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# Value of ultrasound scoring system for assessing risk of pernicious placenta previa with accreta spectrum disorders and poor pregnancy outcomes

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## Abstract

**Purpose** To evaluate a system for assessing the risk of pernicious placenta previa (PPP) with placenta accreta spectrum (PAS) disorders and poor pregnancy outcomes.

**Methods** This prospective study focused on PPP women at ≥ 28 weeks' pregnancy. Transabdominal or transvaginal ultrasonography was used to assess PAS and poor pregnancy outcomes with a system involving uteroplacental demarcation, number and size of lacunae, bladder line, and placental basal and lacunae flow. Every item was assigned 0–2 points, and the sum yielded the final score. Diagnosis of PAS was based on surgery or pathology. One or more of postpartum hemorrhage (PPH) ≥ 1000 ml, hysterectomy, and organ invasion were regarded as a poor pregnancy outcome. Receiver operating characteristic (ROC) curves were generated.

**Results** Fifty-one PPP women were included, with 70.6% having PAS and 75.0% of PAS women having a poor pregnancy outcome. The incidence of PAS diagnosis was 36.4% for those with a score < 5 points, with 0% having a poor outcome; 76.5% for those with a score ≥ 5 to < 8 points, with 61.5% having a poor outcome; and 100% for those with a score ≥ 8 points, with 100% having a poor pregnancy outcome.

**Conclusion** The system for predicting PPP with PAS and poor pregnancy outcomes was of high accuracy.

**Keywords** Ultrasound · Pernicious placenta previa · Placenta accreta spectrum disorders · Poor pregnancy outcomes

## Introduction

Placenta accreta spectrum (PAS) disorders [1, 2] occur as villi attachment to myometrium related to endometrial trauma or dysplasia. They are attributed mainly to prior intrauterine operations, and are more common in the lower anterior wall of the uterus. Placenta previa and cesarean section (CS) are two major risk factors for PAS [3]. Clinically, pernicious placenta previa (PPP), the most serious form of PAS, was considered to be previa placenta overlying CS scars (i.e., the lower anterior uterine segment), and is widely used in China since Chattopadhyay et al. [4] presented this concept. PAS occurs primarily in PPP and rises in incidence with the number of cesarean deliveries [5]. There are three variants according to the depth of implantation: placenta creta (PC), villi adhering to the myometrium surface; placenta increta (PI), villi invading the uterine wall; and placenta percreta (PP), villi penetrating the serosa and/or adjacent organs [3]. In some cases, however, the three types can be coexistent and exacerbated in the subsequent pregnancy [6], and the conclusive diagnosis of variants is difficult for various reasons. Assessing the severity has always been a challenge for physicians. In our study, the presence of at least one of the following three complications is regarded as a poor pregnancy outcome: postpartum hemorrhage (PPH), urgent hysterectomy, and damage to adjacent organs. According to the latest guidelines [7], PPH is defined as blood loss ≥ 1000 ml or that accompanied by signs and symptoms of hypovolemia within 24 h after a fetal delivery, regardless of delivery modes.

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Prenatal assessment may suggest the need for multidisciplinary care before the procedure. Ultrasonography remains the preferred tool for prediction and should begin with risk factors [8, 9]. Typical ultrasound findings include obliteration of a clear zone (hypoechoic retroplacental plane) [10], placental–uterine wall interface disruption (focal uterine musculature is thin and disrupted by placental protrusions) [11], myometrial thinning to < 1 mm or undetectable [6, 12], bladder hyperechoic line disruption or loss [6], exophytic mass (placental bulge) convexing to bladder [12], placental lacunae with high-speed arterial flow from maternal radial or arcuate artery (placental lacunae feeder vessels) [6], placenta basal hypervascularity [6, 13], and bridging vessels (vessels perpendicular to the placenta and myometrium) [6, 14]. Nevertheless, a single sign often yields false-positive results, and at least two have a high incidence of accreta [15, 16].

In the present study, we used an ultrasound scoring system with more than one characteristic sign to suggest the possibility of PPP combined with PAS and even adverse outcomes.

## Materials and methods

This study was carried out at a single tertiary institute. Data on PPP were collected prospectively from December 2016 through March 2018. Inclusion criteria were prior cesarean delivery, previa placenta covering cesarean scars (usual lower anterior uterus) diagnosed at ≥ 28 weeks' pregnancy at our ultrasound unit, and delivery at our hospital.

