Archives of Gynecology and Obstetrics (2019) 299:1579–1586
https://doi.org/10.1007/s00404-019-05136-6

MATERNAL-FETAL MEDICINE

An observation study of the emergency intervention in placenta accreta spectrum

Yan Wang[1] · Lin Zeng[1] · Ziru Niu[1] · Yiwen Chong[1] · Aiqing Zhang[1] · Ben Mol[2] · Yangyu Zhao[1]

Received: 24 December 2018 / Accepted: 25 March 2019 / Published online: 5 April 2019

Abstract

Objective This study explored the probability and outcome of delivery in women with placenta accreta spectrum (PAS) according to gestational age at delivery.

Methods A retrospective cohort study among women with PAS who had cesarean section was conducted. The gestational week (gw) of delivery and estimated blood loss (EBL) were recorded. The proportion of urgent delivery beyond 32 gw and EBL in women with or without antepartum suspected diagnosis of placenta accreta was compared.

Results Totally, 180 women with PAS were enrolled. Of these, 54 (30.0%, 95% CI 23.8–37.1%) were delivered by urgent cesarean delivery and 126 (70.0%, 95% CI 62.9–76.2%) by elective cesarean section. The probability of emergent delivery was increased from 3.1 to 5.7% at 33–36 weeks, and increased by > 10% beyond 37 weeks. Among 121 antenatal suspected PAS patients, 25 (20.7%, 95% CI 14.4–28.7%) had emergency cesarean section, and 96 (79.3%, 95% CI 71.3–85.6%) experienced elective cesarean. The EBL of PAS in both emergent group ($r = -0.276$, $p = 0.044$) and elective group ($r = -0.370$, $p < 0.001$) was significantly decreased with gestational age progression. The antepartum hemorrhage increased the risk of urgent delivery [OR 2.54 (1.19, 5.44)] ($p = 0.016$), while PAS with antepartum diagnosis decreased the risk [OR 0.21 (0.10, 0.43)] ($p < 0.001$).

Conclusion Although the incidence of emergency operation in PAS patients was increased at 32–36 gw, there was no significant difference among the groups. The decision of timing for pregnancy termination should be made cautiously. We recommend scheduled operation at around 36–37 gw. In serious cases, the termination time could be arranged as early as appropriate.

Keywords Emergency intervention · Placenta accreta spectrum · Observational study

Background

Placenta accreta spectrum (PAS) refers to an obstetrical condition in which the placental villi are abnormally adhered or invaded into the uterine myometrium. PAS includes placenta accreta, placenta increta, and placenta percreta [1, 2]. It is always associated with severe postpartum hemorrhage, causing cesarean hysterectomy or peripartum hysterectomy. In US, the data from several units indicated that placenta accreta occurs in about 1 in 4000 deliveries in the 1970s [3], 1 in 2500 deliveries in the 1980s [4], and 1 in 533 to 1 in 730 deliveries recently [5, 6]. In China, the incidence of placenta accreta still remained unclear. Even after the introduction of "Two-child policy" and high cesarean section rate during first pregnancy, the incidence of placenta accreta is still increased [7] and the condition of antepartum suspected placenta accreta is more often recognized. The obstetricians are facing more challenges, especially when accreta patients come along with bleeding, an urgent delivery is unavoidable.

Compared with urgent cesarean delivery, scheduled cesarean section is associated with shorter operative time, lower frequency of transfusions, less complications, lower maternal morbidity, and less intensive care unit (ICU) admissions

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00404-019-05136-6) contains supplementary material, which is available to authorized users.

✉ Yangyu Zhao
zhaoyangyu001@163.com

[1] Department of Obstetrics and Gynecology, Peking University Third Hospital, Beijing, China

[2] Department of Obstetrics and Gynaecology Monash, University Monash Medical Centre, Melbourne, Australia

[8, 9] involving a multidisciplinary care team [10, 11]. To obtain scheduled timing for surgery, the decision should be made individually based on the severity of placental implantation and patient circumstances [12, 13].

Actually, the optimal timing of delivery for patients with PAS is still under controversial. In patients with stable condition, the American College of Obstetricians and Gynecologists recommended a scheduled delivery at 34 gestational weeks (gw) [12]. However, the College and the Society for Maternal–Fetal Medicine (SMFM) indicated that most of the doctors in clinical practice are inclined to deliver women with suspected placenta accreta at or beyond 36 gw [14, 15].

How to deliver cases with suspected placenta accreta is really a serious problem. Hence, in this study, we summarized the patients with PAS in our hospital and classified them into emergent cesarean delivery group or elective cesarean delivery group retrospectively. We hope that these data could present more information for doctors and provide a reference for them regarding the probability of patient's to undergo urgent delivery and estimated blood loss (EBL) at specified gestational weeks.

