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Review article

What we know about placenta accreta spectrum (PAS)

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ABSTRACT

Placenta accreta spectrum (PAS) is an umbrella term for a variety of pregnancy complications due to abnormal placental implantation, including placenta accreta, placenta increta and placenta percreta. During the past several decades, the prevalence of PAS has been increasing, and the clinical importance of this disease is significant because of the severe complications. In this review, we summarized the available evidence-based data for PAS in various aspects: prevalence, risk factors, pathogenesis, clinical presentation and prenatal screening, and clinical management. Meanwhile, we provided a series of prospects in each section for further studies on PAS. Moreover, we first present a visualized workflow for the management of PAS from three steps: predelivery, during delivery and postdelivery.

Contents

Abbreviations: PAS, placenta accreta spectrum; CBMD, caesarean births on maternal demand; PP, placenta previa; ART, assisted reproductive technology; IVF-ET, in vitro fertilization and embryo transfer; BPMF, basal plate myometrial fibers; EVT, extravillous trophoblast; MRI, magnetic resonance imaging; AFP, alpha-fetoprotein; hCG, human chorionic gonadotropin; PAPP-A, pregnancy-associated plasma protein A; HIFU, high-intensity focused ultrasound.

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Background

Placenta accreta is an obstetric term in histopathology, first described by an obstetrician and a pathologist from the USA [1]. It is widely known as abnormal adherence of the placenta in whole or in parts to the myometrium of the underlying uterine wall [2]. However, this description was confined to morbidly adherent placenta without taking into consideration abnormally invasive placentation. In fact, the depth of villous tissue invasiveness into the myometrium is various and thus, modern pathologists have defined this kind of abnormality as a spectrum disorder, with three categories representing the range of pathologic invasiveness of the placenta: placenta accreta (anchoring villi adhere to the superficial myometrium without interposing decidua), placenta increta (the placental villi penetrate into the myometrium), and placenta percreta (anchoring villous tissue penetrates through the entire uterine wall even to the surrounding organs) [3]. Subsequently, a brand new and more accurate terminology, placenta accreta spectrum (PAS) disorders, covering both abnormally adherent and invasive placentas, was introduced worldwide [4].

PAS disorders, usually complicated by massive obstetric hemorrhage which can be life-threatening and may need urgent hysterectomy, is clinically important. The aim of this review is to provide an overview for PAS and summarize evidence-based approaches to the clinical management of PAS disorders.

Prevalence

According to a recent systematic review, placenta accreta is the most 'popular' kind of PAS: of all PAS patients, over 60 percent suffers from placenta accreta, while this figure for placenta increta and placenta percreta is around 15 % and 20 %, respectively [5].

Due to the heterogeneous definition and uneven prenatal detection rates, the reported prevalence of PAS varied from country to country. Collectively, in developed countries, this condition now affects approximately 1 in 500 pregnancies, which is markedly higher compared with the rate in the 1980s [6,7]. However, the reports concerning the prevalence in medium- and low-income countries are insufficient. Over the past four decades, it's estimated that around a 5- to 10-fold increase in the incidence of PAS has occurred in these developing countries [8]. It's believed by most researchers and obstetricians that this increment is epidemiologically associated with constantly increased caesarean delivery rates [8]. In a word, PAS would be more prevalent, if caesarean births on maternal demand (CBMD) were more popular.