Women were required to fill the bladder fully prior to sonograms. All of the following examinations were performed via transabdominal or transvaginal ultrasound by a skilled prenatal ultrasound physician: placental–uterine wall interface (focal uterine musculature is thin and disrupted by placental protrusions) [11], number and size of lacunae (irregular intraplacental spaces throughout the basal plate counted with only one with interconnections) [13], bladder line (hyperechoic line between uterine serosa and bladder lumen, disrupted by low echo or echo loss, which was assigned as one disruption; the lower anterior uterine segment near the cervix was prone to echo loss, so it was necessary to adjust the viewing angle to avoid this artifact) [6], lacunae flow [6], and placental basal flow [6, 13]. According to an ultrasound scoring system based on the severity of observations, each was assigned 0–2 points, and the sum gave a final score ranging from 0 to 12 points (Table 1). Insonation angle adjustment to keep it at ≤ 20° was vital to measure the peak systolic velocity (PSV) of lacunae, and it should be measured near decidua (the site of maternal blood pumping into lacunae). Ultrasound machines (Voluson E8/10; GE Medical Systems, Milan, Italy) were used with curved probes (1–5 MHz) and endovaginal transducers (5–9 MHz). The research protocol was approved by the ethics committee, and the study conformed to the Declaration of Helsinki. Written informed consent was obtained from subjects.

Diagnosis of PC, PI, and PP was based on surgery or pathology, and each was labelled as a deepest variant. Poor pregnancy outcomes were expressed as one or more of the following items: PPH (postpartum blood loss ≥ 1000 ml within 24 h under hemostatic modes such as uterine compression suture, vascular embolism, preoperative catheterization of artery, and hysterectomy to minimize bleeding intraoperatively), hysterectomy, and organ invasion.

Data analysis was performed using SPSS 20.0 (IBM, Armonk, NY, USA) and Medcalc version 15.2.2 (MedCalc Software bvba, Ostend, Belgium) software packages. Continuous values are expressed as mean ± SD or median (range), and frequencies as percentages. *T* test was used to assess continuous values of PAS compared with non-PAS. Receiver operating characteristic (ROC) curves were used to select cut-off points for PAS and poor pregnancy outcomes in terms of sensitivity and specificity. An actual *P* value of < 0.001 was considered statistically significant. A correlation between PPH and PAS score was evaluated by relevant analysis, which was positive with $P < 0.05$ and $r > 0$, and the closer to 1 the *r* (correlation coefficient), the stronger the correlation.

**Table 1** Ultrasound scoring system

| Score | 0 | 1 | 2 |
|---|---|---|---|
| Placental–uterine wall interface | Clear | Disruption | Myometrium undetected |
| Number of lacunae | 0 | 1–5 | ≥ 6 |
| Size of lacunae | None | ≤ 2 cm | > 2 cm |
| Bladder hyperechoic line | Continuous | Disruption | Loss |
| Lacunae flow | None | Venous flow, fetal artery flow, or PSV ≤ 15 cm/s from maternal artery | PSV > 15 cm/s from maternal artery |
| Placenta basal flow | Regular | Hypervascularity and tanglesome | Bridging vessels |

## Results

Fifty-one PPP women, aged 35.04 ± 4.137 years, were included in this study. Based on sonograms (Fig. 1), details of each performance are presented in Table 2. Surgery or pathology (Fig. 2) confirmed 36 PAS (70.6%), 27 (75.0%) of whom had poor pregnancy outcomes. Among the 27 PAS, there was one case with 500 ml of bleeding with bladder invasion and hysterectomy, and 26 PPHs (26/36, 72.2%) with one bladder invasion and three hysterectomies. The number of CS and previous abortions was 1.08 ± 0.272 and 2.00 ± 1.563 times, respectively. Gestational age at sonographic examination and delivery was 32 1/7 weeks (28 weeks–37 1/7 weeks) and 36 2/7 weeks (28 5/7 weeks–38 3/7 weeks), respectively. Neonatal weight was 2717.25 ± 428.382 grams, and all survived within 24 h. Maternal age, the number of CS and previous abortions, gestational age at delivery, and neonatal weight did not differ significantly between PAS and non-PAS ($P > 0.05$).

