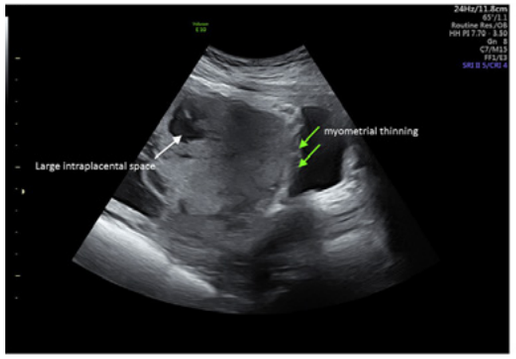
PAS is diagnosed in the antenatal period through a combination of risk factor assessments (see Table 1) and imaging studies. Previous caesarean section is the most important risk factor, and for these women, an ultrasound examination is recommended in the early first trimester to assess for features of caesarean scar pregnancy (CSP), which is a precursor to PAS.[13] Typical PAS features are present on ultrasound scanning in most women by 11-14 weeks' gestation.[14] Early detection facilitates appropriate counselling, referral and planning. Serial scans should be performed throughout the antenatal period to predict the extent of invasion and allow appropriate risk stratification and planning.

Antenatal ultrasound (USS) by transabdominal and transvaginal approaches using grayscale and colour doppler imaging has a high accuracy for diagnosing PAS, although some cases can remain undiagnosed until delivery.[15] It is recommended as the first-line diagnostic tool, given its accessibility and low cost. USS has a reported sensitivity of 90.72% (95% CI, 87.2-93.6%) and a specificity of 96.94% (95% CI, 96.3-97.5%).[16] The ultrasound signs of PAS are listed in Table 2 and demonstrated in Figure 3.[12]

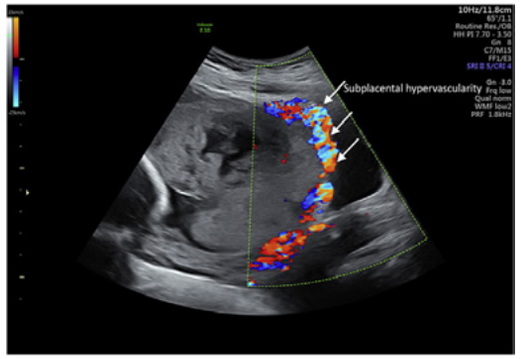
Table 2. Ultrasound signs in placenta accreta spectrum (PAS) disorders

Intra-placental lacunae with diffuse or focal vascular flow
Abnormally thick placenta (>50 mm at 32-34 weeks' gestation)
Loss of retroplacental clear zone with increased sub-placental vascularity
Reduced myometrial thickness (<1 mm) in the inferior uterine segment
Interruption of the bladder flap, placental bulge, exophytic masses

Figure 3. USS images with features of PAS at 21 weeks



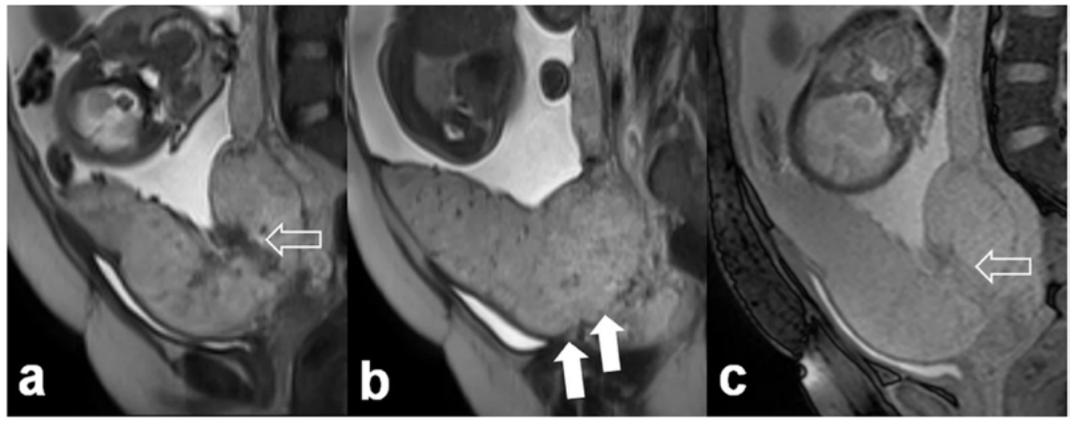
Large irregular sonolucent intra-placental space (white arrow) and myometrial thinning (green arrows).



