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New evidence-based diagnostic and management strategies for placenta accreta spectrum disorders☆

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A B S T R A C T

The increasing incidence of caesarean delivery (CD) has resulted in an increase in placenta accreta spectrum (PAS), adversely impacting maternal outcomes globally. Currently, more than 90% of women diagnosed with PAS present with a placenta praevia (praevia PAS). Praevia PAS can be reliably diagnosed antenatally with ultrasound, and it is unclear whether magnetic resonance imaging improves diagnosis beyond what can be achieved by skilled ultrasound operators. Therefore, any screening programme for PAS will require improved training in the diagnosis of placental disorders and development of targeted scanning protocols. Management strategies for praevia PAS vary depending on the accuracy of prenatal diagnosis, findings at laparotomy and local surgical expertise. Current epidemiological data for PAS are highly heterogeneous, mainly due to wide variation in the clinical criteria used to diagnose the condition at birth. This significantly impacts

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research into all aspects of the condition, especially comparison of the efficacy of different management strategies.

Placenta accreta spectrum

Historical perspective

Irving and Hertig were the first to publish a case series of placenta accreta in 1937 and included a literature review of the cases published before then. They reported that the first case of 'placenta accreta' may have been Mrs. Galla who died at delivery in 1588 and was found at autopsy to have a placenta praevia 'firmly adherent' to the internal os. Langhans [2] and Hart [3] described the histology of placenta accreta at the end of the 19th century and used the term 'adherent placenta', whereas Baisch [4] was the first author to use to term 'placenta accreta' in 1907.

In 1966, Lukes et al. [5] proposed a histological classification for placenta accreta based on the depth of the villous penetration of the myometrium. They separated placenta accreta into three categories: (i) *placenta adherenta or creta* (PC), when the villi adhere directly to the myometrium without a decidual interface, (ii) *placenta increta* (PI), when the villi invade the myometrium and (iii) *placenta percreta* (PP) when the villi invade the full thickness of the uterine wall including the serosa (Fig. 1). Percreta villi can also invade organs, tissues and the pelvic vasculature beyond the uterine serosa. This terminology is used to date by most pathologists. Luke et al. also highlighted the fact that villous penetration of the myometrium is rarely uniform and that both adherent and invasive villi may co-exist in the same specimen (Fig. 2). The term placenta accreta spectrum (PAS), which includes all grades of abnormal placentation, is presently the preferred umbrella term to define this heterogeneous condition and has been recently endorsed by the FIGO [6], the RCOG [7], the ACOG and the SMFM [8].

Modern perspective

The first descriptions of PAS in the international medical literature [9,10] coincided with the first published reports on outcomes of contemporary CD techniques, one century ago [11,12]. A CD was rarely performed in the first half of the 20th century. Unsurprisingly, only one of the 18 cases personally treated by Irving and Hertig in 1937 occurred after CD [1]. CD has currently become an essential component of modern maternity care, and epidemiological studies have shown a strong association between CD rates, number of prior CDs and the incidence of PAS [13]. The steady increase in PAS can be directly linked to the recent increase in CD rates in both low- and high-resource countries, with rates increasing from less than 7% in the 1990s to well above the World Health Organization (WHO) recommendation of 15% in just 2 decades [14]. In middle-income countries such as Turkey, Mexico, Brazil and Egypt, more than half of all births are by caesarean, mostly elective. Consequently, in countries with high birth rates, like Egypt, the prevalence and negative impact of PAS will rapidly outweigh the benefits of improved access to quality obstetric care.

High rates of CDs have also increased the incidence of placenta praevia [15]. The relative risk of placenta praevia increases with each prior CD from 4.5% (95% CI 3.6 to 5.5) for one to 7.4 (95% CI 7.1 to 7.7) for two, 6.5 (95% CI 3.6 to 11.6) for three and 44.9 (95% CI 13.5 to 149.5) for four or more when compared to that of vaginal delivery [16]. Overall, the incidence of placenta praevia increases from 10/1000 deliveries after one previous CD to 28/1000 after three or more CDs [17]. Similarly, in women with prior CD presenting with a placenta praevia, the risk of PAS is 3%, 11%, 40%, 61% and 67% for first, second, third, fourth and fifth or more CD, respectively [18]. The UK national case–control study reported that the incidence of PAS increases from 1.7 per 10,000 to 577 per 10,000 births in women presenting with a placenta praevia and a prior CD [19].

Currently, more than 90% of women diagnosed with PAS also have a placenta praevia [20], and the combination of both conditions leads to high maternal morbidity and mortality due to massive

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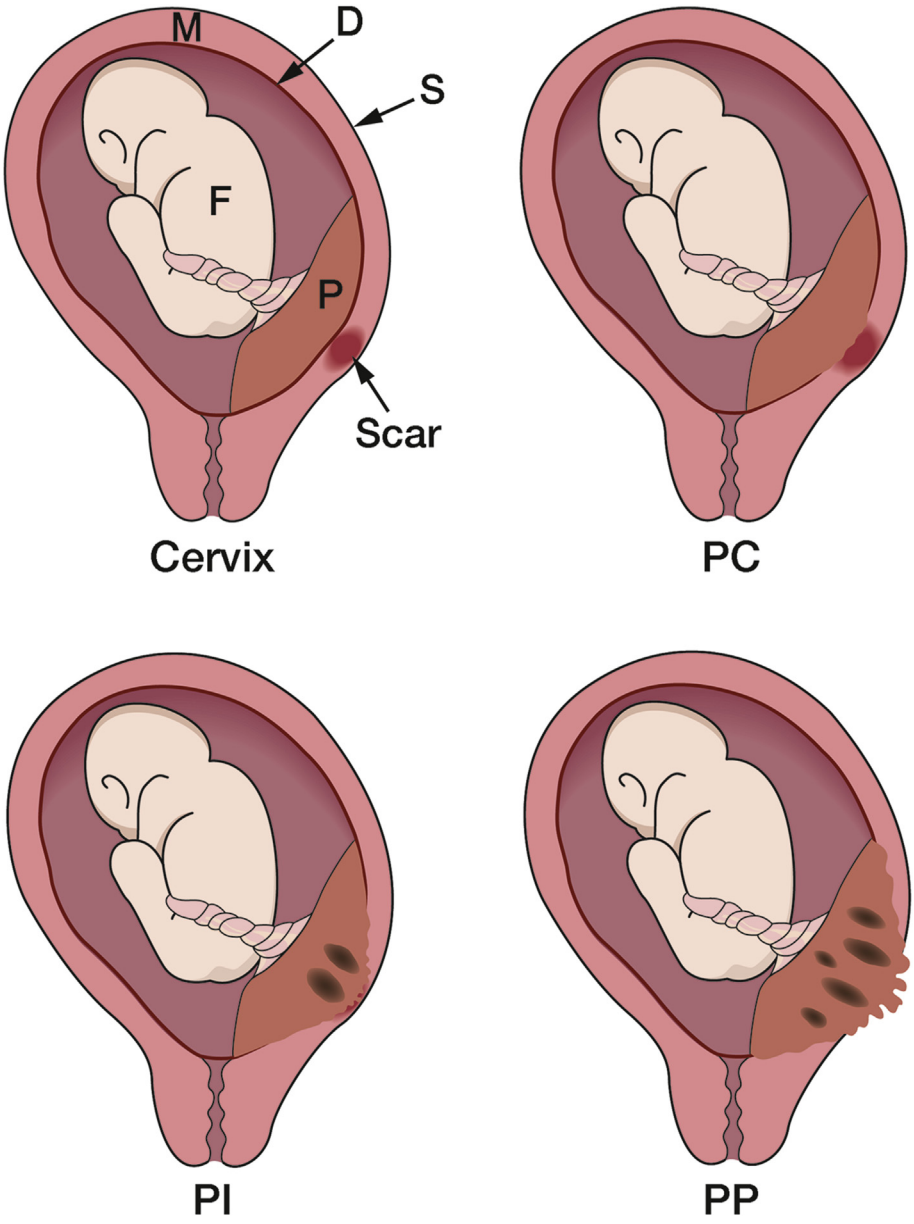