Risk factors

Several established factors, already confirmed by evidence from controlled studies, are associated with increased risk for PAS among pregnant women [9]. Most importantly, a history of previous caesarean delivery is the most common risk factor for development of a PAS [2,10,11]. Notably, the incidence of PAS increases with the number of previous caesarean deliveries, from about 0.3 % in women with one prior caesarean section to around 7% for those with more than five caesarean deliveries [12]. Another important and independent risk factor for PAS is placenta previa (PP). For those pregnant women diagnosed with PP, the frequency of PAS significantly increases with the number of caesarean deliveries (3%, 11 %, 40 %, 61 % and 67 % for the first, second, third, fourth, and fifth or greater caesarean birth, respectively) [13]. Other acknowledged risk factors include previous uterine surgeries (myomectomy, operative hysteroscopic procedures, dilation and curettage, etc.), assisted reproductive technology (ART, especially in vitro fertilization and embryo transfer [IVF-ET]: OR 3.1, 95 % CI (1.6 – 5.8)), advanced maternal age (greater than 35 years: OR 4.6, 95 % CI (3.2 – 6.7) [11,14,15]. It's worth noting that greater maternal age may increase the risk of placenta previa and previous uterine surgery, thereby making PAS more likely occur in these older women [16]. In other words, maternal age is more a confounding factor than an independent risk factor for PAS disorders.

Other maternal factors, such as multiparity, postpartum endometritis, Asherman syndrome and prior history of pelvic irradiation, as well as operative factors like manual removal of the placenta, have been reported to appear to be risk factors for PAS [15,17–23]. However, these factors were only described in observational evidence from case series and reports, requiring verification in larger controlled studies. Similarly, some cases with no relevant history but presenting with a uterine pathology, such as adenomyosis, submucous fibroids, bicornuate uterus, or basal plate myometrial fibers (BPMF) existing in the placenta after delivery, have also been reported [9,24,25]. Unfortunately, these pathologic factors were proposed with no supporting high-quality evidence, calling for more studies to confirm their effects.

Pathogenesis

The exact pathogenesis of PAS remains unknown, but the above risk factors give us some clues. The most prevailing theory is that prior uterine surgery involving the endometrial-myometrial interface leads to defective decidualization in an area with a uterine scar, allowing the anchoring villi of the placenta to adhere to the myometrium abnormally and further trophoblast invasion [26]. This hypothesis is supported by the finding that the vast majority of PAS patients present a history of disruptions within the uterine cavity such as prior caesarean section, previous operative uterine procedures (myomectomy, operative hysteroscopy, etc.), and/or dilation and curettage of the uterus [26,27]. Nevertheless, such theory fails to explain the occurrence of PAS in primigravid women without any prior uterine procedure or instrumentation. The potential explanation was reported to be that this rare minority of PAS patients may suffer from one of a series of uterine pathology, such as adenomyosis, submucous fibroids, or bicornuate uterus, which may subsequently result in microscopic endometrial defects that further affect the normal biological functions of the endometrium and thus allow abnormal attachment of the placenta [26]. Other concepts ascribe placenta accreta spectrum to the dysfunction of maternal vascular remodeling in the scarring areas or excessive invasion of the extravillous trophoblast (EVT), which may account for a small part of cases [28].

As to the extent of pathologic placental adherence or invasion, like accreta versus increta/percreta, the associated regulating factors are not known with certainty. It was thought that there may exist both adherent and invasive villi in the placenta, and the severity of invasion may progress with the advance of the gestational age [26]. However, this hypothesis was contradicted by the observation that placenta percreta can occur in the very early stage during the second trimester (around 16 weeks), which suggests that the eventual outcome concerning depth of invasion may have been determined at the very beginning of implantation

and may not be influenced by advancing gestation. The occurrence of invasive PAS (increta and percreta) may be attributed to that a uterine scar cracks partially or completely, which thereby allows the deeper invasion of EVT (myometrium, serosa, and even beyond) [27]. Subsequent defects caused by this kind of deeper and extensive invasion are usually accompanied by absence of normal epithelialization in an area of a scar [29].

With the development of transcriptomics, those studies on certain obstetric diseases, like preeclampsia, have identified and validated some molecular mechanisms involving the occurrence of the diseases. However, the transcriptional signature of PAS has not been reported until recent years [30,31], probably as a consequence of lacking specimens from both confirmed PAS patients and appropriate controls. So far, limited studies revealed that some molecules, such as DOCK4, may play a role in regulating the general pathogenesis of PAS and the invasion depth of trophoblasts. They also reported a similarity between PAS and cancer, both molecularly and phenotypically [31]. However, details with respect to these molecules have not been clarified, in their regulatory mechanisms, and predicting or therapeutic potentials.