Colour doppler ultrasound images showing increased vascularity at sub-placental region (white arrows).

Magnetic resonance imaging (MRI) is increasingly being used as a second-line diagnostic tool. Evidence suggests a high sensitivity and specificity of MRI for diagnosing PAS and determining depth of invasion.[17] Features such as uterine bulging, heterogeneous signal intensity within the placenta, dark intra-placental bands and focal myometrial interruptions are suggestive of PAS. In women with ultrasound images suggestive of PAS, MRI may be beneficial in further assessing topography of placental invasion and surgical planning.[15] MRI may also be a useful diagnostic tool where ultrasound is non-diagnostic, the placenta is posterior, or in morbidly obese parturients. The MRI signs of PAS are demonstrated in Figure 4.[18]

Figure 4. Placenta accreta with dark bands (open arrows) and loss of the uteroplacental interface (full arrows)



ANTENATAL MANAGEMENT

Preoperative management

Patients with suspected PAS should be referred to a tertiary centre with the expertise and resources for ongoing care. This includes transfusion services, surgical specialities proficient in advanced pelvic surgery, adult and neonatal intensive care, and obstetric anaesthetists.

Multidisciplinary team

Patients should be reviewed and managed by a multidisciplinary team (MDT) experienced in PAS shortly after diagnosis.[3,19] At our institution, all patients with suspected PAS have an MDT that includes experienced obstetricians, obstetric anaesthetists, gynaecological oncology surgeons, maternal-foetal medicine, interventional radiology, neonatology and midwifery. A comprehensive checklist is used to formulate a standard care plan that addresses both elective and emergency delivery options. This includes reviewing imaging to map placental location to discuss surgical and anaesthetic options, identifying key personnel required for delivery as well as determining the appropriate theatre location for surgery. Our MDT model of care is in keeping with guidelines from the International Federation of Gynaecology and Obstetrics (FIGO) and the Royal Australian and New Zealand College of Obstetrics and Gynaecology (RANZCOG). The FIGO consensus statement heavily emphasises the importance of the MDT in reducing morbidity and mortality in women with PAS, particularly those with more invasive forms.[19,21]

Gestation for delivery

There is no robust evidence to specify the optimal gestational age for delivery in women with PAS. The balance between the risk of prematurity and the increased risk of unplanned emergency surgery is required to minimise the risk to the mother while optimising foetal maturity. As the majority of PAS is associated with placenta previa, the likelihood of antepartum haemorrhage increases with gestational age.[19] Consensus guidelines recommend delivery between 34-37 weeks' gestation, unless there are specific risk factors for preterm delivery.[3,21]

Surgical management

No PAS patient is the same, and therefore, the management must be tailored to the individual. The optimal surgical management for PAS is widely debated, and published data is heterogeneous. There are broadly two approaches to the management of PAS - elective caesarean hysterectomy or conservative techniques, which aim to preserve fertility. The major concern during surgical management is the propensity for massive haemorrhage, disseminated intravascular coagulation (DIC) and end-organ dysfunction. The average reported blood loss is 3 to 5 litres, and around 90% will require a blood transfusion.[11,19,22] Other complications include damage to adjacent structures such as the ureters or bladder.

Caesarean hysterectomy is the most common definitive surgical management and the gold standard recommendation of care.[3,9-21] Generally, a vertical midline abdominal incision is undertaken, and the external surface of the uterus is carefully examined. At this stage, intraoperative ultrasound may be used to map the placenta further to avoid the upper margin. The infant is delivered via an upper trans-fundal uterine incision, away from the placenta, and the placenta is left in situ. The incision is then quickly sutured before proceeding with a hysterectomy (Figures 5-6). Manual removal of the placenta should be avoided in confirmed PAS patients undergoing hysterectomy, as this is associated with increased rates of blood loss, blood transfusion and maternal morbidity.[19,21,23] The mortality rate from elective caesarean hysterectomy is low, however, morbidity remains high.[24]