Fig. 1. Diagram showing an anterior placenta praevia on a caesarean scar and the different grades of placenta praevia accreta: Creta (PC), where placental (P) villi adhere to the myometrium (M), Increta (PI), where the villi invade the myometrium and Percreta (PP), where the villi invade the entire myometrium and cross the uterine serosa (S). From reference 50.

haemorrhage at the time of birth [21,22]. Maternal mortality of placenta praevia with percreta has been reported to be as high as 7% of cases [23]. The 2017 report from the UK and Ireland Confidential Enquiries into Maternal Deaths indicated that, although there was no significant change in maternal death rates in the UK, during 2010–12 and 2013–15, there has been an increase in the number of deaths of women presenting with PAS [24].

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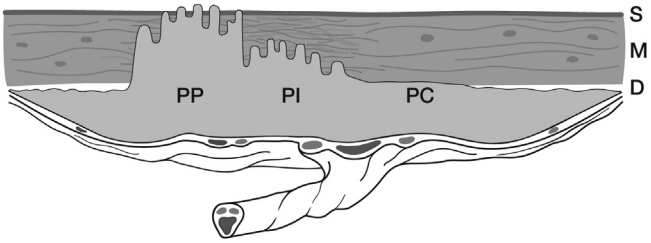

Fig. 2. Diagram showing an anterior placenta praevia accreta combining areas of abnormal adherence and invasion: Creta (PC), Increta (PI) and Percreta (PP). D = Decidua; M = myometrium; S = Serosa. From reference 50.

PAS is not exclusively a consequence of CD and has been reported in primiparous women with a history of operative hysteroscopy, suction curettage, surgical termination, and endometrial ablation [25,26]. In fact, any uterine pathology such as bicornuate uterus, adenomyosis, submucous fibroids, and myotonic dystrophy or any procedure causing surgical damage to the uterine wall integrity has been associated with PAS [13,25]. Accreta placentation can occur after myomectomy, but the risk is relatively low [27]. Finally, in vitro fertilisation (IVF), especially with cryopreserved embryos increases the risk for PAS from 4- to 13-fold. PAS is primarily a consequence of modern obstetric and reproductive practices and is likely to become increasingly common, as women delay childbearing, require reproductive assistance and enter pregnancy with medical comorbidities [25].

Diagnosing PAS at birth

The clinical diagnostic criteria of PAS used since the publication by Irving and Hertig [1] in 1937 have been heterogeneous and vague [29–32]. Not surprisingly, the reported prevalence of PAS at delivery has been highly variable ranging between 1 in 1000 and 1 in 40,000 and deliveries [13], and our recent systematic review and meta-analysis on the prevalence of PAS indicates rates ranging between 0.01% and 1% [30]. An expert review of literature published between 1977 and 2012 found that the pooled prevalence was 1 in 588 deliveries; however, these reflected data from referral centres, which treat more cases than those in the general population [28]. Histopathologic examination remains the confirmatory gold standard, but most current authors of PAS cohort series do not provide complete and transparent information about *both* clinical and histopathological findings. The clinical and pathologic diagnostic standards have stagnated, with little change since 1937.

Clinical diagnosis

The clinical signs of PAS disorders, in particular, in cases of a partially adherent placenta, can be very similar to those of placental retention, i.e. difficult manual or piecemeal removal of the placenta; absence of spontaneous placental separation 20–30 min after vaginal birth, despite active management including bimanual massage of the uterus, use of oxytocin and controlled traction of the umbilical cord; retained placental fragments requiring curettage after vaginal birth and heavy bleeding from the placental bed after placental removal during CD [33–37]. Some authors include sonographic evidence of retained placental tissue requiring curettage [33]. These various criteria are used by many authors and explain the wide heterogeneity in the evaluation of the prevalence of PAS in the general obstetric population [30]. A retained placenta, which is merely entrapped inside the uterine cavity owing to constriction of the cervix, should not be included in the category of PAS nor should cases where a retained placenta is removed whole or spontaneously delivered within 24 h after birth.

Macroscopic changes detected upon entry to the abdomen can also raise suspicion to the presence of accreta placentation such as tortuous large varicosities seen on the serosal surface, distended bulging lower uterine segment, or direct extension of placenta onto the uterine surface, bladder or pelvic sidewalls [38]. Most of these gross changes are common in multiparous women, and thus, at the other end of the spectrum, it is pivotal to make the differential diagnosis between a scar dehiscence and

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a placenta percreta. Women with a history of multiple lower segment CDs may have an anterior myometrial wall largely consisting of fibrotic scar tissue [31,32]. Myofibre loss and the excessive accumulation of collagen impair the function of muscular tissue, which loses elasticity and becomes more prone to dehiscence and rupture in subsequent pregnancies. Lower segment dehiscence becomes more pronounced as pregnancy advances due to the pressure of the foetus and uterine contractions, both of which increase the disruption of the fibrotic tissue. This can create a large uterine 'window' made only of serosa and through which a portion of the placenta is visible without any villous tissue truly invading the serosa and/or the surrounding myometrium (Fig. 3). The high prevalence of PAS in some population studies [33–37] and rates of successful conservative surgical management [39–42] in recent cohort studies may reflect inclusion of a large proportion of cases of non-accreta placental retention and/or uterine dehiscence in their data.

Several authors have also reported using the World Health Organization (WHO) International Classification of Diseases (ICD-10) and related health problems to describe the clinical diagnosis of PAS [43–45]. The WHO ICDs are designed for health information managers, coders, policy-makers, insurers and patient organisations to classify diseases (www.who.int/classifications/icd). This classification provides no clinical description of the condition, makes no distinction between adherent and invasive accreta placentation and relies upon accurate coding. In 2016, Collins et al. proposed a grading system to clearly assess the severity of PAS using clinical findings at birth [46]. This system has been developed into the 2019 FIGO classification (Table 1) for PAS disorders [47].