Materials and methods

This retrospective cohort study was conducted in PAS women delivered at Peking University Third Hospital between January 2015 and December 2016.

We searched the hospital electronic database system for discharge diagnosis with admission codes as equal to or more than "32 gw", "cesarean section" and with one of these "placenta accreta", or "placenta increta", or "placenta percreta". Patients with PAS disorders who delivered vaginally were excluded from this study.

PAS was defined by the failed attempts to remove the placenta during cesarean delivery. PAS diagnosis was confirmed by histopathological placental invasion and clinical diagnosis of direct myometrial invasion during cesarean section [16].

PAS patients presenting with vaginal bleeding or suspected labor with regular uninhibited contractions were included in the emergent cesarean group; otherwise, the patients were enrolled into the elective cesarean group.

For elective cesarean group, the timing of delivery depends on the following principles: (1) for antepartum suspected PAS patients, an ultrasound based scoring system had already been stabilized, and the timing of delivery was based on the score of each patient [17]; (2) women with antepartum diagnosis of placenta previa without suspected PAS were planned to deliver beyond 37 gw; and (3) other reasons for planned cesarean delivery without suspected PAS were performed at 39 gw.

A protocol for antenatally suspected PAS according to "Ultrasound scoring system for placenta accreta (Peking University Third Hospital)" was put forwarded. The score system included 9 items and the score of 0, 1, or 2 was given for each item (Supplemental Table S1). Women with a score of ≥ 10 were considered to have severe PAS and were delivered around $33+0$ to $34+6$ gw, women with a score between 6 to 9 were considered to have moderate placenta accreta and were delivered around $35+0$ to $36+6$ gw, and women with a score of ≤ 5 were delivered beyond $37+0$ gw.

Outcomes were compared in cohorts of women with emergent delivery and elective delivery. Records were reviewed to identify clinical characteristics and delivery outcomes.

Statistical analyses were conducted by SPSS18.0. Data were expressed as mean (SD), medians [interquartile ranges (IQRs)], or *n* (%). Chi-square test was used for categorical variables and Student's *t* test for continuous variables that satisfy normal distribution. If the continuous data did not follow a Gaussian distribution, then a Mann–Whitney test was carried out. Spearman's correlation coefficient was calculated for analyzing the relationship between delivered gestational age and EBL. Kaplan–Meier curves were used to display the timing of delivery, and analyzed the time to delivery in the emergent delivery group and the total patients in the study. Logistic regression analysis was used to identify the risk factors of urgent delivery. p values of < 0.05 were considered to be statistically different.

This study was approved by the Research Ethics Committee of Peking University Third Hospital (2015155) and was conducted in accordance with the Declaration of Helsinki as revised in 2013.

Results

During the 2 year period, 180 women were delivered by cesarean section at 32 gw or greater. Among them, 54 (30.0%, 95% CI 23.8–37.1%) women underwent emergency cesarean section, while the remaining 126 (70.0%, 95% CI 62.9–76.2%) women were delivered by elective cesarean section. Totally, 121 patients were suspected to have PAS antenatally, in which 25 (20.7%, 95% CI 14.4–28.7%) had emergency cesarean section, and 96 (79.3%, 95% CI 71.3–85.6%) had elective cesarean.

The timing of delivery and EBL according to gw are shown in Table 1. The overall patients and those suspected patients with PAS recognized by antepartum screening are listed, respectively. The percentage of delivery was calculated by the number of urgent cases at each week/remaining number of total undelivered patients at that gw. The patients who had already delivered, no matter emergent or elective, were removed. In all cases with cesarean section,

Table 1 Timing of delivery and estimated blood loss (EBL) in patients with placenta accreta according to gestational age in weeks

Outcome	Gestational age (weeks)							
	32	33	34	35	36	37	38	39 or greater
Total patients at this period	180	176	159	141	123	93	49	29
Urgent Delivery ($n=54$)	2 (1)	7 (4)	5 (3)	8 (6)	5 (4)	9 (10)	6 (12)	12 (41)
EBL (ml)	(1000, 3000)[a]	1260 (400, 4000)	1800 (450, 3250)	1450 (700, 2750)	1000 (595, 3760)	700 (250, 1415)	800 (400, 3975)	800 (400, 1385)
Planned Delivery ($n=126$)	2 (1)	10 (6)	13 (8)	10 (7)	25 (20)	35 (38)	14 (29)	17 (59)
EBL (ml)	(600, 2050)[a]	2900 (550, 5100)	1850 (550, 3750)	2150 (475, 2850)	900 (450, 1410)	1000 (400, 1500)	715 (375, 1250)	400 (300, 725)
Suspected antenatally patients at this period	121	118	105	89	74	48	16	6
Urgent delivery ($n=25$)	2 (2)	4 (3)	3 (3)	6 (7)	4 (5)	5 (10)	1 (6)	0
EBL (ml)	(1000, 3000)[a]	4000 (1945, 6250)	(1800, 3050)[a]	1500 (525, 3713)	1495 (693, 4645)	1130 (700, 2350)	(2500)[b]	–
Planned delivery ($n=96$)	1 (1)	9 (8)	13 (12)	9 (10)	22 (30)	27 (56)	9 (56)	6 (100)
EBL (ml)	(3500)[b]	3000 (500, 5200)	1850 (550, 3750)	2500 (450, 2900)	980 (475, 1957)	1000 (400, 1500)	800 (350, 2500)	450 (300, 650)