Figure 5. Exteriorised uterus prior to delivery

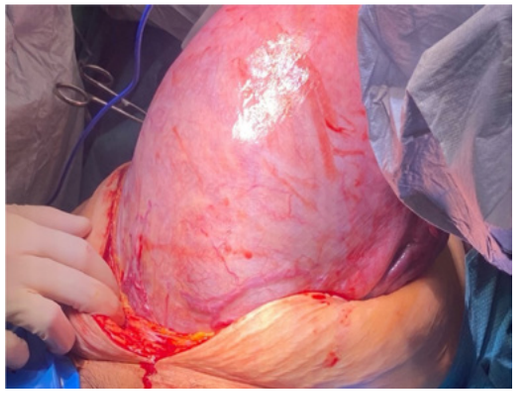


Figure 6. Surgically removed uterus showing placenta percreta

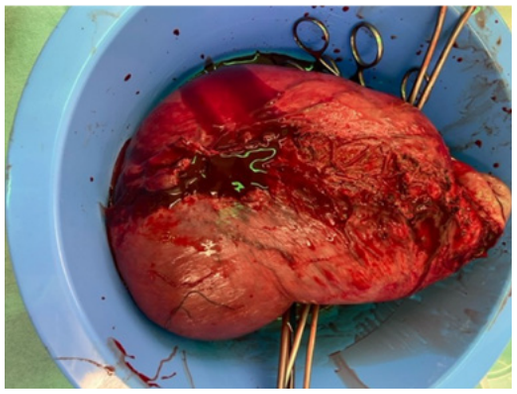
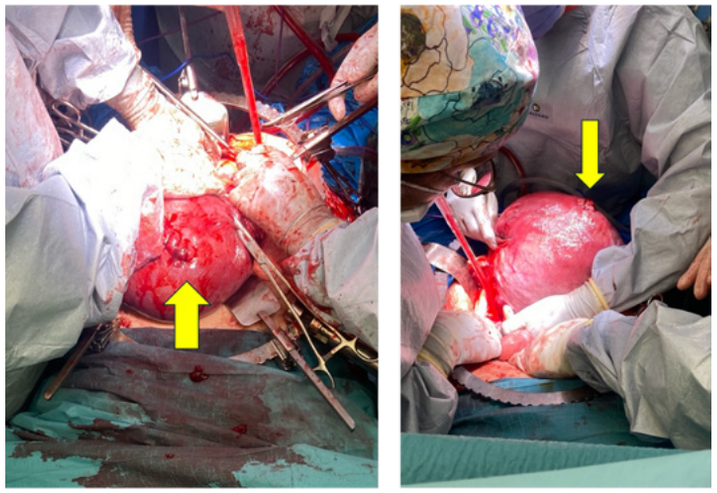


Figure 7. The neonate has been delivered, and the arrows indicate closure of the fundal incision prior to hysterectomy



In cases where there is a significant invasion of the placenta to adjacent structures, making surgical conditions challenging, a staged surgical approach called *delayed hysterectomy* may be undertaken. Following the delivery of the neonate, both the placenta and uterus are left in situ, and the patient undergoes a hysterectomy several weeks later. During this period, the vascularity of the placenta decreases, and there is partial resorption of the placenta, providing improved surgical conditions. Patients who undergo delayed hysterectomy must be highly compliant with close follow-up due to the increased risk of emergency hysterectomy, secondary haemorrhage, sepsis and coagulopathy.

Conservative techniques aim to avoid hysterectomy to preserve fertility, with some studies suggesting decreased blood loss and overall morbidity.[19,22,25] There are four methods of conservative surgical techniques described:[26]

1. The extirpative technique is where the placenta is manually removed.
2. Expectant management – "leaving the placenta in situ".
3. Surgical resection of the accreta area and myometrium.
4. The triple-P procedure, which involves **P**lacental localisation, **P**elvic devascularisation with interventional radiology and **P**lacental non-separation with myometrial excision.

The extirpative technique is not recommended once PAS is diagnosed intraoperatively, as it may lead to catastrophic haemorrhage. Where a diagnosis is uncertain, a "gentle tug test" of the placenta may be employed to observe for normal placental separation before proceeding to manual removal. However, experts agree that manual removal should be avoided if there are any suggestions of abnormality.[26]

Expectant management consists of leaving the entire placenta in situ following delivery of the neonate and waiting for complete resorption. A large retrospective study has found uterine preservation in 78% of women undergoing expectant management, with a maternal morbidity rate of 6%.[27,28] Expectant management has been found to be associated with decreased blood loss and blood transfusion requirement when compared to caesarean hysterectomy.[29] However, arterial embolisation and re-hospitalisation rates were higher in the conservative group.[25] Complete resorption of the placenta may take up to six months and again requires close follow-up. FIGO guidelines recommend weekly follow-up for the first two months and then monthly if no complications are present.[26]

A few centres describe local surgical resection of the myometrium with reconstruction of the uterus and have suggested a lower incidence of complications compared to caesarean hysterectomy.[27,29] The evidence is limited, though expert consensus suggests it may be an appropriate option in select cases for uterine preservation.