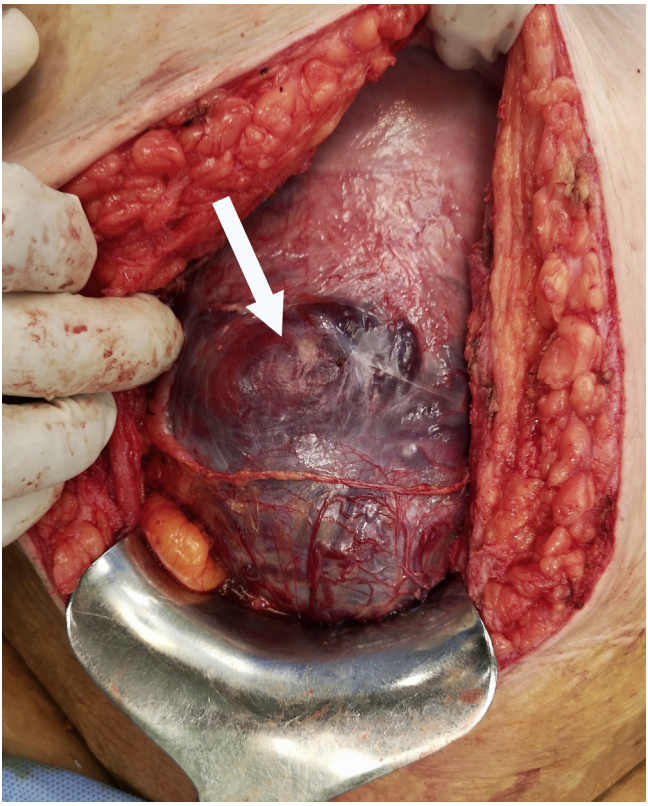

Fig. 3. Large myometrial dehiscence at 35 weeks (arrow) due to multiple prior CDs creating a 'uterine window' where part of the underlying placental tissue is visible through the serosa mimicking a placenta percreta. Detailed histologic examination of the hysterectomy specimen showed no area of invasive PAS.

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Histopathology

Until the 1970s, the diagnosis of PAS was almost exclusively histological [48,49]. The main histopathological criterion used in recent clinical cohorts to confirm the diagnosis of PAS is the absence of decidual/Nitabuch layer the between the tip of anchoring villi and superficial myometrium as

Table 1
FIGO clinical classification for the diagnosis of PAS disorders at delivery [47].

GRADE 1	Abnormally adherent placenta (PLACENTA ADHERENTA OR CRETA)
Clinical criteria	At vaginal delivery - No separation with synthetic oxytocin and gentle controlled cord traction. - Attempts at manual removal of the placenta results in heavy bleeding from the placental implantation site requiring mechanical or surgical procedures. If laparotomy is required - The same as above. - Macroscopically, the uterus shows no obvious distension over the placental bed (placental 'bulge'), no placental tissue is seen invading through the surface of the uterus, and there is no or minimal superficial vascular changes.
Histologic criteria	- Microscopic examination of the placental bed samples from hysterectomy specimen shows extended areas of absent decidua between villous tissue and myometrium with placental villi attached directly to the superficial myometrium. - The diagnosis cannot be made on just delivered placental tissue nor on random biopsies of the placental bed.
GRADE 2	**Abnormally invasive placentation (PLACENTA INCRETA)**
Clinical criteria	At laparotomy - Abnormal macroscopic findings over the placental bed: bluish/purple colouring, distension (placental 'bulge'). - Increased vascularity around the placental bed (dense tangled bed of vessels or multiple vessels running parallel cranio-caudially in the uterine serosa. - No placental tissue seen to be invading through the surface of the uterus. - Gentle cord traction results in the uterus being pulled inwards without separation of the placenta (the 'dimple' sign).
Histologic criteria	Hysterectomy specimen or partial myometrial resection of the increta area shows placental villi within the muscular fibres and sometimes in the lumen of the deep uterine vasculature.
GRADE 3	**Abnormally invasive placentation (PLACENTA PERCRETA)**
GRADE 3a	**Limited to the uterine serosa**
Clinical criteria	At laparotomy - Abnormal macroscopic findings on uterine surface (as above) and placental tissue seen to be invading through the surface of the uterus (serosa). - No invasion into any other organ, including the posterior wall of the bladder (a clear surgical plane can be identified between the bladder and uterus).
Histologic criteria	Hysterectomy specimen showing villous tissue within or breaching the uterine serosa.
GRADE 3b	**With urinary bladder invasion**
Clinical criteria	At laparotomy - The same as 3a. - Placental villi are seen to be invading into the bladder but no other organs. - Clear surgical plane cannot be identified between the bladder and the uterus.
Histologic criteria	Hysterectomy specimen showing villous tissue breaching the uterine serosa and invading the bladder wall tissue or urothelium.
GRADE 3c	**With invasion of other pelvic tissues/organs**
Clinical criteria	At laparotomy - The same as 3a. - Placental villi are seen to be invading into the broad ligament, vaginal wall, pelvic sidewall or any other pelvic organ (+/− invasion of bladder).
Histologic criteria	Hysterectomy specimen showing villous tissue breaching the uterine serosa and invading pelvic tissues/organs.

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originally described by Irving and Hertig [1]. This is an elusive and simplistic histological criterion for the diagnosis of PAS, as such areas are found with increasing incidence with advancing gestation in pregnancies without evidence of PAS [50]. It is also important to highlight that Irving and Hertig [1] did not have cases of invasive PAS in their series, and thus, their definition would only apply to abnormally adherent placenta, not to placenta increta or percreta.

Confirmation of the depth of villous invasion of the uterine myometrium in cases of PAS is essential to improve prenatal detection and clinical management strategies. However, most recent studies lack clear descriptions of the histological criteria used to define the different grades of PAS [29,30]. This is surprising considering the high rates of caesarean hysterectomy in many studies and may reflect limited access to experienced perinatal pathologists. A summary of the few studies that do provide PAS grading indicate that the prevalence of both adherent and invasive PAS is not as high as that previously reported (Table 2).

Dannheim et al. [51] recently proposed methods for gross dissection, microscopic examination and reporting of hysterectomy specimens containing PAS. Histopathologic diagnosis of PAS, however, can be very difficult if the surgeon has attempted to remove the placenta, or impossible in cases of conservative management where the whole placenta is left *in situ*. Therefore, collaboration between the surgical team and pathologists to guide the sampling of the hysterectomy specimen is paramount to obtain accurate grading and extent of the villous invasion.

Prenatal diagnosis

Prenatally, unsuspected PAS is often associated with massive obstetric haemorrhage (MOH) due to attempts by the surgical team to remove the placenta manually from the uterine wall [52]. In these cases, the total blood loss is increased twofold, and the need to administer blood products is 86% compared to 57% when the placenta is left undisturbed [53]. The risk of MOH is particularly high in cases of invasive PAS due to the involvement of the main branches of uterine arteries and the possible invasion of the bladder wall and surrounding pelvic vessels [41,54]. A recent systematic review and meta-analysis confirmed that antenatal diagnosis of PAS reduces perioperative complication rates, particularly the risk of surgical bleeding [55]. Imaging by a skilled ultrasound operator enables precise localisation of the placenta and has become crucial in improving the management of PAS [56]. However, recent population studies have shown that PAS remains undetected before delivery in half [53,57] to two-thirds of the cases [44]. While antenatal diagnostic precision nears 95% in series from expert centres [20,56], recent series show that up to a third of cases of PAS are not diagnosed during pregnancy [58].