Data are *n*, *n* (%), or median (quartile 1, quartile 3) unless otherwise specified

[a]Data are (min, max)

[b]Data are only one record (the value)

1% (2/180) women with PAS underwent urgent delivery owing to bleeding or suspected labor at 32 gw, 4% (7/176) at 33 gw, 3% (5/159) at 34 gw, 6% (8/141) at 35 gw, and 4% (5/123) at 36 gw. With the progression of gestational age, the percentage of delivery was also increased, which was more than 10% at ≥ 37 gw. In antepartum-suspected cases, 121 placenta accreta cases were recognized in antepartum diagnosis and finally confirmed after delivery. Among them, 79% (96/121) had planned delivery, while 21% (25/121) had emergent delivered [32 gw: 2% (2/121), 33 gw: 3% (4/118), 34 gw: 3% (3/105), 35 gw: 7% (6/89), 36 gw: 5% (4/74), 37gw: 10% (5/48), 38 gw: 6% (1/16), and ≥ 39 gw: 0%] (Fig. 1).

Demographics and clinical characteristics are shown in Table 2. Overall, data of both emergent cesarean group and selective cesarean group were similar with respect to maternal age, parity, multiple pregnancy, in vitro fertilization–embryo transfer pregnancy, pregnancy-induced hypertension disease, and the presence of antepartum hemorrhage. However, the gravidity, cesarean history, the presence of placenta previa (67% compared with 86%, $p=0.003$), and the percentage of antepartum-suspected diagnosis of placenta accreta (46% compared with 76%, $p<0.001$) showed significant differences among the two groups.

Table 3 summarizes the maternal delivery outcomes of the entire cohort. There were no significant differences in gestational age at delivery, the rate of cesarean hysterectomy and in situ hysterectomy, and the percentage of maternal ICU admissions. EBL was higher in urgent delivery group compared to the planned delivery group (1000 ml compared with 800 ml, $p=0.512$), but showed no significant differences.

The median EBL in urgent delivery or planned cesarean group at each gw in overall cases is shown in Table 3. Regardless of suspected antepartum or not, the EBL at delivery was significantly decreased with the progression of gestation in the urgent group (all cases with $r=-0.276$, $p=0.044$, the antepartum suspected cases with $r=-0.345$, $p=0.091$). The results of planned group showed similar trends in total accreta patients ($r=-0.370$, $p<0.001$) and in the suspected patients ($r=-0.334$, $p=0.001$) (Fig. 2). From 33 to 39 gw or greater, the EBL of urgent delivery group/planned cesarean group in overall cases was 1260 ml/2900 ml, 1800 ml/1850 ml,