Further studies are required to determine the reliable pathogenesis of PAS. In this process, multi-omics and molecular biology are as important as micromorphology. Emerging techniques like single cell sequencing and spatial transcriptomics may be helpful, as cell-interaction and dimensional features are of great importance in PAS.

Clinical presentation and prenatal screening

Usually, the first clinical presentation for PAS is massive obstetric hemorrhage occurring during delivery, when attempting to remove the placenta manually. Notably, antenatal bleeding may be observed among those women with placenta previa. Besides, presenting with abdominal pain is sometimes a warning of uterine rupture, probably as a consequence of placenta percreta.

For those women who are asymptomatic (most without certain risk factors), obstetric ultrasound examination may have some suspected findings. Routine prenatal screening is essential for early detection of PAS especially in women with less prominent risk factors [32]. The screening process offers perfect opportunities for them and their families to be counselled about the suspected abnormal placentation. Then, appropriate predelivery or preoperative preparations, involving multidisciplinary management in a tertiary maternity care center, can be developed for suspected cases. As a result, prenatal care and timely diagnosis of PAS would significantly improve eventual outcomes, such as less blood loss and fewer transfusions of blood products, compared with those diagnosed at delivery [33].

Obstetric ultrasonography for the screening of PAS

Obstetric ultrasonography is the primary diagnostic modality for prenatal diagnosis of PAS. The earliest features of PAS in ultrasound may occur in the first trimester [34,35], and usually if a gestational sac is found to be located in the lower uterine segment and near or lower than the caesarean scar during the first-trimester ultrasound examination, or if a caesarean scar pregnancy is considered by ultrasound, placenta accreta spectrum should be suspected [34,35]. Nevertheless, the majority of these patients were diagnosed in the middle or late period of pregnancy, due to the presence of placenta previa [32,36,37]. Interestingly enough, population-based studies showed that approximately one-half to two-thirds of cases were not diagnosed antenatally [16,38,39], demonstrating the necessity of a targeted prenatal screening for PAS with appropriate timing and candidates [40].

As for those high-risk women with prior caesarean section or placenta previa, thorough obstetric ultrasonography on the interface between the placenta and myometrium (transabdominal and transvaginal) should be evaluated by a multidisciplinary team, which assembles experienced sonographers and obstetricians with expertise in the diagnosis of PAS [3]. The ideal timing for such evaluations may occur between 18 and 24 weeks of gestation, as the diagnosis of PAS can be confirmed or excluded with up to 90 % of pregnant women [16,38,39]. However, there are very limited evidences regarding the schedule for ultrasound examinations among pregnant women without specific risk factors of PAS. Further studies are warranted to guide clinical practice in this setting. Still, we argue that the suspicious signs on ultrasonography for PAS should never be neglected, though these items may not be considered as the primary part of a certain prenatal care for this low-risk group.

Nowadays, available sonographic techniques consist of two-dimensional greyscale imaging, color flow Doppler ultrasonography, and three-dimensional power Doppler ultrasound [26,41–44].

The most common used procedure of ultrasonography is two-dimensional greyscale imaging, for its cheap price, relatively simple operation process, and favorable effectiveness. There are a series of reports on the findings by greyscale imaging which are thought to be associated with PAS: (1) Multiple placental vascular lacunae. The sensitivity and specificity of placental lacunae for the identification of PAS disorders were estimated to be over 75 % and more than 95 %, respectively [45]. (2) Loss of the clear zone. The terminology "clear zone" refers to the normal hypoechoic area between the placenta and myometrium. Under the context of PAS, this area may be irregular or even missing. This sonographic sign has a similar diagnostic value with "multiple placental vascular lacunae" [45]. (3) Abnormalities of the bladder line. The bladder line is defined as the normally continuous white line representing the uterine serosa-bladder interface shown in ultrasound. Abnormalities of the bladder line, such as loss or disruption of this continuous line, can appear in placenta accreta with neovascularity or invasive forms of PAS disorders (e.g., placenta percreta) [46,47]. (4) Decreased myometrial thickness. Due to a previous caesarean scar or placental invasion, the thickness of the retroplacental myometrium can be as thin as less than 1 mm in some cases [46,47]. In addition, other signs, such as abnormal vascularity, placental bulge, and exophytic mass, indicate the placental extension into myometrium, serosa, or bladder, which usually heralds the occurrence of placenta percreta [46,47].