**Table 2** Scoring details

| | 0 | 1 | 2 |
|---|---|---|---|
| Placental–uterine wall interface | 5 | 23 | 23 |
| Number of lacunae | 7 | 35 | 9 |
| Size of lacunae | 7 | 15 | 29 |
| Bladder hyperechoic line | 30 | 14 | 7 |
| Lacunae flow | 18 | 12 | 21 |
| Placenta basal flow | 15 | 26 | 10 |

The number of each score of every single sign is shown in the table

For the 51 PPP women, the area under the curve (AUC) for PAS diagnosis was 0.887 ($P < 0.0001$), and the 95% confidence interval (CI) was 0.798–0.977. Score was ≥ 2 points with sensitivity of 100%. Score was ≥ 5 points with maximum Youden index, where sensitivity and specificity

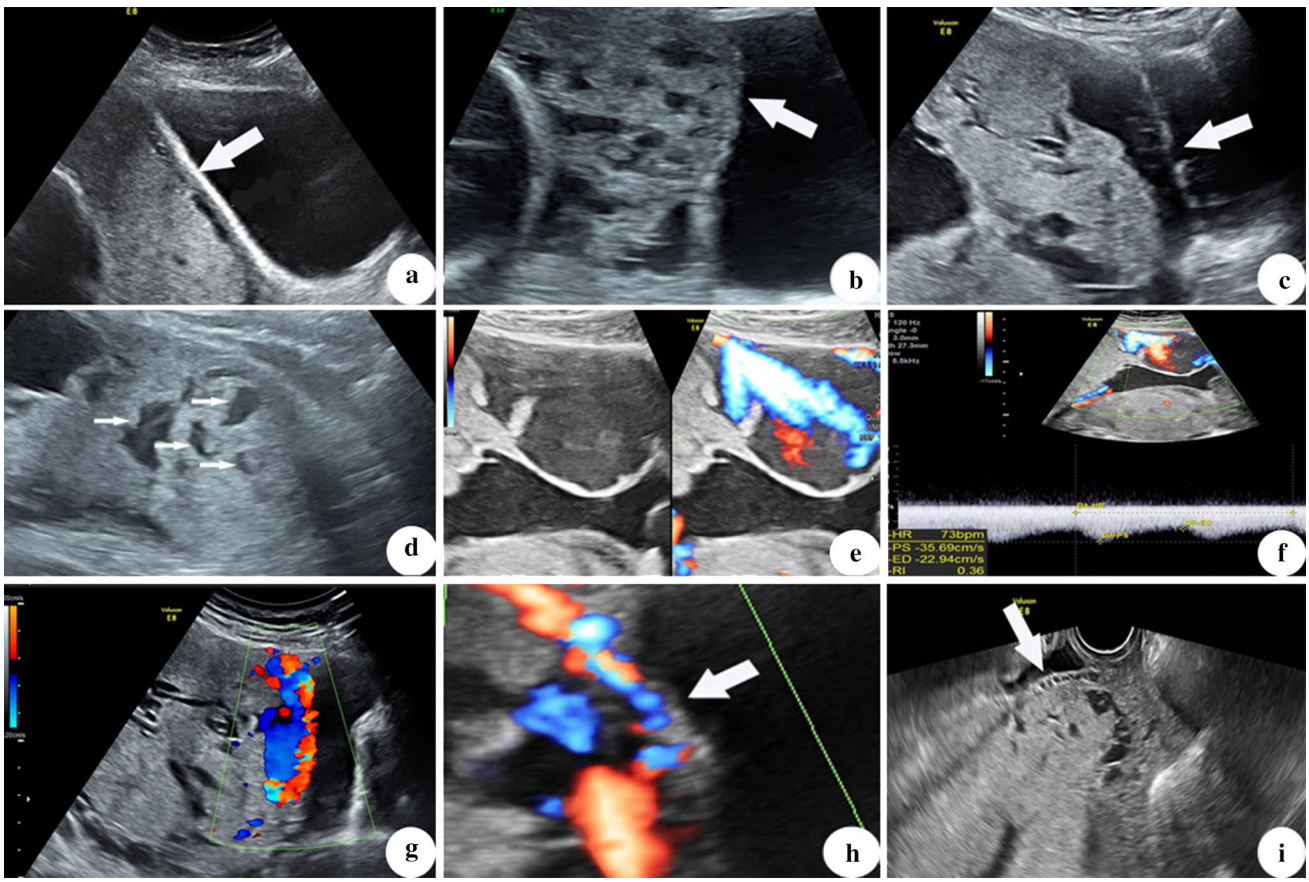


**Fig. 1** PAS ultrasonograms. **a** Disruption of the placental–uterine wall (arrow) was seen at PAS site (1 point), e.g., loss of clear zone. **b** Focal