The triple-P procedure describes a combination of approaches. It requires interventional radiologists to

place prophylactic occlusive balloons in the common iliac arteries prior to surgery. Following the neonate's delivery, the occlusive balloons are inflated to allow pelvic devascularisation and limit blood flow to the uterus. The adherent placenta and underlying myometrium are then removed. This method has been described by a handful of institutions with promising outcomes, including lower blood loss and transfusion rates overall.[22,26]

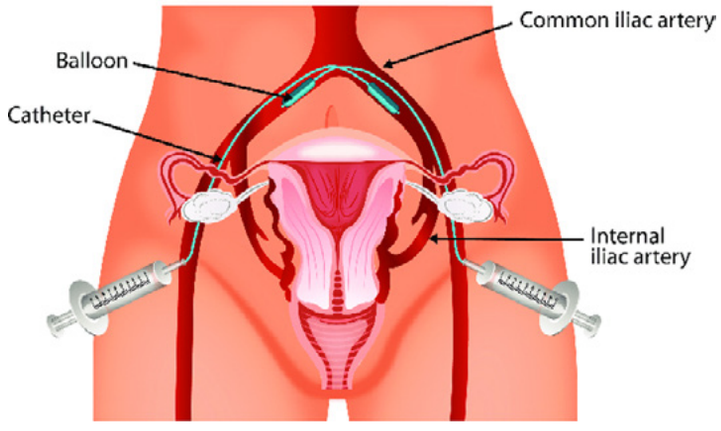
Interventional radiology (IR)

IR's evidenced-based role in PAS is unclear, and the evidence is conflicting. IR is not routinely recommended in the management of PAS,[3,21] but may be useful in complex cases when challenging surgical conditions are anticipated, along with high bleeding risk. The primary blood supply of the uterus is the uterine arteries, which originate from the anterior division of the internal iliac arteries. Secondary blood supply from the ovarian arteries originates below or from the renal arteries.[30] There is also collateral blood supply from the inferior epigastric and inferior mesenteric arteries. This dense vascular network enlarges significantly during pregnancy to increase uterine blood flow.

Pelvic arterial embolisation has mostly been used to prevent major haemorrhage in conservative management of PAS. The literature is mixed and of low quality. The International Society of Abnormally Invasive Placenta (IS-AIP) does not recommend routine prophylactic uterine artery embolisation in conservative management.[27] However, they do suggest therapeutic embolisation in the management of severe PPH during conservative surgery to prevent hysterectomy.

Prophylactic balloon occlusion catheters can be placed within the internal iliac arteries (PBOIIA), common iliac arteries (PBOCIA), uterine arteries (PBOUA) or abdominal aorta (PBOAA) (see Figure 8). To date, one meta-analysis has assessed the effectiveness and safety of these interventions in PAS.[31] The review found less blood loss in patients who underwent intervention compared to those who did not, as well as a lower hysterectomy rate. However, the data was highly heterogeneous and predominantly consisted of low-quality cohort studies or case series.[31] The review found one small, randomised control trial that compared PBOIIA to no intervention, which showed minimal differences in blood loss, blood transfusion or hysterectomy rates.[32]

Figure 8. Prophylactic balloon occlusion catheters can be placed within the internal iliac arteries, common iliac arteries, uterine arteries or abdominal aorta



The meta-analysis also found PBOAA was potentially superior to PBOIIA for blood loss, transfusion rates, drier surgical field and overall complication rates. This is in keeping with emerging literature favouring PBOAA (abdominal aorta) for haemorrhage control in PAS. Due to extensive neovascularisation and possible aberrant blood supply from the external iliac arteries in PAS, PBOIIA (internal iliacs) may be less effective and possibly even worsen bleeding.[33,34] PBOAA has the advantage of one insertion point in the femoral artery compared with bilateral placement in PBOIIA/PBOCIA, and lower radiation doses. The use of balloon catheters is not without risk, and complications are not infrequent.[35] These include vascular injury, thrombosis, lower leg ischaemia and infection. It is unclear from the literature which patients benefit from the radiological intervention for PAS, and larger-scale trials are required.