On some occasions, color flow Doppler imaging can act as a supplementary approach to facilitate the diagnosis. Specific findings of this Doppler imaging include turbulent lacunar blood flow, prominent sub-placental vascularity, diffuse or focal intraparenchymal flow, and vessels bridging the placenta to the uterine margin [46–50].

Recently, as a promising method, three-dimensional power Doppler ultrasound has been proved to be helpful in the diagnosis of PAS [42,49]. This approach in combination with the two sonographic technique mentioned above can improve the diagnostic accuracy for PAS. Specifically, potential positive presentations include irregular intraplacental vascularization, accompanied by tortuous confluent blood vessels which cross placental width, and hypervascularity of serosa-bladder interface [43]. However, related findings came from small case series or cohort studies, which should be evaluated in larger prospective studies.

These ultrasound signs mentioned above have been summarized as a staging system [51], which has a favorable correlation with the FIGO clinical grading system for PAS [52]. In China, where PAS has a profound influence, a three-point scale based on sonographic signs has been developed; however, current evidence

from clinical practice remains inadequate to demonstrate its efficacy [53].

The role of magnetic resonance imaging (MRI)

The role of magnetic resonance imaging (MRI) for PAS detection remains uncertain. Current concepts are that MRI is the other primary tool used for the prenatal diagnosis of PAS other than ultrasound. In addition, MRI may have advantages over ultrasound in some clinical scenarios. Specifically, when a PAS occurs in a posterior position, it's hard to assess the condition by ultrasound as the bladder cannot be used to identify the placental-myometrial interface, where MRI may play a role [54,55]. Moreover, MRI has a better potential to evaluate the invasive depth of PAS including myometrial and parametrial involvement, and bladder involvement than ultrasonography [54,55].

The optimal timing of MRI screening for invasive forms of PAS is considered to be performed between 24 and 30 weeks of gestation, because false positive and negative rates are significantly higher beyond this period [56]. However, this recommendation was only provided by a single-center study [56] and thus, more large evidence-based studies are required.