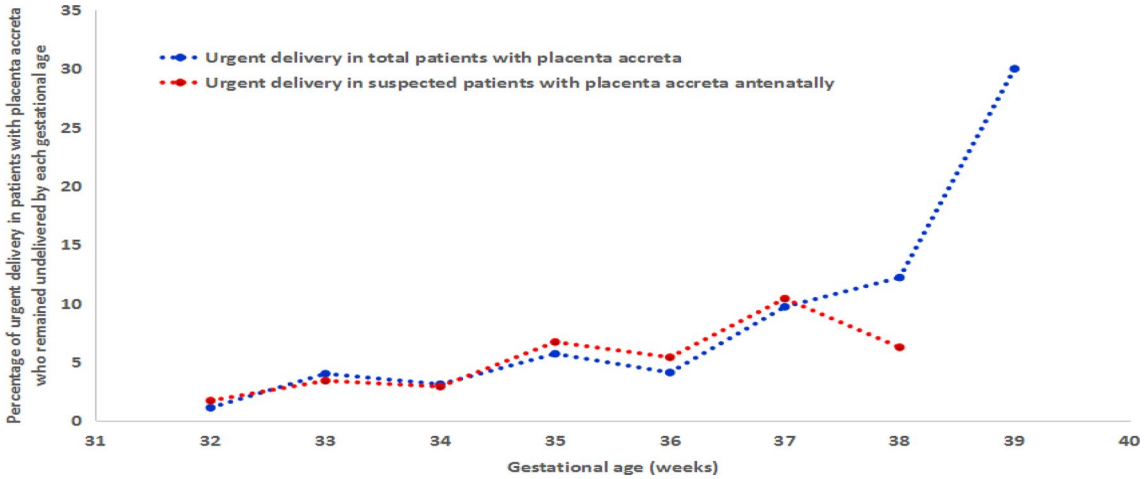


Fig. 1 Percentage of urgent delivery in patients with placenta accreta at each gestational week during the study period. As gestational age at delivery progresses, the percentage of delivery was also increased, which was more than 10% at 37 gw or greater. In antepartum suspected cases of PAS, 121 cases were recognized during antepartum diagnosis and finally confirmed after delivery. Among them, 79% (96/121) had planned delivery, while 21% (25/121) had emergent delivery [32 gw: 2% (2/121), 33 gw: 3% (4/118), 34 gw: 3% (3/105), 35 gw: 7% (6/89), 36 gw: 5% (4/74), 37 gw: 10% (5/48), 38 gw: 6% (1/16), and ≥ 39 gw: 0%]

Table 2 Demographic characteristics in patients with placenta accreta, grouped according to whether performed urgent cesarean delivery

	Emergency CS ($n=54$)	Elective CS ($n=126$)	p	
Maternal age at delivery (years)	33.6 ± 4.8	33.6 ± 5.0	0.981	$t=0.023$
Gravidity	2 (2, 3)	3 (2, 4)	0.003	$Z=-2.963$
Parity	1 (1, 2)	1 (1, 1)	0.589	$Z=0.540$
Multiple pregnancy	4 (7)	6 (5)	0.490	Fisher
In Vitro Fertilization-embryo transfer pregnancy	10 (19)	15 (12)	0.240	Pearson Chi-square 1.382
Pregnancy inducted hypertension disease	2 (4)	8 (6)	0.725	Fisher
Previous cesarean delivery	24 (44)	76 (60)	0.050	Pearson Chi-square 3.857
Placenta previa	36 (67)	108 (86)	0.003	Pearson Chi-square 8.571
Antepartum hemorrhage	21 (39)	36 (29)	0.173	Pearson Chi-square 1.860
Suspected antenatally	25 (46)	96 (76)	< 0.001	Pearson Chi-square 15.331

Data are mean ± standard deviation, median (quartile 1, quartile 3), or n (%) unless otherwise specified

Table 3 Delivery outcomes in patients with placenta accreta, grouped according to whether performed urgent cesarean delivery

	Urgent delivery ($n=54$)	Planned delivery ($n=126$)	p	
Gestational age at delivery (week)	36.7 ± 2.4	36.7 ± 1.9	0.985	$t=-0.19$
Median estimated blood loss (ml)	1000 (400,2125)	830 (400,2000)	0.512	$Z=0.656$
hysterectomy	4 (7)	9 (7)	> 0.999	Fisher
In situ hysterectomy	1 (2)	4 (3)	> 0.999	Fisher
Admission to ITU/HDU	13 (24)	26 (21)	0.608	Pearson Chi-square 0.263

Data are mean ± standard deviation, median (quartile 1, quartile 3), or n(%) unless otherwise specified