The first case of prenatal identification of a placenta accreta was performed by Sadovsky et al., in 1967 using placentography with radioactive isotopes [59]. Tabsh et al. were the first to report in 1982 on prenatal grey scale ultrasound diagnosis of placenta increta [60]. Since then, more than 1200 cases of prenatal ultrasound diagnosis have been described in the international literature [29], and ultrasound imaging is considered as highly accurate when performed by a skilled operator [7,20]. The absence of ultrasound findings does not preclude the diagnosis of focal PAS (especially, abnormally adherent placenta), and clinical factors (CDs and placenta praevia) remain important in identifying women at high risk [7,8].

Numerous techniques have been added to grey-scale imaging over the years, including colour Doppler imaging (CDI) and three-dimensional (3-D) power Doppler sonography, raising the sensitivity

Table 2
Distribution and prevalence of the different grades of PAS disorders in histopathology and prenatal diagnosis series [13] and population studies [30].

Author (year)	Total No. of cases of PAS	No. of PC (%)	No. of PI (%)	No. of PP (%)
Histopathology studies (1966–1978)	118	82 (69.5%)	28 (23.7%)	8 (6.8%)
Prenatal diagnosis studies (2000–2016)	203	103 (50.7%)	49 (24.2%)	51 (25.1%)
Population studies (1982–2018)	757	473 (62.5%)	117 (15.4%)	167 (22.1%)
Prevalence (PAS/births)	1/2415	1/3865	1/15,628	1/10,949

PC= Placenta Creta (abnormally adherent); PI= Placenta Increta (abnormally invasive); PP= Placenta Percreta (abnormally invasive).

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of ultrasound [20,56]. However, the results of well-conducted prospective cohort studies have shown that the sensitivity and specificity of grey-scale imaging alone in diagnosing PAS are as high as 90% when performed by experienced operators [61,62]. As with clinical studies, there has been wide heterogeneity in terminology and study designs used in the published reports on the prenatal ultrasound diagnosis of PAS [29]. Standardised descriptions of ultrasound signs associated with PAS were recently proposed by the European Working Group on Abnormally Invasive Placenta (AIP) [63], and a reporting proforma based on these descriptions was suggested by an AIP international expert group [64]. Although there is good to excellent agreement between expert observers for the diagnostic accuracy of the individual signs such as placental lacunae and subplacental hypervascularity [65], some are artefacts and the consequence of myometrial damage due to prior CD (myometrial thickness) and some signs are extremely rarely reported (placental bulge amd focal exophytic mass). Use of a combination of signs increases the detection rate of ultrasound for PAS, in particular for placenta percreta [66].

Magnetic resonance imaging (MRI) has been used increasingly for the antenatal detection of PAS and has been reported by earlier authors to be useful in assessing the depth of myometrial and parametrial invasion [7,56]. Recent systematic reviews have found that prenatal MRI is highly accurate in identifying disorders of invasive placentation and that ultrasound and MRI have comparable predictive parameters [67,68]. However, a recent study found that MRI resulted in a change in diagnosis that could alter clinical management of PAS disorders in more than one-third of cases, but when changed, the diagnosis was often incorrect [69].

Overall, it is unclear whether MRI improves the diagnosis of PAS beyond what can be achieved by trained ultrasound operators [7,8]. MRI may be less operator-dependent, but the cost and limited access to equipment and expert radiologists make it impractical as a screening tool for PAS, in particular in early pregnancy [70]. The implementation of standardised prenatal targeted ultrasound protocols in specialist centres for pregnant women with risk factors for PAS is associated with improved maternal and neonatal outcomes [71]. However, placental imaging is not routinely taught during ultrasound and radiology training courses. The increase in the rates of CD and PAS highlights the need to develop training programs for sonographers and other operators providing the mid-pregnancy detailed fetal ultrasound examination and to use targeted scanning protocols at national and international levels.

Management strategies

For the majority of specialists, the principal management strategy to prevent excessive bleeding is to leave the placenta *in situ* and perform a primary peripartum hysterectomy (PH) at delivery [71–75]. In cases where suspicion of PAS is high during CD, most US obstetricians proceed with PH, with less than a third attempting conservative management [72,73]. Similarly, a recent international survey of experts found that 61% opt for a primary PH with the placenta left *in situ* as their first-choice management approach [75]. Controversies still exist among experts regarding optimal timing of delivery, use of adjunctive measures and conservative (uterine-sparing) methods. Overall, there are no RCTs nor prospective well-controlled observational studies comparing surgical and conservative approaches for the same grade of PAS. Management strategies for PAS will vary depending on prenatal diagnosis, local surgical expertise and, more recently, access to a specialist multidisciplinary team (MDT). The different management strategies and supporting evidence have been recently reviewed by the RCOG [7], FIGO [76], ACOG and SMFM [8].

Surgical management

Planned preterm (34–35 weeks) caesarean hysterectomy with the placenta left *in situ* is the recommended management strategy for PAS by ACOG [8]. Both general and regional anaesthetic techniques have been shown to be safe for surgical procedures required for the delivery of PAS [7]. The choice of anaesthetic technique for CD for placenta praevia and PAS should therefore be made by the anaesthetist conducting the procedure, and the woman should be informed of the possible need to convert from regional to general anaesthesia [76].

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If the placenta is anterior and extending towards the level of the umbilicus, a midline skin incision is often needed to allow for a high upper-segment transverse uterine incision above the upper border of the placenta [76]. A large extended transverse incision (Cherney. Joel-Cohen or Maylard) can be used to avoid a vertical incision, but there are limited data available on their use in the management of PAS [76].

Total PH is the preferred method due to the potential risk of malignancy developing in the cervical stump, the need for regular cervical cytology and other associated problems such as bleeding or discharge [76]. This is always necessary if invasive placental tissue has been seen within the cervix on prenatal imaging. Devascularisation of the uterus laterally on both sides and clamping the uterus at the lowest possible point just below the edge of the placenta while sparing the ureters has been recently shown to reduce maternal bleeding morbidity [77]. Unless there are significant concerns regarding the risk of malignancy, the ovaries should always be left as oophorectomy is always a risk due to adhesions precluding safe separation or bleeding occurring proximal to the ovary.

Planned delayed or secondary hysterectomy is an alternative 'definitive' surgical management strategy for PAS [7]. Delayed hysterectomy may be necessary where extensive invasion (percreta) of surrounding structures would render immediate caesarean hysterectomy extremely difficult or if the diagnosis of PAS is made at the time of birth, and the operating team has limited surgical experience in performing complex surgical procedures.

Conservative management

Planned PH may be unacceptable to women desiring to preserve their fertility, and conservative management techniques for uterine preservation for both adherent and invasive placenta accreta have been used increasingly in many centres around the world. These techniques include leaving the placenta *in situ*, partial myometrial resection of the accreta area with myometrial repair and various suturing methods around the accreta area [78]. These methods have been used either alone or in combination with additional procedures such as uterine artery devascularisation techniques with either surgery or interventional radiology (IR).

When the extent of the PAS area is limited in depth and can be entirely visualised (i.e. completely anterior, fundal or posterior without deep pelvic or cervical invasion) and is accessible, a conservative uterus-preserving surgery may be appropriate. Partial myometrial resection can be attempted to allow a conservative management of the uterus [7,78]. However, this should only be attempted by teams with experience and appropriate expertise in complex pelvic surgery and prepare for emergency hysterectomy if required [78].