myometrium was undetected (arrow, 2 points) with bladder lining loss (2 points). **c** Myometrium was undetected (2 points) with bladder line interruption (1 point). **d** Four lacunae (1 point) were present, and the maximal diameter was > 2 cm (2 points) in the system. **e**, **f** Lacunae turbulent flow with maternal arterial spectrum (2 points, PSV = 35.7 cm/s, HR = 73 bpm), maternal uterine artery HR = 77 bpm and fetus HR = 135 bpm. **g** Basal plate hypervascularity was tanglesome (1 point). **h**, **i** Bridging vessels (2 points) in the system

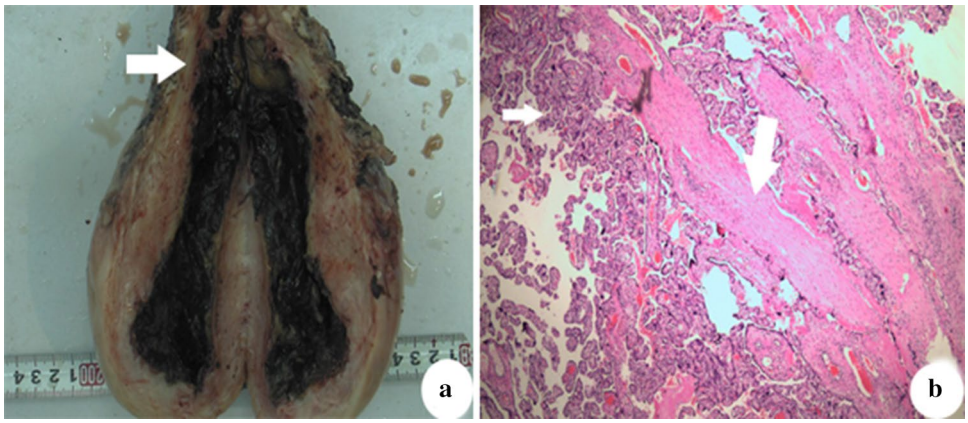


**Fig. 2** PAS pathology. **a** Hysterectomy specimen: placenta tissue invaded the myometrium, with deeper invasion indicated by arrow. **b** Microscopic specimen: villous trophoblast (narrow arrow) cells embedded in the chapped myometrium (thick arrow)