The use of IR can increase the total length of the surgical time and possibly require transfer between multiple locations. At our institution, women having balloon occlusion intervention are managed in the main hybrid operating room to avoid transfer between different clinical areas and potential displacement of catheters. The catheters are usually placed under neuraxial anaesthesia before proceeding to caesarean section (Figures 9 and 10).

Figure 9. Insertion of bilateral balloon occlusion catheters

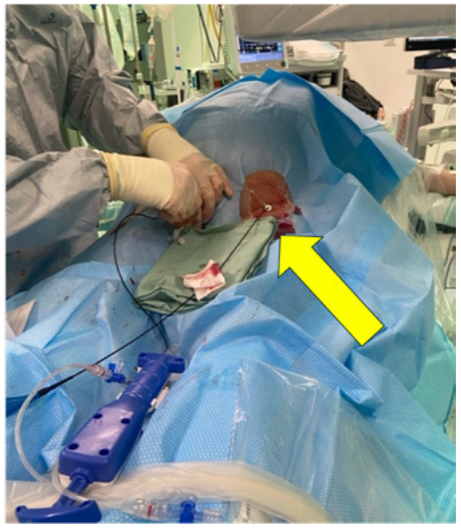


Figure 10. Balloon occlusion catheters secured to legs in lithotomy position

Pre-anaesthetic assessment

At our institution, patients are reviewed in the high-risk obstetric anaesthetic clinic pre-operatively. In addition to routine anaesthetic assessment, particular attention should be given to factors that will influence anaesthetic management, such as potential difficult airway, contraindications to neuraxial procedures, venous access and risk factors for haemorrhage.

Anaemia is common in pregnancy and should be optimised given the high risk of bleeding. A valid group and hold should be taken to identify antibodies to allow transfusion services time to prepare for delivery.

When discussing the anaesthetic approach with the patient, past birth experiences and wishes for delivery should be explored. Important points to highlight include theatre environment, procedures, likelihood of massive transfusion, need for intensive care postoperatively and pain management. A shared decision-making approach allows the anaesthetic plan to be tailored to the patient. The risks and benefits of the approach are discussed in detail and formalised as part of the PAS MDT plan.

INTRAOPERATIVE MANAGEMENT

Preparation is key and can be categorised into personnel, environment, and patient issues. Anaesthetic-specific checklists can decrease cognitive load and be tailored to institutional preferences (Figure 11). Surgical safety checklists and team timeouts have been shown to improve patient safety and are a standard recommendation of care in PAS.[27]

Figure 11. Anaesthetic checklist for PAS

Placenta Accreta anaesthetic checklist

Westmead Anaesthesia

Day prior to surgery

- ❑ Valid G+H, notify transfusion Haematologist. Place eOrder for blood products to be placed in theatre blood fridge. Consider Cryo thawed in blood bank
- ❑ Confirm MDT plan, location (K3 Hybrid or F4), start time, personnel.
- ❑ Confirm ICU is aware

Monitoring and equipment

- ❑ Large bore peripheral access - minimum 2 (consider RICC)
- ❑ Arterial line
- ❑ +/- CVC
- ❑ BIS
- ❑ Urinary catheter temp probe, under body and upper body Bair Hugger
- ❑ NMT monitor
- ❑ Ultrasound in bay
- ❑ 2 TIVA pumps + 2 standard pumps available
- ❑ 2 IV pump sets with fluid warmers (resus lines) or Rapid infuser device
- ❑ Consider separate IV line for infusions (e.g. TIVA, vasopressors)
- ❑ Cell salvage
- ❑ Pre-labelled TEG (blue) coagulation blood tubes, FBC (purple) blood tubes
- ❑ Video laryngoscope
- ❑ 7.0 ETT
- ❑ Supraglottic airway device
- ❑ Positioning low lithotomy
- ❑ If balloon catheters placed – urinary catheter inserted prior
- ❑ Correct operating table for lithotomy if in hybrid operating room
- ❑ Correct arm boards for hybrid bed

Regional

- ❑ Neuraxial kits (spinal needles/CSE)
- ❑ Abdominal block needles/catheters and local anaesthetic of choice

Drugs

- ❑ +/- IT morphine, fentanyl, heavy marcain
- ❑ Dilute adrenaline drawn up
- ❑ Routine antibiotics prophylaxis
- ❑ Tranexamic acid 1g
- ❑ Uterotonics **NOT** to be administered unless already discussed
- ❑ +/- PCA