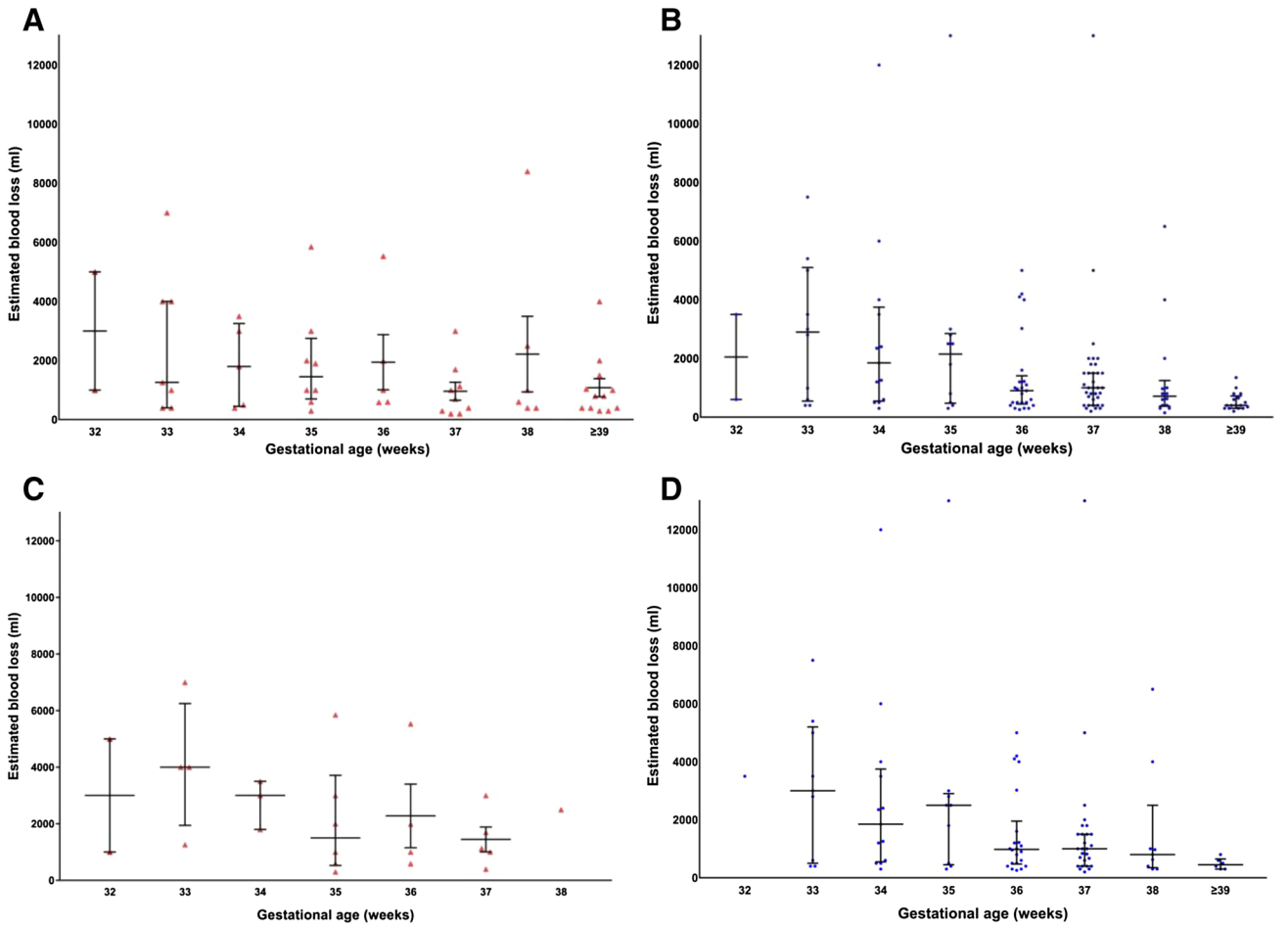
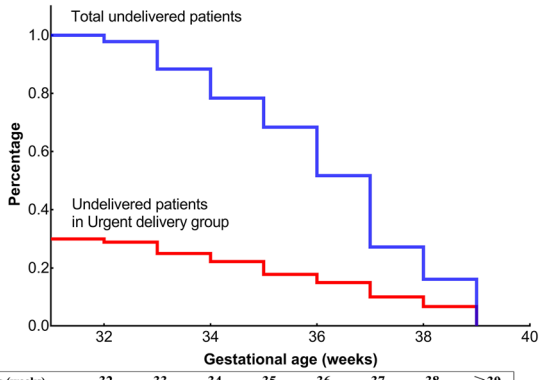


Fig. 2 Estimated blood loss (EBL) of patients. **a** EBL of patients with PAS of emergent delivery group in total. **b** EBL of patients with PAS of elective delivery group in total. **c** EBL of patients with PAS of emergent delivery group in antenatally suspected. **d** EBL of patients with PAS of elective delivery group in antenatal suspected placenta accreta

1450 ml/2150 ml, 1000 ml/900 ml, 700 ml/1000 ml, 800 ml/715 ml, and 800 ml/400 ml, respectively.

Totally, 30% (54/180) patients experienced urgent delivery, and 21% (25/121) were suspected antepartum patients. Kaplan–Meier curve was performed to show the proportion of women who remained undelivered in all cases and in urgent delivered group in Fig. 3 by Kaplan–Meier curve. Of all, 88% (159/180) and 68% (123/180) of patients were delivered at or beyond 34 gw and 36 gw, respectively, in our cohort. The proportion of women who had urgent delivery with placenta accreta was 28% (45/159) at or beyond 34 gw, and 26% (32/123) at ≥ 36 gw.

Logistic regression analysis showed that antepartum hemorrhage increased the risk of urgent delivery [OR 2.54 (1.19, 5.44)] ($p = 0.016$), and placenta accreta with antepartum diagnosis decreased the risk [OR 0.21 (0.10, 0.43)] ($p < 0.001$).