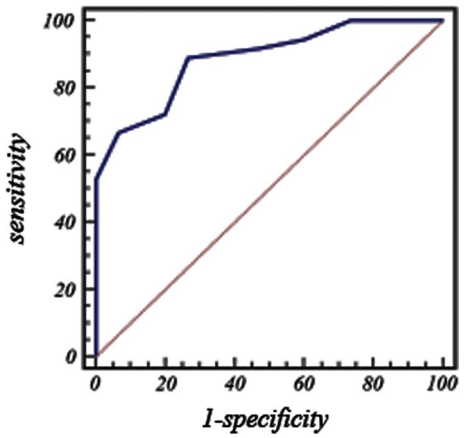


**Fig. 3** ROC curve for PAS diagnosis. AUC was 0.887 (95% CI 0.798–0.977), $P < 0.0001$

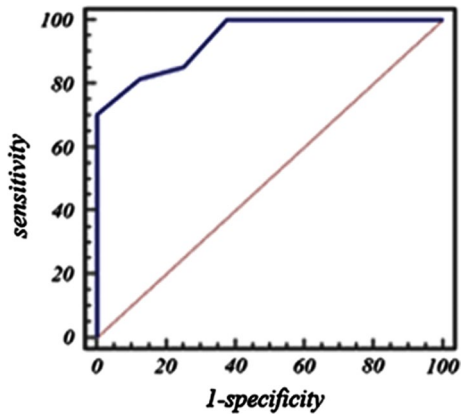


**Fig. 4** ROC curve for predicting poor pregnancy outcomes. AUC was 0.940 (95% CI 0.836–0.987), $P < 0.0001$

were 88.89% and 73.33%, respectively. When the score was ≥ 8 points, specificity was 100% (Fig. 3). With regard to these signs, placental–uterine wall interface accompanied by lacunae flow had a maximal AUC (0.905, 95% CI 0.827–0.983) for PAS. AUC for predicting poor pregnancy outcomes was 0.940 ($P < 0.0001$, 95% CI 0.836–0.987). Score was ≥ 5 points with sensitivity of 100%. Score was ≥ 8 points with maximum Youden index, with sensitivity of 70.37% and specificity of 100% (Fig. 4). Clinical reference values of the system for PPP with PAS and poor pregnancy outcomes are listed in Table 3.

Blood loss in PAS was greater versus that in non-PAS (1350 ml (200–6500 ml) versus 400 ml (200 ~ 2000 ml), $P < 0.001$). A scatter diagram of the score to hemorrhage for PAS is shown in Fig. 5. There was a positive correlation between the two, and $r$ was 0.680 ($P < 0.001$), which indicated that the higher the score, the more the blood loss (Table 4). Meanwhile, 11 PAS women had a score of ≥ 10 points, and 63.6% (7/11) underwent abdominal arterial balloon intubation during surgery, while those with a score < 10 points did not.

**Table 3** Clinical reference values

| Score (points) | PAS disorders | Poor pregnancy outcomes |
|---|---|---|
| < 2 | 0% (0/4) | 0% (0/4) |
| ≥ 2 to < 5 | 36.4% (4/11) | 0% (0/4) |
| ≥ 5 to < 8 | 76.5% (13/17) | 61.5% (8/13) |
| ≥ 8 | 100% (19/19) | 100% (19/19) |

Percentages of PAS/total women and poor pregnancy outcomes/PAS women in the score range, respectively

## Discussion

PAS used to be a rare maternal pathology. However, with the popularity of uterine procedures, the incidence observed has risen to at least 1/533 [17], and the increasing CS rate should not be overlooked [18]. Among those with previous