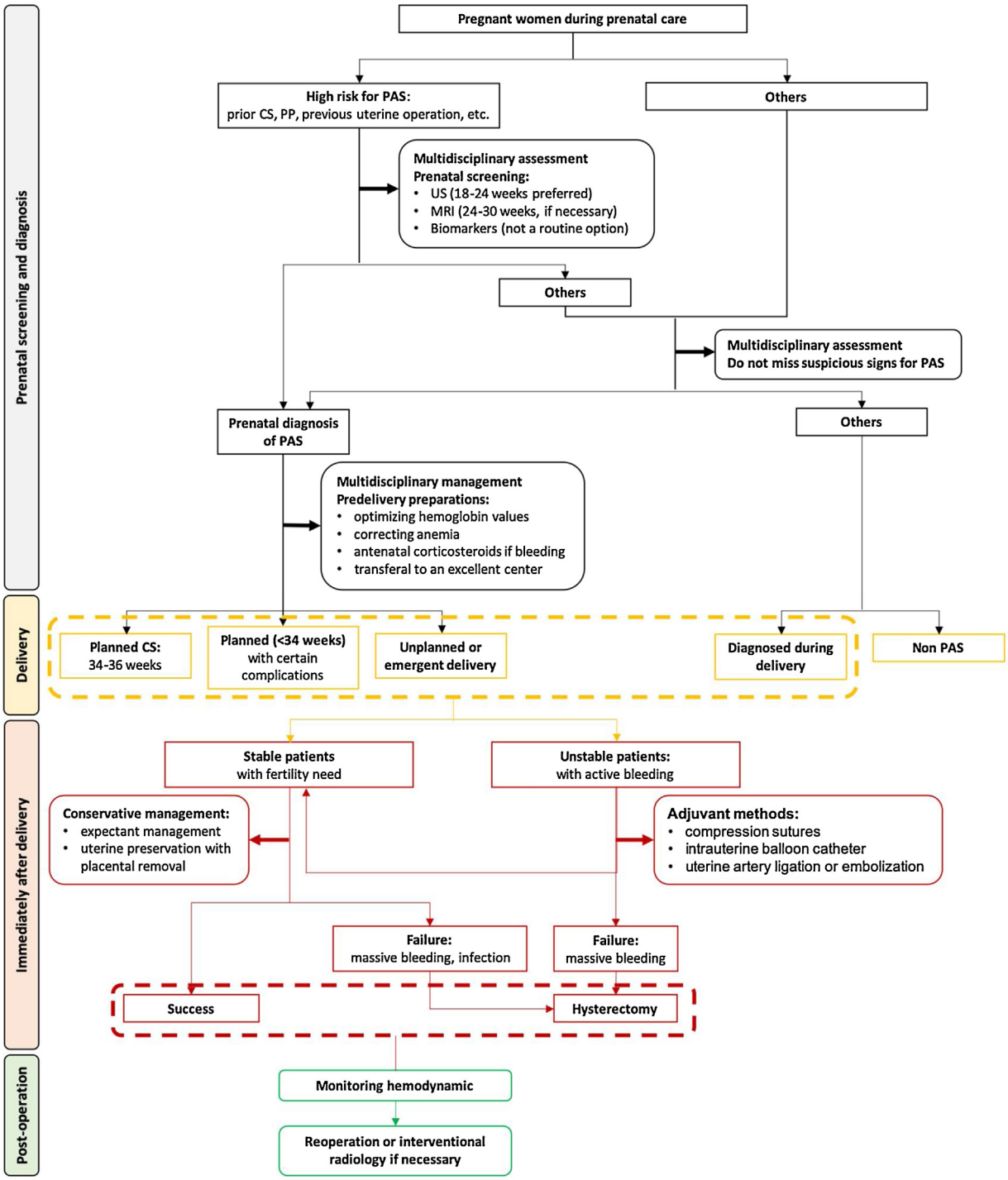

Fig. 1. The flow chart of the management for PAS.

Contrast agents, such as Gadolinium which may allow a better diagnostic performance [57], are generally abandoned during pregnancy because of the safety issues. In the future, if new agents can address the safety issues with no harm to pregnant mothers and fetuses, the utilization of this technique should be promising.

MRI features associated with placenta accreta spectrum include abnormal bulging of the uterus into the bladder, presence of dark intraplacental bands on T2-weighted imaging, focal interruption of the zone between the uterus and the placenta, and abnormal or disorganized placental vascularity [56,58–60].

Comparison between ultrasound and MRI

Overall, according to the results of recent meta-analyses [45,61], the average sensitivity and specificity of obstetric ultrasonography for the identification of different placental invasion depths were approximately 90 % and 95 %, respectively. As for MRI, these numbers were reported to be about 93 % and 94 % [62]. In other words, MRI and ultrasound may have comparable accuracy for the prenatal diagnosis of PAS. However, the interpretation of these data warrants caution.

