Received: 25 January 2024 | Revised: 30 June 2024 | Accepted: 10 July 2024

DOI: 10.1111/aogs.14931

AOGS Acta Obstetricia et Gynecologica Scandinavica

ORIGINAL RESEARCH

Emergency delivery in case of suspected placenta accreta spectrum: Can it be predicted?

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Abstract

Introduction: The main goal of placenta accreta spectrum (PAS) screening is to enable delivery in an expert center in the presence of an experienced team at an appropriate time. Our study aimed to identify independent risk factors for emergency deliveries within the IS-PAS 2.0 database cohort and establish a multivariate predictive model.

Material and Methods: A retrospective analysis of prospectively collected PAS cases from the IS-PAS database between January 2020 and June 2022 by 23 international expert centers was performed. All PAS cases (singleton and multiple pregnancies) managed according to local protocols were included. Individuals with emergent delivery were identified and compared to those with scheduled delivery. A multivariate analysis was conducted to identify the possible risk factors for emergency delivery and was used to establish a predictive model. Maternal outcomes were compared.

Results: Overall, 315 women were included in the study. Of these, 182 participants (89 with emergent and 93 with scheduled delivery) were included in the final analysis after exclusion of those with unsuspected PAS antenatally or who lacked information about the urgency of delivery. Gestational age at delivery was higher in the scheduled group (34.7 vs. 32.9, $p<0.001$). Antenatal bleeding (OR 2.9, $p=0.02$) and a placenta located over a uterine scar (OR 0.38, $p=0.001$) were the independent predictive factors for emergent delivery (AUC 0.68). Ultrasound (US) markers: loss of clear zone ($p=0.001$), placental lacunae ($p=0.01$), placental bulge ($p=0.02$), and presence of bridging vessels ($p=0.02$) were more frequently documented in the scheduled group. None of these markers improved the predictive values of the model. Higher PAS grades were identified in the scheduled group ($p=0.01$). There were no significant differences in maternal outcomes.

Abbreviations: CD, cesarean delivery; IS-PAS, International Society for Placenta Accreta Spectrum; MRI, magnetic resonance imaging; PAS, placenta accreta spectrum; US, ultrasound.

*International Society for Placenta Accreta Spectrum (IS-PAS) Group collaborators are in Appendix A.

Conclusions: Antenatal bleeding and the placental location away from the uterine scar remained the most significant predictors for emergent delivery among patients with PAS, even when combining more predictive risk factors, including US markers. Based on these results, patients who bleed antenatally may benefit from transfer to an expert center, as we found no differences in maternal outcomes between groups delivered in expert centers. Earlier-scheduled delivery is not supported due to the low predictive value of our model.

KEYWORDS
antenatal bleeding, cesarean section, placenta accreta spectrum, predictive model, US markers

1 | INTRODUCTION

Placenta accreta spectrum (PAS) is one of the leading causes of severe maternal morbidity, maternal mortality, and peripartum hysterectomy worldwide.[1,2]

The incidence of this diagnosis has increased in recent years, mainly due to the increasing number of cesarean sections, which lead to surgical damage to the uterine wall and, together with the presence of placenta previa, are the most significant risk factors for PAS.[1–4] All pregnant women presenting with risk factors benefit from an ultrasound (US) screening.[4–6] PAS descriptors have been previously described by our group.[5,6] Despite routine screening and detection of up to 80% of PAS cases when patients are screened at experienced centers, the establishment of a precise diagnosis antenatally and of the risk for emergent delivery remains challenging.[6]

No international consensus exists about a singular, optimal management of pregnancies with PAS.[7] Whatever the surgical strategy, a prelabor, scheduled cesarean delivery in an expert center is associated with lower blood loss, shorter operative time, and fewer intensive care unit admissions than an emergency delivery.[8,9] Ideal delivery timing in patients with PAS disorders remains controversial. Scheduled delivery is recommended at 34–37 weeks of gestation.[7,8] According to the Royal College of Obstetrics and Gynecology (RCOG), in the absence of risk factors, planned delivery at 35 + 0 to 36 + 6 weeks gestation may provide the best balance between fetal maturity and the risk of unscheduled delivery.[7] In recent guidelines, the International Society for Placenta Accreta Spectrum (IS-PAS) recommended scheduled delivery without risk factors at 36 weeks and for women at risk (risk of premature labor, vaginal bleeding during pregnancy) at 34 weeks.[8]

Iatrogenic prematurity for suspected PAS is only justified by the need to avoid bleeding, rupture, or other causes of emergent cesarean delivery. Identifying patients at risk of emergent delivery meets two objectives: keeping patients at the highest risk for early delivery close to an expert center and timing delivery appropriately while avoiding iatrogenic premature delivery for others. Among patients with PAS disorders, those who present with prenatal bleeding and preterm premature rupture of membranes are more frequently delivered emergently or ahead of schedule. Morlando et al.[9] demonstrated in the previous version of the IS-PAS database from 2018 to 2020[10] that antenatal bleeding was the only independent predictor of emergent delivery (aOR: 4.3). Similar results were also reported in other studies.[11–14] However, the predictive value of this single risk factor is low.