Prior to starting

- ❑ Team huddle
- ❑ Surgical safety check list
- ❑ Time out

Massive haemorrhage considerations

- ❑ X-match 4-6 units RBCs in blood fridge ready
- ❑ Minimise large crystalloid administration (>2L)
- ❑ Quantify blood loss volume every 30 mins
- ❑ TEG and arterial blood gas every 15-30mins
- ❑ Activate massive transfusion protocol early for unstable bleeding
- ❑ Consider early cryoprecipitate administration
- ❑ Aim normothermia
- ❑ Re-dose antibiotics if blood loss > 1.5L
- ❑ Calcium administration
- ❑ Close communication with surgical team +/- interventional radiologist regarding ongoing management of uncontrolled bleeding
- ❑ Consider aortic compression/damage control surgery
- ❑ Cell salvage return

Personnel preparation

PAS management involves collaboration between several teams. Before commencing anaesthesia, a "team huddle" allows all team members to introduce themselves and their specific roles. Beyond the routine elements of the WHO surgical checklist and time out, specific issues to discuss for PAS are:

- Mode of anaesthesia.
- Specifics of IR, if used, e.g. placement of balloons and who will operate them.
- Major haemorrhage management.
- Plan for uterotonics.
- Post-op disposition confirmed.

The anaesthetist plays a central leadership role intraoperatively. The goals are to provide optimal surgical conditions for a complex and challenging procedure while maintaining vigilance in a rapidly dynamic situation. This requires excellent communication and preparation for massive haemorrhage. The presence of two senior anaesthetists allows cognitive offloading and prevention of task fixation. Roles can be divided into someone leading resuscitation and the other to leading anaesthesia. Anaesthetic nurses provide an essential role, and at least two should be allocated in these high-risk cases. Prior role allocation to tasks, such as blood checking, administration, cell salvage and having a "blood runner" streamlines resuscitation management.

Environment preparation

It is important to ensure the layout and ergonomics of the operating room enable a cohesive work environment for all team members and to prevent overcrowding. Our institution's hybrid and main operating rooms allocated to PAS surgery provide sufficient space for these complex cases. Specific areas should be allocated for the neonatal and midwifery team, as well as cell salvage and rapid infusion devices. If a hybrid setting is used, this may be an unfamiliar setting for the obstetric and gynaecological surgical teams. The anaesthetist should maintain adequate space and access to the patient to enable a coordinated approach to resuscitation and anaesthesia.

Patient preparation

In addition to routine monitoring, bilateral, large-bore intravenous cannula access should be established and dedicated to resuscitation. These should have in-line fluid warmers with pump sets or rapid infusion devices. A third separate intravenous cannula can be used for drug administration and peripheral vasopressors. Intra-arterial cannulation is established before anaesthesia, allowing close blood pressure monitoring, regular blood gas analysis, and viscoelastic testing. Central venous access is not necessarily indicated unless there are significant comorbidities, such as cardiac disease or pre-eclampsia. The patient is positioned in a low-lithotomy position with arms abducted, allowing access to intravenous lines. The anaesthetist should be aware of balloon occlusion catheter placement and access points.

Choice of anaesthesia

There is no strong evidence regarding the optimal form of anaesthesia in PAS, and the choice is widely debated. Both neuraxial and general anaesthetic (GA) techniques have been described successfully, with some literature suggesting lower morbidity related to haemorrhage with regional compared to GA.[19] Conversion from regional to GA is reported between 8-45% but appears predominantly to be in lower-income countries and undiagnosed PAS cases.[19] Elective general anaesthesia has the advantage of avoiding the sympatholytic effect of neuraxial anaesthesia. GA is preferable in a patient with a potentially difficult airway to ensure intubation is controlled at the beginning of the case. In high-risk patients where there is anticipated bleeding and the likelihood of blood transfusion with significant volume shifts, controlled ventilation is desirable. For a regional approach, a combined spinal-epidural (CSE) technique allows titration of anaesthesia and the ability to extend the duration of anaesthesia in longer cases. The surgical incision may be extensive, and therefore, the regional technique of choice must provide adequate coverage. Given the high risk of intraoperative conversion to GA, airway equipment and drugs should be prepared beforehand.