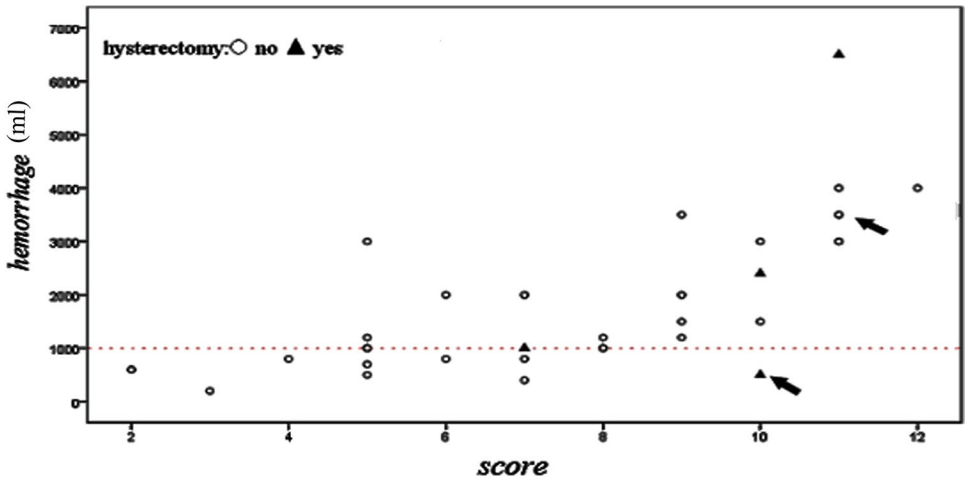


**Fig. 5** Bladder invasion present in two PAS for 10 and 11 points, respectively (arrow)

**Table 4** Pregnancy outcomes of PPP women with PAS disorders

| Score | Blood loss—median (range) ml | Amount of blood products—packed red cells, cryoprecipitate-median (range) units and fresh-frozen plasma—median (range) ml | PAS variants | Number of PPH/PAS |
|---|---|---|---|---|
| ≥2 and ≤4 | 600 (200–800) | 0, 0, 0 | 4 PC | 0/4 |
| 5 | 1000 (500–3000) | 2.5 (0–4), 0, 0 (0–400) | 3 PI, 3 PC | 4/6 |
| 6 | 1400 (800–2000) | 2 (0–4), 0, 0 | 1 PI, 1 PC | 1/2 |
| 7 | 1000 (400–2000) | 3.85 (0–7.25), 0, 0 (0–350) | 5 PI | 3/5 |
| 8 | 1000 (1000–1200) | 4 (0–4), 0, 0 (0–200) | 1 PP, 1 PI, 1 PC | 3/3 |
| 9 | 2000 (1200–3500) | 5.8 (3–6), 0, 0 (0–400) | 4 PI, 1 PC | 5/5 |
| 10 | 1950 (500–3000) | 5.3 (2–16.5), 5 (0–10), 550 (0–800) | 1 PP with bladder invasion, 1 PI, 2 PC | 4/4 |
| 11 | 3500 (3000–6500) | 10.78 (4.75–12.5), 5 (0–10), 400 (0–1600) | 3 PP (one with bladder invasion), 3 PI | 6/6 |
| 12 | 4000 | 19.25, 0, 0 | 1 PP | 1/1 |

CS alone, the incidence of PAS for four CSs was only 2.33%, lower than 3% (a single CS) with both CS and placenta previa [5]. PPP is the most common manifestation of PAS due to severe damage of the endometrium and myometrium, and impaired blood supply at scars. PAS can appear at different depths of implantation to satisfy fetal growing needs. Superficial PAS and great uterine contraction have little effect, but deep invasion can threaten life due to excessive hemorrhage, hysterectomy, shock, disseminated intravascular coagulation, Sheehan's syndrome, and so on [6]. PPH was the most common complication of PAS with a 50% incidence (412/819) [19]. Identifying symptoms and signs of PPH intraoperatively is critical to improve the prognosis of puerperae. Actual blood loss may reach 25% of total blood volume (1500 mL or more), causing tachycardia or hypotension [20]. Therefore, prenatal ultrasound prediction for PAS and poor pregnancy outcomes has great value for perioperative management and should be considered.

There are few reports of prediction of poor pregnancy outcomes, and most multi-parameter studies have only been applied to PAS diagnosis. Martha et al. [14] conducted a retrospective study of 184 cases that were diagnosed as low-lying or previa placenta in the third trimester together with CS using a scoring method (included minimal myometrial thickness, lacunae size and number, vascular bridge, placenta position, and number of CS) to diagnose PAS. Sensitivity, specificity, and other parameters were received from 0 to 9 points, which showed that the higher the score, the greater the accuracy. Weiniger et al. [21] performed PAS diagnosis in 92 suspected gravidas with a mathematical prediction model (included sonograms, placenta previa, and number of CS). The score was higher than 0.174 with a sensitivity of 100%; however, low specificity (25%) would cause a high false-positive rate. When the score was above 0.208, sensitivity (94%) and specificity (53%) were best. And the cut-off spot could be selected for different clinical needs. Tovbin et al. [10] established a scoring system containing number of CS, placental position, lacunae size and number, uteroplacental demarcation, and Doppler color flow to assess 258 gravidas. Low, moderate, and high scores were analyzed to get low (0.9%), moderate (29.4%), and high (84.2%) likelihood of PAS, respectively. In one word, the

higher the score was, the greater the likelihood that PAS occurred. Gilboa et al. [9] also integrated a scoring scale retrospectively based on grayscale images involving number of lacunae, bladder line, and clear zone. Results were classified into four grades: grade 0 (normal placenta), 1 (low probability of PAS), 2 (moderate probability of PAS), and 3 (high probability of PAS). And the higher the grade, the more blood loss, blood product transfusions, and hysterectomies there were ($P < 0.001$). The purpose of this scale was to filter out grade 3 cases to prompt prophylactic pelvic artery catheterization. Zhang et al. [22] proposed that a novel marker with PSV ≥ 41 cm/s of subplacental flow was a cut-off spot to diagnose PAS. When PSV was < 41 cm/s, even if PAS disorders were present, the amount of blood loss would be less. And when PSV was > 49 cm/s, maternal complications would be more common.