First, potential bias should never be ignored when assessing the accuracy of ultrasonography and MRI. On one hand, selection bias between the two imaging groups may exist in any individual studies. In fact, the utilization of these two examinations is sequential not randomized. In other words, if PAS is not inclusive by ultrasound, then MRI becomes the supplementary method for further diagnosis; if invasive placentation (increta or percreta) is not considered in terms of sonographic findings, the choice of MRI will be discouraged. As a result, MRI is performed solely on a proportion of the population screened by obstetric ultrasound, which leads to a difference in the subjects of these two groups and a higher diagnostic possibility in the MRI group. In such case, the diagnostic accuracy of MRI may be overestimated. On the other hand, many pregnant women in these studies, who were clinically suspected for PAS and treated in excellent care centers, had established risk factors such as prior caesarean delivery and/or placenta previa, and the ultrasound providers or radiologists may have foreknowledge of the clinical setting. Consequently, detection bias has also been introduced. Overall, we cannot draw a conclusion on the accuracy from biased findings, but we can acquire that MRI has advantages over ultrasound on the evaluation of invasive placentation. The protocols for future studies to investigate the real accuracy of ultrasound and MRI in PAS disorders should be formulated in a well-defined population with sufficient sample size. One such group is women with established risk factors, for whom both ultrasound and MRI are carried out prospectively, and reported independently of each other without knowledge of the clinical status of subjects, while another group is those without certain risk factors [62].

Second, a high heterogeneity may exist among the included studies of the existing meta-analyses. The heterogeneity was most probably due to different study design, diverse populations, considerable interobserver variation, and inconsistency in diagnostic criteria. Under this context, it is hard to obtain a real comparison of diagnostic accuracy for PAS between MRI and ultrasound [62]. Therefore, the predictive ability of the universally utilized and newly proposed imaging signs should be tested in the same population, in order to determine which imaging criteria, alone or in combination, can get to a more reliable diagnosis. Fortunately, to improve this dilemma, many obstetric expert panels are working on providing uniform criteria for findings by ultrasound or MRI [43,63].

Last, other limitations of these findings are that clinicopathological correlation between imaging assessments and histologic evidences was not well defined in some studies, making the evaluation of the prediction accuracy difficult. Therefore, as the gold standard, pathologic evidence should never be abandoned.

The value of maternal biomarkers

Several maternal biomarkers have been found to be potentially associated with PAS. In the second-trimester, maternal serum alpha-fetoprotein (AFP) levels have been reported to be higher in PAS cases compared to normal pregnancies, usually with a change to 2–2.5 multiples of the median [64–66]. Some secretory placental hormones, such as human chorionic gonadotropin (hCG) and its free beta-subunit (β-hCG), and pregnancy-associated plasma protein A (PAPP-A), may also be relevant to the development of placenta accreta spectrum. At around 12 weeks of gestation, the level of hCG and β-hCG is lower while the concentration of PAPP-A is higher in the maternal serum of PAS cases [64,66–68].

Unfortunately, these biomarkers from maternal blood alone may not be very useful clinically, as their diagnostic accuracy is very low and many of them are not available in most hospital laboratories. Overall, the added value of these biomarkers on the basis of imaging examinations for prenatal screening remains unknown and thus, more prospective data are needed to prove their benefit.

Clinical management

A visualized workflow for the management of PAS from three steps (predelivery, during delivery and postdelivery) is summarized in Fig. 1.

Clinical management of patients with PAS disorders varies largely worldwide [22,69]. Although the harmful consequences of PAS have been well recognized, few randomized controlled trials or prospective studies have investigated the optimal management of accreta placentation. Current recommendations are mainly based on expert consensus, case reports or series, and clinical experience.

General management

Generally, the management for the three different types of PAS disorders is essentially the same, except some special conditions, such as placenta percreta extending to extrauterine tissue. Given the potential hemorrhage, optimizing predelivery hemoglobin values and correcting anemia, especially iron deficiency anemia, are desirable. For women with antepartum bleeding, the option of antenatal corticosteroids may be considered between 23 and 34 weeks of gestation [70–73]. Notably, the risks of using antenatal corticosteroids should be fully informed to the patients and their family members, especially to those with lower gestational ages. Hospitalization in late period of pregnancy can be considered, particularly on the occasions when vaginal bleeding or contractions occur, or when living far away from a tertiary care center; outpatient follow-ups can be implemented in asymptomatic women with appropriate counsels and rapid access to the hospital [74]. Notably, management by a multidisciplinary team, including obstetrician-gynecologists with expertise in placenta accreta spectrum, experienced anesthesiologists, neonatologists, interventional radiologists, urologist, nursing panel and blood bank, is desirable given its ability to improve maternal and neonatal outcomes [36,37,75]. If such a multidisciplinary team is not available, transferal to a large tertiary center, which has the capability to handle massive obstetric hemorrhage and provide intensive care, should be recommended.