Key message

In our multivariate predictive model of emergent cesarean section among women with PAS, antenatal bleeding remains the strongest predictor, followed by placental location away from the presumed uterine scar. The predictive value of the model is low.

The IS-PAS database 2.0 was developed to improve the quality of data recording by participating centers[10] following analysis of data and publication of results using the original version of the database. The current FIGO classification[15] and more precise descriptions of US and MRI markers were added to the database. Changes to the database included moving from retrospective to prospective data collection and refinement of data collected based on discussion and feedback by the IS-PAS participating centers.

In this study, we aimed to identify independent risk factors for emergency deliveries within this new cohort using IS-PAS 2.0 and establish a multivariate predictive model.

The primary aim of our study was to identify independent risk factors for emergent deliveries within the IS-PAS 2.0 database and establish a multivariate predictive model using maternal, pregnancy, US, and MRI characteristics. The secondary aim was to determine whether emergent deliveries are associated with adverse maternal outcomes.

2 | MATERIAL AND METHODS

2.1 | Patient recruitment

This retrospective cohort study was conducted using the IS-PAS database 2.0. Between January 2020 and June 2022, 23 centers prospectively included data on PAS cases in the IS-PAS database.

Overall, 315 patients with suspected and/or pathologically proven PAS were included in the database. Data were collected via chart review using a standardized, secured, and password-protected online data collection platform (FetView, Zeitgeist Health SE).[10] Prenatal detection of PAS was made according to local guidelines in each center. The severity of PAS was classified at the delivery according to the FIGO clinical classification.[15]

2.2 | Selection criteria

The inclusion criteria were antenatal suspicion of PAS, age > 18, and underwent transabdominal/ transvaginal ultrasound or MRI assessment at least in the third trimester. Individuals with antenatal suspicion of PAS were categorized into two groups based on our primary outcome: scheduled vs. emergent delivery. The delivery was defined as scheduled when it was performed on the planned date and time and as emergent when performed for maternal or fetal compromise occurring at any time before the scheduled date. Secondarily, within the emergency group, we also aimed to identify the "crash" or "stat" cases for which women faced immediate life-threatening deterioration and to identify clinical and imaging factors that predict the risk of emergent delivery. Exclusion criteria were PAS unsuspected before delivery (57 cases were excluded), pregnancy outcome other than cesarean delivery (CD) (spontaneous vaginal delivery, miscarriage, spontaneous abortion or intrauterine fetal demise <22 gestational week, and termination of pregnancy), and missing or unprecise information regarding the delivery acuity (scheduled or emergent) (another 76 cases were excluded) (Table 1).

2.3 | Statistical analyses

The following potential predictors for emergency delivery were collected: demographic data, clinical history, pregnancy comorbidities and complications, and placental location. Antenatal imaging descriptors (ultrasound and MRI) and FIGO clinical grade at delivery were also recorded (Table 2).

In univariate analysis, maternal characteristics were described and compared by sub-groups of scheduled, emergency, or "crash" delivery. A chi-squared test (with continuity correction) was performed for categorical variables, and the Mann–Whitney *U* or *t*-test was used for numerical variables as appropriate ($p < 0.05$ = significance). Univariate/multiple logistic regression models were fitted independently to estimate a probability of (i) emergency CD (vs. scheduled CD) and (ii) antenatal bleeding ("yes, bleeding" vs. "no bleeding") based on independent variables or a combination of independent variables. "Antenatal bleeding" was defined as bleeding occurring at any moment during the ongoing pregnancy but not warranting immediate emergent delivery.

All statistically significant variables from the univariate and multiple logistic models were used as inputs for final predictive modeling using a penalized logistic (lasso) regression, which was fitted by the penalized maximum likelihood with 10-fold cross-validation. The reported effect size (R^2) is Nagelkerke's pseudo-R squared that assesses the fit quality (the higher, the better).

All statistical tests were run with a two-tailed alternative hypothesis and with type statistical significance (type I error) at $p < 0.05\%$. All computations were performed in system R (https://www.r-project.org, version 4.3.1 (2023-06-16)). To obtain the penalized logistic regression model fit, the package glmnet was used.[16]

3 | RESULTS

From the 315 cases in the IS-PAS database, 57 patients were excluded in whom PAS was not suspected before the delivery. Another 76 patients who had vaginal delivery or who lacked precise information about the acuity of cesarean delivery (scheduled or emergent). In total, 182 women were included and grouped by delivery

TABLE 1 Flowchart—attrition table.

Total number of patients in the database	315
Antenatally suspected PAS	258
Only cesarean deliveries (CD) with a known grade of urgency	182
Only cesarean deliveries (CD) with a known grade of urgency	Emergency CD = 89, of which: • An immediate threat to the life of a woman or fetus ("crash/stat") = 15 • Maternal or fetal compromise which is not immediately life-threatening = 27 • Needing early delivery but no maternal or fetal compromise = 47 Scheduled CD = 93, of: • At a time to suit the woman and maternity team (elective) = 93 Missing = 76

Note: Provides insights into the threat to the internal validity of selection bias.