There are no RCTs comparing the different conservative management techniques. Uterus-preserving surgical techniques are associated with a 16% unintentional urinary tract injury rate compared to 57% for standard hysterectomy and that use of ureteric stents reduces the risk of urologic injury [79]. An increasing number of authors claim to have high success rates, sometimes even 100%, for uterine preservation surgery for PAS using compressive suture, intra-uterine balloon, uterine devascularisation, etc. [39,80–83], The retrospective design of these studies, small number of cases, lack of controls, absence of histopathological evidence and lack of standardised clinical or photographic evidence of PAS at birth considerably limit the value of their data [30]. Specifically, it is often difficult to reproduce such results in other centres, or carry out meaningful meta-analysis unless a clear clinical definition of the severity of PAS encountered is described. For these reasons, FIGO have developed a standardised clinical classification for PAS that clearly defines features of any given case (Table 1) and can be corroborated with histopathology where available.

Additional therapeutic techniques

There are no RCTs on the use of ureteral stents in PAS. Ureteral stents or catheters are more commonly used in the US, where 26% of ACOG fellows are using them for the management of PAS [74], but there are currently insufficient data to recommend the routine use of ureteric stents in PAS.

Interventional radiology (IR) including intraoperative internal iliac artery and/or postoperative uterine artery embolisation and internal iliac artery or abdominal balloon occlusion has been proposed to reduce bleeding in women at high risk of perioperative and post-partum haemorrhage. A systematic

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review has reported success rates of approximately 90% for arterial embolisation in PAS, with secondary PH being necessary in 11.3% [78]. Arterial balloon occlusion catheters have been associated with a success rate of nearly 70%, but the use of prophylactic placement of balloon catheters in the iliac arteries in cases of PAS is still controversial, mainly because of the high risks of complications. A more recent systematic review and meta-analysis has shown that IR reduces the risks of bleeding during surgery, but the studies were heterogeneous and of very low quality [84]. A small RCT on preoperative prophylactic balloon catheters versus controls of women presenting with a prenatal diagnosis of PAS found no significant difference in blood loss >2500 ml, number of plasma products transfused, duration of surgery, peripartum complications and hospital stay [85]. Some argue that the vast collateral blood supply to the gravid uterus, particularly to the invasive placenta, may require higher vascular occlusion, such as at the infra-renal aorta, to significantly reduce blood loss during surgery for PAS. Larger, higher quality studies are necessary to determine the safety and efficacy of IR before this technique can be advised in the routine management of PAS [7].

Internal iliac artery ligation was first described by surgeons at the beginning of the 20th century and used in obstetrics to reduce the risks of post-partum haemorrhage before the advent of IR. In low-resource countries, where IR is not available, it has remained in use, in particular, in the context of uterine preservation in PAS. A recent RCT from Egypt of bilateral internal iliac artery ligation (n = 29 cases) versus controls (n = 28 cases) reported no significant difference between the two groups regarding the intraoperative estimated blood loss [86].

Multidisciplinary team (MDT) approach

A recent observational study of obstetric-led units in England found that 70% manage their PAS cases 'in-house', despite one-third of these units reporting that they only treat one or fewer cases each year [87]. However, there is mounting evidence that women with PAS diagnosed prenatally and managed by an MDT in a centre of excellence are less likely to require emergency surgery, large-volume blood transfusion and reoperation within 7 days of delivery for bleeding complications than women managed by standard obstetric care without a specific protocol [38,88,89]. In addition, women with PAS admitted at 34 weeks of gestation and delivered between 34 and 35 weeks of gestation by a specialist MDT have a significantly lower emergency surgery rate than those not cared for by such a team despite a similar median gestational age at delivery. These studies have also shown that maternal outcomes are improved with time along with increasing experience within a well-established MDT performing 2–3 cases per month. A recent systematic review and meta-analysis has confirmed these findings but has also highlighted that all the studies included in the review are retrospective [90]. Furthermore, these studies provide no data on the differential clinical diagnosis between abnormally adherent and abnormally invasive PAS nor on the detailed pathologic confirmation of the depth and lateral extension of villous myometrial invasion. There is therefore a need for more prospective studies with detailed clinical and histopathological data.

Conclusion

Accreta placentation is a potentially life-threatening condition. The incidence of PAS will predictably increase further over time, if modern obstetric caesarean delivery trends continue. It is therefore incumbent on all healthcare providers to systematically improve upon the recognition of risk factors, the accuracy of antenatal diagnosis and the intrapartum management for women with PAS.

Summary

The recent rapid increase in caesarean delivery (CD) rates has changed the epidemiology of placenta accreta spectrum (PAS) worldwide from a rare, serious, pathological condition to an increasingly common major obstetric complication. The risk of placenta praevia increases following CD, and women presenting with a low-lying/placenta praevia and a history of CD are at the highest risk of PAS (praevia PAS). Prenatal identification has been shown to improve the outcomes in PAS. In specialist centres, the diagnostic accuracy of ultrasound in identifying praevia PAS is more than 90%; therefore, there is often no need for magnetic resonance imaging (MRI), in particular, when the imaging team has experience of

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transvaginal pelvic ultrasound. Ultrasound screening for PAS requires the development of targeted training with standardised protocols and reporting tools. A planned preterm caesarean hysterectomy with the placenta left *in situ* is the strategy most often used for invasive PAS, although conservative management may be considered when the woman wants fertility preservation and the PAS area is limited. Access to specialist centres with multidisciplinary expertise and essential resources such as blood products and neonatal and maternal intensive care is pivotal to improving the management of these complex cases. There are no RCTs or prospective, well-controlled observational studies comparing surgical and conservative management strategies. The evaluation of epidemiological trends and management outcomes has been limited to date by poor-quality study design, in particular by the lack of a standardised description of the clinical grade of PAS at birth and histopathological confirmation of the clinical diagnosis.

Practice points

- Increased caesarean delivery (CD) rates have been the main epidemiological factor for the increase in the prevalence of placenta accreta spectrum (PAS), and this phenomenon has been observed in high-income and low-income countries.
- Women presenting with a low-lying/placenta praevia and a history of prior CD are the group with the highest risk of PAS, and there is a need to identify them antenatally to plan a management approach tailored to their individual need.
- The lack of standardised protocols for the diagnosis of PAS at birth undermines the value of clinical data in particular in the evaluation of the epidemiology of the different grades of PAS and the outcome of different management strategies.
- The development of specialist centres with multidisciplinary expertise in the management of complex obstetric surgery with access to adult and neonatal intensive care and blood transfusion that perform at least 2 cases per month are essential to improve the management and outcome of invasive PAS.

Research agenda

There is a need for prospective studies on the diagnosis and management of PAS using standardised protocols for reporting on the prenatal imaging diagnostic criteria and on the clinical grade of PAS of birth including histopathological confirmation of the clinical diagnosis when possible. No further progress will be made in evaluating the epidemiology and outcome of PAS until all studies present data that differentiate accurately between cases that exclusively adherent and cases that are invasive or mixed adherent and invasive. Authors of future studies should also be able to provide detailed data of prenatal imaging, intra-operative findings and detailed histropathology reports.

Conflict of interest

The authors report no conflict of interest. Sally Collins is supported by Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) Human Placenta Project of the National Institutes of Health (UO1 HD087209).