Gestational age (weeks)	32	33	34	35	36	37	38	≥39
Total undelivered patients	180	176	159	141	123	93	49	29
Urgent undeliveryed patients	54	52	45	40	32	27	18	12

Fig. 3 Kaplan–Meier curve of patients with placenta accreta showing the percentage of undelivered number in all cases and in urgent delivery group weekly. 88% (159/180) and 68% (123/180) of patients were delivered at or beyond 34 gw and 36 gw, respectively. The proportion of women who had urgent delivery with placenta accreta is 28% (45/159) at or beyond 34 gw and 26% (32/123) at or more than 36 gw

Discussion

During the 2 year study period, patients with or without antepartum were diagnosed, and approximately 95% of patients with PAS did not undergo urgent delivery at ≥ 32 gw by weekly estimation. However, after 37 gw, the percentage of antepartum bleeding or labor necessitating urgent delivery was increased by more than 10%. The investigation of SMFM members showed that 90% specialists tend to deliver patients with placenta accreta at or beyond 36 gw when there were no other indications [15, 18]. With the experience of performing a scheduled delivery before 36–38 weeks, Rac and his colleagues [19] reported that 11% patients with placenta accreta due to bleeding underwent delivery at ≥ 36. Our data showed that the percentage of emergent delivery from 32 gw may help clinicians to estimate the occurrence of urgent delivery according to their gestational age. Moreover, this may also provide information on EBL of patients and assist the doctors to evaluate the emergency situations of patients.

We also found that the EBL was decreased with advancing gestational age in the urgent surgery group. About 3% of patients with placenta accreta in urgent delivery group experienced massive bleeding with 1800 ml of the median EBL at 34 gw, 6% with 1450 ml at 35 gw, and 4% with 1000 ml at 36 gw. Few authors reported that patients with PAS had early delivery in gw and had higher EBL, which are similar to ours [20]. Specifically, in urgent group, whether antepartum suspected or not, the episode of antepartum bleeding or suspected labor occurred earlier with more EBL or occurred later with less EBL. This would be an alarm signal of massive hemorrhage for urgent delivery at gestational age that is far away from the full-term period.

The maternal and neonatal outcomes are similar in both the groups in our study. The reason for this might be that the worse cases were already recognized by ultrasound scoring system and the pregnancy was terminated at early gestational age, avoiding the urgent delivery. In general, a scheduled delivery with a multidisciplinary team showed a better maternal and neonatal outcome when compared with an emergent delivery [10]. Urgent delivery of patients with PAS can lead to profuse hemorrhage [21] and difficulty in surgical procedure to control bleeding for many reasons, including the attempted placental separation without antepartum suspicion, the limited time for preparation, and the staffing arrangement in such an emergent condition. On the other hand, the planned delivery in the late preterm period could avoid the unscheduled surgery and decrease the neonatal morbidity. Similar outcome of maternal complications and EBL in both groups may be due to our experienced multiple disciplinary team. This recommends that patients with suspected PAS should be delivered in a center with suitable experience and expertise [22]. Delivery in such centers is associated with low rates of hemorrhage and other complications than with standard care [11].

As a rescue center, the patients with placenta accreta were referred from different provinces in the north, central, and east of China for several years. For a scheduled surgery, an antenatally preoperative checklist is used by all doctors who is on duty in our unit to remind about the severity and preparation of patient with placenta accreta. In addition, the anesthesiology team has special management protocol for patients with suspected placenta accreta. The use of an antenatal or preoperative checklist, team training, and simulation are advised, although the efficacy has not been proved [11]. Even the emergency surgery was also prepared as well as possibly tried to equally plan to a surgery with a professional team constituted by a senior obstetrician with more than 20 year experience, neonatologist, anesthesiologist, and experienced nurses. Meanwhile, the doctors from gynecologic surgery, gynecologic oncology, urology, transfusion medicine, ICU, interventional radiology, trauma, and vascular surgery should also be a standby for this.

The data from antepartum suspected placenta accreta patients showed that 25 cases (20%) underwent experienced urgent surgery of 121 patients and 30% of all 180 cases. Meller and colleagues reported that 33% patients with placenta accreta underwent an unscheduled delivery [23]. A lower percentage of urgent delivery in our unit may be due to the protocol of antepartum suspicious accreta according to "Ultrasound scoring system for placenta accreta" in Peking University Third Hospital. If the score was more than 10, it meant the most severe condition that required a planned delivery and we performed it around 34 gw, and this has also been recommend by Robinson [24]. As a result, the EBL of the scheduled delivery was increased by progression of gestational age and the probability of urgent delivery was decreased in total patients.