According to the previous literatures, it was important to acknowledge that the placental–uterine wall interface, number and size of lacunae, bladder line, placental basal, and lacunae flow were strongly associated with PAS [6, 11]. Predicting PAS prenatally on the basis of the markers mentioned above was highly feasible. Among these signs, both placental–uterine wall interface and lacunae flow concurrently led to a greater diagnosis of PAS. Lacunae needed to be distinguished from placental lakes, chorionic hemangioma, and placenta abruption. (1) Placental lakes were difficult to distinguish, but they were distinguished mainly based on shape, location, number, and flow [6]. It was physiological expansions of villus interval with regular shape, small number, and surrounded by normal placenta. Flow was seen with more gain on grayscale, and non-pulsating vein or no flow signals were detected on color Doppler sonograms. Otherwise, lacunae were irregular vascular entities within the placenta like "Swiss cheese" adjacent to the implantation site throughout the basal plate [23–25]. And the more the lacunae, the more the hemorrhage [26]. Lacunae flow had a characteristic change deriving from uterus radiation or arcuate artery where PSV (usual > 15 cm/s [27, 28] or > 10 cm/s [6]) was fast with a maternal heart rate. The measurement site should be the flow root near decidua, closer to maternal uterine-artery frequency and with fastest PSV, while other sites would be affected by turbulent flow. (2) Chorionic hemangioma was a round hypoechoic mass in the placenta with fetal artery flow [29]. (3) Placenta abruption was hematoma between the placenta and myometrium formed by rupture of decidua vasculature without flow [23]. Our research also emphasized poor pregnancy outcomes induced by PAS with such a system. When the score was < 2 points, there was no PAS. When the score was ≥ 2 to < 5, the rate of PAS was 36.4% with an extremely low probability of poor pregnancy outcomes. Four PAS were all PC with superficial implantation with no devastating consequences. When the score was ≥ 5 to < 8, the probability of PAS was high, and the incidence of poor pregnancy outcomes was 61.5%, with the average hemorrhage less than that for ≥ 8 points, surprisingly. The score was ≥ 8 points in all PAS women with poor pregnancy outcomes. The higher the score, the more the hemorrhage. And arterial balloon intubation should be applied preoperatively if necessary, to avoid excessive bleeding during surgery. PAS-induced PPH is more common in the third stage of labor [19], and this result applied to our study in 100% of cases, including two cases with postnatal hemorrhagic shock within 24 h (atonic postpartum hemorrhage) that underwent acute hysterectomy. PPH appeared in 72.2% of PAS women, significantly higher than the 50% reported by Mehrabadi et al. [19], because of the inclusion criteria for PPP, which did not include all types of PAS. A high incidence of PAS is an important reason for the increase in PPH and hysterectomy [2, 8]. However, hysterectomy and organ invasion are rarely severe complications. The higher the score, the greater the probability in our study. And as most women had only one CS, the correlation between PAS and number of CS was not significant.

Our study was a prospective design. Sonographers could obtain well-scoring sonograms through a targeted placenta search, which made up for drawbacks of a retrospective study. A multi-parameter analysis of this scoring system had a greater prediction than single ultrasound performance, providing an effective reference value for prenatal counseling and preoperative management, and recommending women to a skilled tertiary hospital to avoid an unnecessary hysterectomy. There were some limitations that should be acknowledged regarding the suggested system. The major one was that surgeons were not blind to ultrasound and MRI results. Multidisciplinary treatments were performed such as prophylactic artery intubation in severe PAS to reduce hemorrhage and preserve the uterus during surgery. Placenta previa alone could also cause notable hemorrhage [30, 31], but the system had a low prediction for notable bleeding caused by epicardial PAS with a poorly contracted uterus. Furthermore, sonography was limited by obesity and posterior low-lying PAS disorders. And cystoscopy was a better device to predict bladder invasion suspected on ultrasound. The posterior wall inside the bladder could be observed clearly [32]. Cystoscopic findings included submucosally pulsating arterial vessels [33], and an exophytic and partially calcified mass of the bladder wall [34]. Despite these limitations, the system could still serve as an effective method to valuate PAS and PAS-associated outcomes.

## Conclusion

Overall, this system could be of great value to evaluate PPP combined with PAS and poor pregnancy outcomes, enhancing relations between sonographic findings and PAS

complications. Clearly, it is suggested that more clinical experience in a larger population will be required to validate and further improve the system.

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**Ethical approval** All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions.

**Conflict of interest** Lingling Zhu and Limei Xie declare that they have no conflicts of interest.

**Informed consent** Informed consent was obtained from all patients for being included in the study.

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