References

[1] Irving C, Hertig AT. A study of placenta accreta. Surgery. Gynecol Obstet 1937;64:178–200.
[2] Langhans T. Die losung der muetterlichen eihaeute. Arch F Gynaek 1875;8:287–97.
[3] Hart DB. A contribution to the pathology symptoms and treatment of adherent placenta. Edinb Med J 1889;34:816–9.
[4] Baisch K. Zur pathologischen anatomie der placenta accreta. Arb Geb Pathol Anat Bact 1907-1908;6:265–70.
*[5] Luke RK, Sharpe JW, Greene RR. Placenta accreta: the adherent or invasive placenta. Am J Obstet Gynecol 1966;95:660–8.

Please cite this article as: Jauniaux E et al., New evidence-based diagnostic and management strategies for placenta accreta spectrum disorders, Best Practice & Research Clinical Obstetrics and Gynaecology, https://doi.org/10.1016/j.bpobgyn.2019.04.006

[6] Jauniaux E, Ayres-de-Campos D. FIGO placenta accreta diagnosis and management expert consensus panel. FIGO consensus guidelines on placenta accreta spectrum disorders: introduction. Int J Gynaecol Obstet 2018;140:261–4.
*[7] Jauniaux E, Alfirevic Z, Bhide AG, Belfort MA, Burton GJ, Collins SL, et al. Placenta praevia and placenta accreta: diagnosis and management: green-top guideline No. 27a. BJOG 2019;126:e1–48.
*[8] Obstetric care consensus No. 7 summary: placenta accreta spectrum. Obstet Gynecol 2018;132:1519–21.
[9] Forster DS. A case of placenta accreta. Can Med Assoc J 1927;17:204–7.
[10] Kearns PJ. Placenta increta. Can Med Assoc J 1931;25:198–9.
[11] Munro Kerr JM. Indications for caesarean section. J Obstet Gynaecol Br Emp 1921;28:338–48.
[12] Holland E. Methods of performing caesarean section. J Obstet Gynaecol Br Emp 1921;28:349–57.
*[13] Jauniaux E, Chantraine F, Silver RM, Langhoff-Roos J. FIGO placenta accreta diagnosis and management expert consensus panel. FIGO consensus guidelines on placenta accreta spectrum disorders: epidemiology. Int J Gynaecol Obstet 2018;140:265–73.
[14] Boerma T, Ronsmans C, Melesse DY, Barros AJD, Barros FC, Juan L, et al. Global epidemiology of use of and disparities in caesarean sections. Lancet 2018;392:1341–8.
[15] Gurol-Urganci I, Cromwell DA, Edozien LC, Smith GC, Onwere C, Mahmood TA, et al. Risk of placenta previa in second birth after first birth cesarean section: a population-based study and meta-analysis. BMC Pregnancy Childbirth 2011;11:95.
[16] Ananth CV, Smulian JC, Vintzileos AM. The association of placenta previa with history of cesarean delivery and abortion: a meta-analysis. Am J Obstet Gynecol 1997;177:1071–8.
[17] Marshall NE, Fu R, Guise JM. Impact of multiple cesarean deliveries on maternal morbidity: a systematic review. Am J Obstet Gynecol 2011;205:262.e1-8.
[18] Silver RM, Landon MB, Rouse DJ, Leveno KJ, Spong CY, Thom EA, et al. National institute of child health and human development maternal-fetal medicine units network. Maternal morbidity associated with multiple repeat cesarean deliveries. Obstet Gynecol 2006;107:1226–32.
[19] Fitzpatrick KE, Sellers S, Spark P, Kurinczuk JJ, Brocklehurst P, Knight M. Incidence and risk factors for placenta accreta/increta/percreta in the UK: a national case-control study. PLoS One 2012;7:e52893.
[20] Jauniaux E, Bhide A. Prenatal ultrasound diagnosis and outcome of placenta previa accreta after cesarean delivery: a systematic review and meta-analysis. Am J Obstet Gynecol 2017;217:27–36.
[21] Brookfield KF, Goodnough LT, Lyell DJ, Butwick AJ. Perioperative and transfusion outcomes in women undergoing cesarean hysterectomy for abnormal placentation. Transfusion 2014;54:1530–6.
[22] Green L, Knight M, Seeney FM, Hopkinson C, Collins PW, Collis RE, et al. The epidemiology and outcomes of women with postpartum haemorrhage requiring massive transfusion with eight or more units of red cells: a national cross-sectional study. BJOG 2015;123:2164–70.
[23] Solheim KN, Esakoff TF, Little SE, Cheng YW, Sparks TN, Caughey AB. The effect of cesarean delivery rates on the future incidence of placenta previa, placenta accreta, and maternal mortality. J Matern Fetal Neonatal Med 2011;24:1341–6.
[24] on behalf of MBRRACE-UK. In: Knight M, Nair M, Tuffnell D, Shakespeare J, Kenyon S, Kurinczuk JJ, editors. Saving lives, improving mothers' care – lessons learned to inform maternity care from the UK and Ireland confidential Enquiries into maternal deaths and morbidity 2013–15. Oxford: National Perinatal Epidemiology Unit, University of Oxford; 2017. www.npeu.ox.ac.uk/mbrrace-uk.
[25] Jauniaux E, Jurkovic D. Placenta accreta: pathogenesis of a 20th century iatrogenic uterine disease. Placenta 2012;33:244–51.
[26] Baldwin HJ, Patterson JA, Nippita TA, Torvaldsen S, Ibiebele I, Simpson JM, et al. Antecedents of abnormally invasive placenta in primiparous women: risk associated with gynecologic procedures. Obstet Gynecol 2018;131:227–33.
[27] Gyamfi-Bannerman C, Gilbert S, Landon MB, Spong CY, Rouse DJ, Varner MW, et al. Eunice kennedy shriver national institute of child health and human development (NICHD) maternal-fetal medicine units (MFMU) network. Risk of uterine rupture and placenta accreta with prior uterine surgery outside of the lower segment. Obstet Gynecol 2012;120:1332–7.
[28] Balayla J, Bondarenko HD. Placenta accreta and the risk of adverse maternal and neonatal outcomes. J Perinat Med 2013;41:141–9.
*[29] Jauniaux E, Collins SL, Jurkovic D, Burton GJ. Accreta placentation. A systematic review of prenatal ultrasound imaging and grading of villous invasiveness. Am J Obstet Gynecol 2016;215:712–21.
*[30] Jauniaux E, Bunce C, Grønbeck L, Langhoff-Roos J. Prevalence and main outcomes of placenta accreta spectrum: a systematic review and metaanalysis. Am J Obstet Gynecol 2019;220. https://doi.org/10.1016/j.ajog.2019.01.233 [Epub ahead of print].
[31] Jauniaux E, Bhide A, Burton GJ. Pathophysiology of accreta. In: Silver R, editor. Placenta accreta syndrome. Portland: CRC Press; 2017. p. 13–28.
[32] Jauniaux E, Burton GJ. Pathophysiology of placenta accreta spectrum disorders: a review of current findings. Clin Obstet Gynecol 2018;61:743–54.
[33] Gielchinsky Y, Rojansky N, Fasouliotis SJ, Ezra Y. Placenta accreta–summary of 10 years: a survey of 310 cases. Placenta 2002;23:210–4.
[34] Sheiner E, Levy A, Katz M, Mazor M. Identifying risk factors for peripartum cesarean hysterectomy. A population-based study. J Reprod Med 2003;48:622–6.
[35] Bencaiova G, Burkhardt T, Beinder E. Abnormal placental invasion experience at 1 center. J Reprod Med 2007;52:709–14.
[36] Woodring TC, Klauser CK, Bofill JA, Martin RW, Morrison JC. Prediction of placenta accreta by ultrasonography and color Doppler imaging. J Matern Fetal Neonatal Med 2011;24:118–21.
[37] Klar M, Laub M, Schulte-Moenting J, Proempeler H, Kunze M. Clinical risk factors for complete and partial placental retention: a case-control study. J Perinat Med 2014;41:529–34.
[38] Silver RM, Fox KA, Barton JR, Abuhamad AZ, Simhan H, Huls CK, et al. Center of excellence for placenta accreta. Am J Obstet Gynecol 2015;212:561–8.