In Bowman's study [25], the unscheduled patients were delivered earlier (mean 32.3 vs 35.7 weeks, $p < 0.001$) and more likely have had vaginal bleeding (86.8% vs 35.9%, $p < 0.001$) and uterine activity (47.4% vs 2.6%, $p < 0.001$). In another study by Meller [26], the scheduled delivery was achieved in 67% (53/79), with a mean of 36.0 gw, and an unscheduled delivery occurred in 33% (26/79), with a mean of 30.9 gw. They also suggested that vaginal bleeding, vaginal bleeding with preterm premature rupture of membranes, preeclampsia, and macroscopic hematuria are the main reasons that contributed to unscheduled delivery. The occurrence of emergency operation in our study is similar to other, but the average gw are later. This may due to the application of our ultrasound score system and enough preparation for all the PAS patients. After the scoring for the patients, the

patients were handled individually. The operation of serious cases was scheduled earlier, while the less one may hold on until full term.

However, there were several limitations that should be noted in our study. First, this is a retrospective observational analysis with differences in baseline characteristics and severity of placenta accreta. For the same reason, there is lack of information about the details of antepartum bleeding, including the first time bleeding, the number of bleeding episodes, and the maximum volume of bleeding. Second, as a management and rescue center of placenta accreta and other obstetric complications, many severe patients were referred to our hospital from all around the country, and this may cause higher rate of placenta accreta in our unit. However, the timing of delivery of patients with PAS had already been established in our unit during this observational period, assisting clinicians to make the decision on the timing of delivery in each patient. Moreover, the pathological diagnosis was impossible in cases without a hysterectomy, and the diagnosis of some cases was based on only clinical findings during surgery, leading to the inclusion of some cases who did not have placenta accreta, especially patients with placental adhesion. Finally, although this study includes a relatively large number of cases of placenta accreta, the cases at each gw are still limited, making it not suitable for statistical analysis in some situations.

Considering about the risk of neonatal morbidity and mortality during the late preterm period, how to balance it against the chance of maternal complications due to massive hemorrhagic condition with expectant management in patients with placenta accreta is an important issue. There are two factors that need to be considered during the timing of delivery in patients with PAS. First, urgent delivery should be avoided, especially in patients with massive antepartum hemorrhage, intraperitoneal hemorrhage, and with inexperienced obstetric team. The clinicians could from our data suggest the probability of urgent delivery and change of EBL with pregnancy progression in PAS patients and create an individual delivery plan for each case. The second issue is how to distinguish the severity of PAS. The timing of delivery in patients with placenta accreta, which we tried to figure out by ultrasound [27, 28], should be diagnosed early, but may not be suitable for patients with mild placenta accreta.

In conclusion, the probability of urgent delivery of PAS is around 5% weekly from 33 to 36 gw, meaning that 95% of patients can experience a scheduled delivery. From our study, during the period of 32–40 gw, the occurrence of emergency operation in PAS was more frequent in patients with 37 gw or greater. The rate of emergency operation rises up to 10% after 37 gw, suggesting that the termination of pregnancy in patients with PAS should be conducted between 36 and 37 gw and is as close to term pregnancy as possible. Besides, for the serious cases, such as estimation of difficult surgery, blood loss is over 1000 ml, and the timing of termination could be arranged as early as appropriate. From our data, the incidence of emergency operation before 35 gestational weeks is below 5% and increases with the progression of pregnancy. With the risk of emergency operation and immature fetus into consideration, the advantage and disadvantage of termination before 35 gw in serious cases remain controversial. Prospective studies are further needed to confirm this, and the decision of timing to terminate pregnancy should be made more cautiously.

Author contributions Prof. YZ and Dr. YW design the study and wrote the manuscript. Dr. LZ and Dr. ZN collected the data, analysis the data, and wrote the manuscript. Dr. YC and Dr. AZ done the ultrasound and analyzed the data of this study. Prof. BM analyzed the data and wrote the manuscript.

Funding This work was fund by the National Key R&D program of China, 2016YFC1000404.

Compliance with ethical standards

Conflict of interest The authors declared that they have no conflicts of interest to this work.