At our institution, the predominant surgical approach is caesarean hysterectomy under GA. However, depending on the location of PAS, risk of bleeding, airway assessment and patient wishes, neuraxial anaesthesia has been undertaken for delivery of the baby, with subsequent GA for hysterectomy. This allows the mother and partner to partake in the birth experience, minimise GA exposure to the neonate and provide superior pain relief postoperatively. The risks of immediate bleeding, instability and rapid conversion to GA must be explicitly informed to the patient.

Uterotonics

The role of uterotonics in preventing and treating PPH is well established. However, there are no studies evaluating uterotonics in PAS, and as such, their use is contentious. With normal placentation, uterotonics promote placental separation and uterine contraction, thereby decreasing PPH secondary to atonic uterus. In PAS, however, there is abnormal neovascularisation and invasion of the placenta to adjacent structures, where separation can lead to catastrophic bleeding. Consensus expert guidelines suggest omitting uterotonics in confirmed PAS patients undergoing caesarean hysterectomy.[19,21] If the diagnosis of PAS is uncertain or not confirmed, then uterotonics may be administered in fertility conserving techniques in conjunction with preparation for massive haemorrhage. The plan for uterotonics must be discussed and clearly documented during the MDT, then re-confirmed during the team huddle prior to surgery.

HAEMORRHAGE MANAGEMENT

Measurement of blood loss

Accurately quantifying blood loss is essential to guide appropriate resuscitation and should be conducted at regular intervals. A multimodal approach is recommended to estimate intraoperative blood loss.[36] This includes blood collection drapes, weighing surgical sponges, and assessing surgical suction canisters.

Control of bleeding

Where attempts are being made to preserve fertility, surgical haemostatic measures include balloon tamponade of the uterus, brace suturing and ligation of uterine or internal iliac arteries.[37] The use of manual aortic compression may provide temporary haemostasis and allow surgical field visualisation to aid definitive haemorrhage control by hysterectomy.

Pharmacological interventions

Tranexamic acid has been well-established in the trauma setting and is also recommended for PPH following the WOMAN trial.[38] The recommended dose is 1 gram intravenously, with the consideration of re-dosing for ongoing haemorrhage.

Ionised calcium levels fall in massive blood transfusions due to the presence of citrate in packed cells. Therefore, calcium levels should be monitored and replaced to maintain ionised calcium levels greater than 1.1 mmol/L to aid coagulation.

Volume resuscitation

Large volumes of crystalloid solution (>2 litres) are not recommended for infusion, as they exacerbate coagulopathy through dilution of coagulation factors.[39] The judicious use of crystalloids with permissive hypotension has been associated with improved survival and lower blood product requirement.[40] A systolic blood pressure target of 80 to 90 mmHg or mean arterial pressure of 50 to 60 mmHg is recommended until bleeding has been controlled.[41]

Blood products (packed red cells, fresh frozen plasma and platelets) should be administered in a 1:1:1 ratio during haemostatic resuscitation.[40] Several large studies in trauma patients have shown survival benefits from this balanced approach in severe bleeding,[42,43] and the same ratios are applicable in the management of obstetric bleeding.[44] In addition, early fibrinogen replacement (cryoprecipitate or fibrinogen concentrates) is recommended in managing severe PPH, as these factors are rapidly consumed in obstetric haemorrhage.[36] Autologous blood recovered by cell salvage can be safely re-infused via a leukocyte depletion filter, reducing the requirement for allogeneic blood products.[45]

Standardised massive transfusion protocols (MTPs) assist in the efficient delivery and use of blood products in major haemorrhage scenarios in PAS patients.[40] The expedited preparation and delivery of balanced blood product packs to the operating theatre, along with early communication with a haematologist, allows rapid and effective haemostatic resuscitation. In our institution, blood fridges are kept in close proximity to the operating theatres to allow storage and accessibility to urgent blood products.