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[39] Acar A, Ercan F, Pekin A, Elci Atilgan A, Sayal HB, Balci O, et al. Conservative management of placental invasion anomalies with an intracavitary suture technique. Int J Gynaecol Obstet 2018;143:184–90.
[40] Peng Q, Zhang W, Liu Y. Clinical application of stage operation in patients with placenta accreta after previous caesarean section. Medicine (Baltim) 2018;97:e10842.
[41] Marcellin L, Delorme P, Bonnet MP, Grange G, Kayem G, Tsatsaris V, et al. Placenta percreta is associated with more frequent severe maternal morbidity than placenta accreta. Am J Obstet Gynecol 2018;219:193.e1–9.
[42] Wei Y, Cao Y, Yu Y, Wang Z. Evaluation of a modified "Triple-P" procedure in women with morbidly adherent placenta after previous caesarean section. Arch Gynecol Obstet 2017;296:737–43.
[43] Mehrabadi A, Hutcheon JA, Liu S, Bartholomew S, Kramer MS, Liston RM, et al. Maternal health study group of Canadian perinatal surveillance system (public health agency of Canada). Contribution of placenta accreta to the incidence of postpartum hemorrhage and severe postpartum hemorrhage. Obstet Gynecol 2015;125:814–21.
*[44] Thurn L, Lindqvist PG, Jakobsson M, Colmorn LB, Klungsoyr K, Bjarnadóttir RI, et al. Abnormally invasive placenta-prevalence, risk factors and antenatal suspicion: results from a large population-based pregnancy cohort study in the Nordic countries. BJOG 2016;123:1348–55.
[45] Colmorn LB, Krebs L, Klungsøyr K, Jakobsson M, Tapper AM, Gissler M, et al. Mode of first delivery and severe maternal complications in the subsequent pregnancy. Acta Obstet Gynecol Scand 2017;96:1053–62.
[46] Collins SL, Stevenson GN, Al-Khan A, Illsley NP, Impey L, Pappas L, et al. Three-dimensional power Doppler ultrasonography for diagnosing abnormally invasive placenta and quantifying the risk. Obstet Gynecol 2015;126:645–53.
*[47] Jauniaux E, Ayres-de-Campos D, Langhoff-Ross J, Fox KA, Collins SL. FIGO Placenta Accreta Diagnosis and Management Expert Consensus Panel. FIGO classification for the clinical diagnosis of placenta accreta spectrum disorders. Int J Gynecol Obstet 2019;142 [in press (June)].
[48] Weekes LR, Greig LB. Placenta accreta: a twenty-year review". Am J Obstet Gynecol 1972;113:76–82.
[49] Breen JL, Neubecker R, Gregori CA, Franklin Jr JE. Placenta accreta, increta, and percreta. A survey of 40 cases. Obstet Gynecol 1977;49:43–7.
*[50] Jauniaux E, Collins SL, Burton GJ. Placenta accreta spectrum: pathophysiology and evidence-based anatomy for prenatal ultrasound imaging. Am J Obstet Gynecol 2018;218:75–87.
[51] Dannheim K, Shainker SA, Hecht JL. Hysterectomy for placenta accreta; methods for gross and microscopic pathology examination. Arch Gynecol Obstet 2016;293:951–8.
[52] Silver RM, Branch DW. Placenta accreta spectrum. N Engl J Med 2018;378:1529–36.
[53] Fitzpatrick K, Sellers S, Spark P, Kurinczuk J, Brocklehurst P, Knight M. The management and outcomes of placenta accreta, increta, and percreta in the UK: a population-based descriptive study. BJOG 2014;121:62–71.
[54] Hubinont C, Mhallem M, Baldin P, Debieve F, Bernard P, Jauniaux E. A clinico-pathologic study of placenta percreta. Int J Gynaecol Obstet 2018;140:365–9.
[55] Buca D, Liberati M, Calì G, Forlani F, Caisutti C, Flacco ME, et al. Influence of prenatal diagnosis of abnormally invasive placenta on maternal outcome: systematic review and meta-analysis. Ultrasound Obstet Gynecol 2018;52:304–9.
[56] Jauniaux E, Bhide A, Kennedy A, Woodward P, Hubinont C, Collins S. FIGO Placenta Accreta Diagnosis and Management Expert Consensus Panel. FIGO consensus guidelines on placenta accreta spectrum disorders: prenatal diagnosis and screening. Int J Gynaecol Obstet 2018;140:274–80.
[57] Bailit JL, Grobman WA, Rice MM, Reddy UM, Wapner RJ, Varner MW, et al. Eunice kennedy shriver national institute of child health and human development (NICHD) maternal-fetal medicine units (MFMU) network. Morbidly adherent placenta treatments and outcomes. Obstet Gynecol 2015;125:683–9.
[58] Bowman ZS, Eller AG, Bardsley TR, Greene T, Varner MW, Silver RM. Risk factors for placenta accreta: a large prospective cohort. Am J Perinatol 2014;31:799–804.
[59] Sadovsky E, Palti Z, Polishuk WZ, Robinson E. Atypical placentography in placenta accreta. Obstet Gynecol 1967;29:784–7.
[60] Tabsh KM, Brinkman 3rd CR, King W. Ultrasound diagnosis of placenta increta. J Clin Ultrasound 1982;10:288–90.
[61] Finberg HJ, Williams JW. Placenta accreta: prospective sonographic diagnosis in patients with placenta previa and prior cesarean section. J Ultrasound Med 1992;11:333–43.
[62] Comstock CH, Love Jr JJ, Bronsteen RA, Lee W, Vettraino IM, Huang RR, et al. Sonographic detection of placenta accreta in the second and third trimesters of pregnancy. Am J Obstet Gynecol 2004;190:1135–40.
*[63] Collins SL, Ashcroft A, Braun T, Calda P, Langhoff-Ross J, Morel O, et al. Proposed for standardized ultrasound descriptions of abnormally invasive placenta (AIP). Ultrasound Obstet Gynecol 2016;47:271–5.
[64] Alfirevic Z, Tang A-W, Collins SL, Robson SC. Palacios-Jaraquemadas, on behalf of the Ad-hoc International AIP Expert group. Pro forma for ultrasound reporting in suspected abnormally invasive placenta (AIP); an international consensus. Ultrasound Obstet Gynecol 2016;47:276–8.
[65] Zosmer N, Jauniaux E, Bunce C, Panaiotova J, Shaikh H, Nicholaides KH. Interobserver agreement on standardized ultrasound and histopathologic signs for the prenatal iagnosis of placenta accreta spectrum disorder. Int J Gynaecol Obstet 2018;140:326–31.
[66] Cali G, Forlani F, Timor-Trisch I, Palacios-Jaraquemada J, Foti F, Minneci G, et al. Diagnostic accuracy of ultrasound in detecting the depth of invasion in women at risk of abnormally invasive placenta: a prospective longitudinal study. Acta Obstet Gynecol Scand 2018;97:1219–27.
[67] Meng X, Xie L, Song W. Comparing the diagnostic value of ultrasound and magnetic resonance imaging for placenta accreta: a systematic review and meta-analysis. Ultrasound Med Biol 2013;39:1958–65.
[68] Familiari A, Liberati M, Lim P, Pagani G, Cali G, Buca D, et al. Diagnostic accuracy of magnetic resonance imaging in detecting the severity of abnormal invasive placenta: a systematic review and meta-analysis. Acta Obstet Gynecol Scand 2018;97:507–20.
[69] Einerson BD, Rodriguez CE, Kennedy AM, Woodward PJ, Donnelly MA, Silver RM. Magnetic resonance imaging is often misleading when used as an adjunct to ultrasound in the management of placenta accreta spectrum disorders. Am J Obstet Gynecol 2018;218:618.e1–7.