References

1. Silver RM (2015) Abnormal placentation: placenta previa, vasa previa, and placenta accreta. Obstet Gynecol. 126(3):654–668
2. Silver RM, Branch DW (2018) Placenta accreta spectrum. N Engl J Med. 378(16):1529–1536
3. Read JA, Cotton DB, Miller FC (1980) Placenta accreta: changing clinical aspects and outcome. Obstet Gynecol 56:31–34
4. Miller DA, Chollet JA, Goodwin TM (1997) Clinical risk factors for placenta previa-placenta accreta. Am J Obstet Gynecol 177:210–214
5. Bailit JL, Grobman WA, Rice MM et al (2015) Morbidly adherent placenta treatments and outcomes. Obstet Gynecol 125:683–689
6. Wu S, Kocherginsky M, Hibbard JU (2005) Abnormal placentation: twenty-year analysis. Am J Obstet Gynecol 192:1458–1461
7. Zhongying D (2008) Nomenclature, incidence and etiology of invasive placenta. J Pract Obstetr Gynecol 12:705–707
8. Warshak CR, Ramos GA, Eskander R, Benirschke K, Saenz CC, Kelly TF et al (2010) Effect of predelivery diagnosis in 99 consecutive cases of placenta accreta. Obstet Gynecol 115:65–69
9. Briery CM, Rose CH, Hudson WT, Lutgendorf MA, Magann EF, Chauhan SP et al (2007) Planned vs emergent cesarean hysterectomy. Am J Obstet Gynecol 197(154):e1–5
10. Eller AG, Bennett MA, Sharshiner M et al (2011) Maternal morbidity in cases of placenta accreta managed by a multidisciplinary care team compared with standard obstetric care. Obstet Gynecol 117:331–337
11. Shamshirsaz AA, Fox KA, Salmanian B et al (2015) Maternal morbidity in patients with morbidly adherent placenta treated with and without a standardized multidisciplinary approach. Am J Obstet Gynecol 212(2):218.e1–9

12. Placenta accreta. Committee Opinion No. 529 (2012) American College of Obstetricians and Gynecologists. Obstet Gynecol 120:207–211.
13. Committee Publications (2010) Society for Maternal-Fetal Medicine, Belfort MA. Placenta accreta. Am J Obstet Gynecol 203:430–439
14. Wright JD, Silver RM, Bonanno C, Gaddipati S, Lu YS, Simpson LL et al (2013) Practice patterns and knowledge of obstetricians and gynecologists regarding placenta accreta. J Matern Fetal Neonatal Med 26:1602–1609
15. Esakoff TF, Handler SJ, Granados JM, Caughey AB (2012) PAMUS: placenta accreta management across the United States. J Matern Fetal Neonatal Med 25:761–765
16. Gielchinsky Y, Rojansky N, Fasouliotis SJ, Ezra Y (2002) Placenta accreta–summary of 10 years: a survey of 310 cases. Placenta 23(2–3):210–214
17. Warshak CR, Eskander R, Hull AD, Scioscia AL, Mattrey RF, Benirschke K et al (2006) Accuracy of ultrasonography and magnetic resonance imaging in the diagnosis of placenta accreta. Obstet Gynecol 108:573–581
18. Jolley JA, Nageotte MP, Wing DA, Shrivastava VK (2012) Management of placenta accreta: a survey of Maternal-Fetal Medicine practitioners. J Matern Fetal Neonatal Med 25:756–760
19. Rac MW, Wells CE, Twickler DM, Moschos E, McIntire DD, Dashe JS (2015) Placenta accreta and vaginal bleeding according to gestational age at delivery. Obstet Gynecol. 125(4):808–813
20. Wright JD, Pri-Paz S, Herzog TJ, Shah M, Bonanno C, Lewin SN et al (2011) Predictors of massive blood loss in women with placenta accreta. Am J Obstet Gynecol 205(38):e1–6
21. Wright JD, Herzog TJ, Shah M et al (2010) Regionalization of care for obstetric hemorrhage and its effect on maternal mortality. Obstet Gynecol 115:1194–1200
22. Silver RM, Fox KA, Barton JR et al (2015) Center of excellence for placenta accreta. Am J Obstet Gynecol 212:561–568
23. Meller CH, Izbizky GH, Otaño L (2014) Timing of delivery in placenta accreta. Am J Obstet Gynecol. 211(4):438–439
24. Robinson BK, Grobman WA (2010) Effectiveness of timing strategies for delivery of individuals with placenta previa and accreta. Obstet Gynecol. 116(4):835–842
25. Bowman ZS, Manuck TA, Eller AG, Simons M, Silver RM (2014) Risk factors for unscheduled delivery in patients with placenta accreta. Am J Obstet Gynecol 210(241):e1–6
26. Meller CH, Izbizky GH, Otaño L (2014) Timing of delivery in placenta accrete. Am J Obstet Gynecol
27. Chong Y, Zhang A, Wang Y, Liu Z, Chen Y, Zhao Y (2016) Value of ultrasonic scoring system for predicting risks of placenta accreta. Zhonghua wei chan yi xue za zhi. 19(9):705–709
28. Wang Y, Gao Y, Zhao Y, Chong Y, Chen Y (2018) Ultrasonographic diagnosis of severe placental invasion. J Obstet Gynaecol Res. 44(3):448–455