Some recommendations, such as avoiding rigorous activity and pelvic examination, haven't been proven to generate any benefit and thus should be provided with caution. In addition, autologous donation is infrequently used because much more units of blood

products are needed when hemorrhaging than the estimated maximum volume of safe autologous donation and thus, this procedure is not routinely recommended. The use of some drugs preventing bleeding among women with placenta accreta spectrum is still on debate. For instance, the efficacy of tranexamic acid in prophylactic use and treatment for PAS remains uncertain which limits the administration of this drug [3], requiring further large studies. Similarly, prophylactic use of clotting factors like recombinant activated VIIa is under investigation and use in PAS lacks of supporting evidence-based data.

The routine strategy for the delivery of women with PAS disorders is planned caesarean section. The optimum timing of such planned delivery, which needs to balance between maternal risks and neonatal benefits, remains unclear. Generally speaking, given the ability to deal with maternal and neonatal complications in most large tertiary care centers at this gestational age and potentially higher risk of hemorrhage beyond 36 weeks in women with PAS disorders, delivery planned at 34 weeks of gestation was considered reasonable and close to optimal [32,76–78]. As for those stable patients with favorable systematic conditions, the ideal gestational age for scheduled caesarean section or hysterectomy is suggested around 36 weeks of gestation [76]. However, for patients with preeclampsia, rupture of membranes, lasting bleeding, fetal compromise, or progressive maternal comorbidities, delivery should be planned in advance and sometimes unscheduled delivery becomes possible. Notably, the recommendations on the timing of pregnancy cessation are various in different counties and associations, necessitating further studies on the optimum timing of pregnancy termination.

Nonconservative management

Caesarean hysterectomy, with the placenta left undisturbed in situ after delivery of the fetus, is the most universally accepted procedure in the nonconservative management of placenta accreta spectrum [69,79–81]. It's noted that prenatal diagnosis of PAS, made by clinical risk assessment and ultrasound imaging, is essential to this approach. Prophylactic antibiotics before surgery are also of great importance and should be one of the standard managements for PAS [82]. Additionally, the decisions of skin incision should take the location of placenta into consideration and eventually judged by operators, given insufficient data on the comparison among different incisions [3].

Cystoscopy or intentional cystotomy should be considered in cases of suspected bladder invasion to evaluate the degree of bladder, and potential ureteral involvement [83]. Further, partial cystectomy may be an option of placenta percreta with confirmed bladder invasion [84].

In addition to these mentioned nonconservative approaches, in order to further deal with massive hemorrhage and prevent potential pelvic hemorrhage, several procedural strategies have been proposed. Nevertheless, further discussions are needed to adopt these supplementary procedures [3]. Internal iliac artery ligation is thought to have capability to reduce blood loss, but its time-consuming feature and unproven efficacy for handling pelvic hemorrhage preclude the possibility of using this procedure more widely [85–87]. In addition, interventional radiologic techniques, such as endovascular intervention with a balloon catheter and embolizing the internal iliac arteries or uterine artery, are not routine considerations, because these procedures are difficult to perform and specialist-dependent, with controversial effectiveness [85–88]. Other approaches like aortic compression or clamping and pelvic packing are not supported by high-quality data; therefore, the practical use of them should be cautious. Overall, large prospective studies are still required for these adjuvant methods to decrease blood loss.

Due to the significant impacts of above nonconservative operations on the maternal hemodynamic homeostasis, postoperative monitor of hemodynamic is necessary and can be conducted in the intensive care unit. On some occasions, interventional radiology and reoperation may be necessary, in order to address some severe issues related to maternal complications after surgery.