Please cite this article as: Jauniaux E et al., New evidence-based diagnostic and management strategies for placenta accreta spectrum disorders, Best Practice & Research Clinical Obstetrics and Gynaecology, https://doi.org/10.1016/j.bpobgyn.2019.04.006

[70] Panaiotova J, Tokunaka M, Krajewska K, Zosmer N, Nicolaides KH. Screening for morbidly adherent placenta in early pregnancy. Ultrasound Obstet Gynecol 2019;53:101–6.
[71] Melcer Y, Jauniaux E, Maymon S, Tsviban A, Pekar-Zlotin M, Betser M, et al. Impact of targeted scanning protocols on perinatal outcomes in pregnancies at risk of placenta accreta spectrum or vasa previa. Am J Obstet Gynecol 2018;218:443.e1.
[72] O'Brien JM, Barton JR, Donaldson ES. The management of placenta percreta: conservative and operative strategies. Am J Obstet Gynecol 1996;175:1632–8.
[73] Esakoff TF, Handler SJ, Granados JM, Caughey AB. PAMUS: placenta accreta management across the United States. J Matern Fetal Neonatal Med 2012;25:761–5.
[74] Wright JD, Silver RM, Bonanno C, Gaddipati S, Lu YS, Simpson LL, et al. Practice patterns and knowledge of obstetricians and gynecologists regarding placenta accreta. J Matern Fetal Neonatal Med 2013;26:1602–9.
[75] Cal M, Ayres-de-Campos D, Jauniaux E. International survey of practices used in the diagnosis and management of placenta accreta spectrum disorders. Int J Gynaecol Obstet 2018;140:307–11.
[76] Allen L, Jauniaux E, Hobson S, Papillon-Smith J, Belfort MA. FIGO Placenta Accreta Diagnosis and Management Expert Consensus Panel. FIGO consensus guidelines on placenta accreta spectrum disorders: nonconservative surgical management. Int J Gynaecol Obstet 2018;140:281–90.
[77] Hussein AM, Kamel A, Raslan A, Dakhly DMR, Abdelhafeez A, Nabil M, et al. Modified cesarean hysterectomy technique for management of cases of placenta increta and percreta at a tertiary referral hospital in Egypt. Arch Gynecol Obstet 2019. https://doi.org/10.1007/s00404-018-5027-7 [Epub ahead of print].
[78] Sentilhes L, Kayem G, Chandraharan E, Palacios-Jaraquemada J, Jauniaux E. FIGO placenta accreta diagnosis and management expert consensus panel. FIGO consensus guidelines on placenta accreta spectrum disorders: conservative management. Int J Gynaecol Obstet 2018;140:291–8.
[79] Mei J, Wang Y, Zou B, Hou Y, Ma T, Chen M, et al. Systematic review of uterus-preserving treatment modalities for abnormally invasive placenta. J Obstet Gynaecol 2015;35:777–82.
[80] Tam Tam KB, Dozier J, Martin Jr JN. Approaches to reduce urinary tract injury during management of placenta accreta, increta, and percreta: a systematic review. J Matern Fetal Neonatal Med 2012;25:329–34.
[81] Wolf MF, Maymon S, Shnaider O, Singer-Jordan J, Maymon R, Bornstein J, et al. Two approaches for placenta accreta spectrum: B-lynch suture versus pelvic artery endovascular balloon. J Matern Fetal Neonatal Med 2018;18:1–191.
[82] Ratiu AC, Crisan DC. A prospective evaluation and management of different types of placenta praevia using parallel vertical compression suture to preserve uterus. Medicine (Baltim) 2018;97:e13253.
[83] Rauf M, Ebru C, Sevil E, Selim B. Conservative management of post-partum hemorrhage secondary to placenta previa-accreta with hypogastric artery ligation and endo-uterine hemostatic suture. J Obstet Gynaecol Res 2017;43:265–71.
[84] D'Antonio F, Iacovelli A, Liberati M, Leombroni M, Murgano D, Cali G, et al. Role of interventional radiology in pregnancies complicated by placenta accreta spectrum disorders: a systematic review and meta-analysis. Ultrasound Obstet Gynecol 2019. https://doi.org/10.1002/uog.20131.
[85] Salim R, Chulski A, Romano S, Garmi G, Rudin M, Shalev E. Precesarean prophylactic balloon catheters for suspected placenta accreta: a randomized controlled trial. Obstet Gynecol 2015;126:1022–8.
[86] Hussein AM, Dakhly DMR, Raslan AN, Kamel A, Abdel Hafeez A, Moussa M, et al. The role of prophylactic internal iliac artery ligation in abnormally invasive placenta undergoing caesarean hysterectomy: a randomized control trial. J Matern Fetal Neonatal Med 2018:1–7. https://doi.org/10.1080/14767058.2018.1463986 [Epub ahead of print].
[87] Sargent W, Collins SL. Are women antenatally diagnosed with abnormally invasive placenta receiving optimal management in England? An observational study of planned place of delivery. Acta Obstet Gynecol Scand 2019. https://doi.org/10.1111/aogs.13487 [Epub ahead of print].
[88] Shamshirsaz AA, Fox KA, Salmanian B, Diaz-Arrastia CR, Lee W, Baker BW, et al. Maternal morbidity in patients with morbidly adherent placenta treated with and without a standardized multidisciplinary approach. Am J Obstet Gynecol 2015;212:218.e1-9.
[89] Shamshirsaz AA, Fox KA, Erfani H, Clark SL, Salmanian B, Baker BW, et al. Multidisciplinary team learning in the management of the morbidly adherent placenta: outcome improvements over time. Am J Obstet Gynecol 2017;216:612.e1–5.
[90] Bartels HC, Rogers AC, O'Brien D, McVey R, Walsh J, Brennan DJ. Association of Implementing a multidisciplinary team approach in the management of morbidly adherent placenta with maternal morbidity and mortality. Obstet Gynecol 2018;132:1167–76.

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