Point-of-care testing and targets

Serial assessment of arterial blood gases, blood counts and coagulation are recommended to guide treatment during haemorrhage related to PAS.[36] Targeted clinical and laboratory goals will guide appropriate therapy and cessation of massive transfusion protocols, minimising unnecessary blood product transfusion.[46]

Table 3. Clinical and laboratory targets in massive haemorrhage

MAP > 65 mmHg	Ca^{2}+ >1.1 mmol/L
Temperature >35°C	Platelets >50 x10^{9}/L
pH >7.2	PT <22 sec
Base excess <-5	APTT <50 sec
Lactate <4 mmol/L	Fibrinogen >2.0 g/L in obstetrics

Viscoelastic testing such as Thromboelastography (TEG) and Rotational Thromboelastometry (ROTEM) provides rapid results, and their use is associated with reduced blood product usage and related morbidities such as transfusion-associated circulatory overload (TACO), and transfusion-related acute lung injury (TRALI).[47,48] Several algorithms have been published describing the use of these viscoelastic tests in guiding targeted coagulopathy treatment in PPH.[49,50] The use of a hybrid strategy, where an MTP with fixed blood product ratios is used initially for severe PAS haemorrhage, followed by targeted therapy guided by viscoelastic point-of-care testing, has been suggested as an optimal approach to resuscitation.[51]

Other considerations

Hypothermia must be avoided, as it worsens coagulopathy. Temperature monitoring, active warming devices, fluid warming, and increased ambient theatre temperature should be used in PAS patients. If blood loss exceeds 1.5 litres, prophylactic antibiotics should be re-administered.[52]

POSTOPERATIVE MANAGEMENT

Women with PAS require careful attention in the postoperative period, particularly focusing on disposition and monitoring, pain management and psychological support.

Disposition

Regardless of which surgical and anaesthetic technique is used, a high proportion of patients with PAS require post operative admission to a high-dependency (HDU) or intensive care unit (ICU). Ongoing high-level care for these patients may be required due to continued fluid or blood product resuscitation, correction of coagulopathy, and the need for vasoactive medications or mechanical ventilation.[35,53] Serial measurements of haemoglobin, acid-base status, coagulation and core temperature are required, with specific monitoring focusing on ongoing bleeding or transfusion-associated pathologies like TRALI or TACO.[51] Mechanical and chemical thromboprophylaxis should be implemented as early as possible in the postoperative period, once bleeding and coagulation are controlled, as patients with PAS are at increased risk of venous thromboembolism.[51] Early mother-child bonding should be prioritised if the mother's condition allows.

Pain management

Post operative pain management in PAS patients may be challenging due to more complex surgical techniques, with larger incisions and longer operating times.[53] Optimal postoperative analgesia is important for maternal mobility, interaction with the newborn and psychological wellbeing. A multimodal analgesia regimen is the gold standard for pain management after caesarean section.[35] If a neuraxial technique is used intraoperatively, long-acting neuraxial opioids like morphine can provide high-quality analgesia for up to 24 hours, with a reduction in systemic opioid requirements. If general anaesthesia alone is used, regional techniques such as transversus abdominal plane block, quadratus lumborum block or erector spinae block can be useful for post-op analgesia.[54] Regular paracetamol and non-steroidal anti-inflammatories should be used unless there are contraindications to their use. Dexamethasone, in addition, may provide analgesic benefits.[55] Rescue opioids should be available for breakthrough analgesia. The oral route is as effective as the intravenous route and should be preferred if available, with patient-controlled intravenous opioid analgesia reserved for severe cases.[56]

Psychological support

Patients with PAS have a significantly higher risk of post-traumatic stress disorder compared with routine caesarean sections.[57] The psychological impact of PAS diagnosis and subsequent interventions during pregnancy, delivery and the postpartum period need to be acknowledged, allowing early intervention to prevent the development of severe and potentially chronic symptoms. Women with PAS should routinely be offered postnatal debriefing sessions, with all members of the multidisciplinary team being available as required.[58] Long-term follow-up options for psychological care should be provided upon hospital discharge.

Future fertility

Although data is limited, subsequent fertility does not appear to be compromised after successful conservative treatment of PAS.[26] Adverse maternal outcomes such as recurrent PAS, uterine rupture and PPH, however, are more likely in future pregnancies. The risk of PAS in subsequent pregnancies is close to 30%.[59] Women who plan for further pregnancies should be warned of the high risk of PAS recurrence.[26]

Team debriefing

All multidisciplinary team members should meet for a debriefing session to discuss management details of the case, what was performed well, and what could be improved.[60] During this session, any communication or safety concerns can be effectively discussed, and system improvements can be planned for future cases.

CONCLUSION

PAS is a growing problem and one that obstetric anaesthetists will increasingly encounter. Women with PAS should be delivered at institutions with the expertise to manage these high-risk women. The optimal surgical and anaesthetic management is not known; however, meticulous assessment, early USS diagnosis, MDT planning and preparation will give the best chance of a healthy outcome for mother and baby.

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