Conservative management

The key of conservative management for placenta accreta spectrum is uterine conservation to preserve the fertility of women especially those with strong intention. In addition, another merit of this approach is thought to have potential to reduce major complications associated with hysterectomy, such as massive obstetric hemorrhage, and injury to adjacent pelvic organs [89]. The decision on conservative management should balance between fertility and associated risks with uterine preservation, such as infection, hemorrhage, potential need for hysterectomy, recurrence or hemorrhage in future pregnancies, and even death [90,91].

Expectant management

Realizing uterine conservation with the placenta left in situ is known as expectant management of PAS disorders. In this strategy, the placenta is left undisturbed in situ after delivery of the newborn; a series of procedures to manage postpartum hemorrhage, such as compression sutures, intrauterine balloon catheter, and uterine artery ligation or embolization, can be employed as needed [74,92]. Notably, postpartum prophylactic oxytocin is not routinely used, for its administration associated with increased risk of bleeding by resulting in potential placental separation [74]. Nevertheless, uterotonic drugs may be considered when the placenta has been mostly or even completely removed or major bleeding has already occurred.

Up to now, very limited data have been reported regarding other approaches to treat bleeding in the setting of expectant management, such as methotrexate therapy, high-intensity focused ultrasound (HIFU), delayed hysteroscopic resection of placental remnants and delayed-interval hysterectomy; therefore, their utilization was not routinely recommended [74, 93–95].

The immediate complications and long-term outcomes of patients who underwent expectant management can be very severe [84,96], indicating that this strategy should be attempted only in fully informed women, or only as part of approved clinical trials [74].

Uterine preservation with placental removal

For women with focal accreta and posterior or fundal placenta accreta, uterine preservation with placental removal, through manual removal or surgical excision followed by repair of the corresponding defect, may be successful in cases without excessive risk [92]. Sonographic findings are of vital importance to determine focal accreta and specific area of accrete [74].

An emerging technique to preserve uterine with removing placenta has already been introduced, called triple P procedure (perioperative localization of the placenta, pelvic devascularization and placental non-separation) [89]. The main process of this approach involves pelvic devascularization as well as partially removal of the uterus, where the invasive placentation occurred. The aim is to achieve the maximum preservation of uterine and its physiologic function [89]. Before its safety and efficacy are demonstrated in more large clinical studies, triple P procedure cannot become the mainstream in the conservative management of placenta accreta spectrum.

Conclusions

Placenta accreta spectrum is becoming increasingly common and corresponds to significant morbidity and mortality. The established risk factors of PAS are a series of prior uterine operations such as caesarean delivery. The detectable and microscopic injuries of the endometrium are currently believed to explain the pathogenesis of PAS.

Prenatal screening is essential for the early detection of PAS. Obstetric ultrasonography on PAS diagnosis and exclusion are recommended to be conducted between 18 and 24 weeks of gestation. As another diagnostic option of PAS, MRI can provide advantages over ultrasound in evaluating the invasive depth and bladder involvement. The value of maternal biomarkers is quite limited in predicting this disease, for their low diagnostic accuracy and relative inaccessibility in lower economic settings.

Management by a multidisciplinary team is of great importance for obtaining better outcomes of PAS patients. The relatively optimal strategy for the delivery of PAS patients is planned caesarean section in 34–36 weeks of gestation. Immediately after delivery, the most used procedure in the nonconservative management of PAS is hysterectomy. Conservative management may be considered among those women with fertility need. Notably, expectant management should not be routinely recommended, while Triple P procedure is a promising technique which has the potential to achieve the maximum preservation of uterine and its physiologic function. Large prospective population-based studies are still needed to address the clinical issues of PAS.

Authors' contributions

HBQ and XYL contributed to the review conception. YW (Yu Wang), YW (Yue Wu) and XY searched the databases for relevant studies. XYL drafted the manuscript, and YW (Yu Wang) and JZ proofread the manuscript. HBQ and CT revised the final version and are the guarantors of this manuscript. All authors made substantial contributions to the paper, and read and approved the final manuscript.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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