TABLE 2 Demographic, clinical, and pregnancy characteristics of women with placenta accreta spectrum disorder (PAS).

Characteristic	Overall ($n=182$)	Scheduled ($n=93$)	Emergency ($n=89$)	p-value	Crash CD ($n=15$)
Maternal characteristic					
Age[1]	34.6 (5.3)	35.2 (5.0)	34.0 (5.5)	0.17	32.1 (4.7)
BMI (kg/m^2)[2]	27.3 [23.3–32.7]	26.2 [22.3–31.2]	28.4 [24.3–33.3]	0.56	31.4 [26.7–33.5]
Previous pregnancies[2]	3 [2, 4]	3 [2, 4]	3 [2, 5]	0.25	2 [1, 4]
Previous deliveries[2]	2 [1, 3]	2 [1, 3]	2 [1, 3]	0.88	1 [0.5, 3.5]
Previous CD[2]	2 [1, 2]	2 [1, 2]	2 [1, 3]	0.24	1 [1, 2]
Self-reported Ethnicity[3]				**0.02**	
Caucasian[3]	123 (76.4)	69 (87.3)	54 (65.9)		8 (57.1)
Asian[3]	14 (7.7)	4 (4.3)	10 (11.2)		0 (0.0)
African[3]	11 (6.8)	4 (5.1)	7 (8.5)		3 (21.4)
Mixed[3]	13 (8.1)	2 (2.5)	11 (13.4)		3 (21.4)
Pregnancy complications					
Antenatal vaginal bleeding[3]	69 (39.2)	23 (25.8)	46 (52.9)	**<0.001**	12 (85.7)
Pregnancy complications (°)[3]	177 (98.9)	26 (28.0)	40 (44.9)	**0.03**	9 (60.0)
GA at delivery (weeks)[2]	34 [33, 35]	35 [34, 36]	34 [32, 35]	**<0.001**	33 [28, 34]
Presence of Ultrasound Signs[3]					
Anterior placenta[3]	146 (80.2)	75 (80.6)	71 (79.8)	1	11 (73.3)
Posterior placenta[3]	33 (18.1)	11 (11.8)	22 (24.7)	**0.039**	4 (26.7)
Placenta over the uterine scar[3]	136 (74.7)	80 (86.0)	56 (62.9)	**0.001**	5 (33.3)
Placenta Previa (PP)[3]	149 (87.6)	78 (88.6)	71 (86.6)	0.863	11 (78.6)
Loss of "clear zone"[3]	58 (46.1)	39 (61.9)	19 (30.2)	**0.001**	2 (15.4)
Myometrial thinning[3]	70 (51.5)	43 (57.3)	27 (44.3)	0.141	3 (21.4)
Abnormal placenta lacunae[3]	56 (39.7)	39 (50.6)	17 (26.6)	**0.008**	2 (15.4)
Placental bulge[3]	34 (25.8)	20 (28.2)	14 (23.0)	**0.019**	1 (9.1)
Bridging vessels[3]	36 (33.0)	26 (41.9)	10 (21.3)	**0.016**	1 (12.5)
Presence of MRI signs[3]					
Abnormal vascularization of the placental bed[3]	11 (23.4)	7 (35.0)	4 (14.8)	**0.029**	0 (0.0)
PAS grade (FIGO)	$N=177$	$N=92$	$N=85$	**0.012**	
1	22 (12.4)	5 (5.4)	17 (20.0)		2 (14.2)
2	51 (28.8)	27 (29.4)	24 (28.2)		6 (42.9)
3A,3B, or 3C	104 (58.8)	60 (65.2)	44 (51.8)		6 (42.9)

Note: The investigated variables are described overall, separately for the scheduled, emergency and crash CD groups, and the scheduled and emergency groups were statistically compared. Numerical variables are reported as [1]mean (standard deviation-SD) or [2] median [lower quartile-p25, upper quartile-p75]. Categorical variables are reported as frequency [3]n (%). The bold emphasized variables show statistically significant (at a 5% significance level) differences in proportion between groups.° Complications of the pregnancy: Previable preterm rupture of membranes, hypertension, preeclampsia, gestational diabetes, placental abruption, ruptured uterus, thromboembolism, cerclage.

timing: scheduled ($n=93$) and emergent ($n=89$) for the final analysis (Table 1).

Maternal, pregnancy, and imaging characteristics of both groups are reported in Table 2. The placenta was located over the uterine scar area in 80/93 (86%) cases of scheduled cesarean section, compared to 56/89 (62.9%) cases of emergent delivery, $p=0.001$. The posterior placenta was reported in 11 of the 93 (11.8%) patients who underwent scheduled CD, compared to 22 of the 89 (24.7%) who delivered emergently ($p=0.04$). The mean gestational age at delivery was significantly lower in the emergent group (scheduled = 34.7 +/− SD1.9 weeks vs. emergent = 32.9 +/− SD 3.2, $p<0.001$). The mean gestational age for patients who required "crash" or "stat" cesarean due to acute maternal decompensation was 31.5 +/− SD 4.4 gestational weeks.

Scheduled deliveries were more commonly associated with the most severe PAS grade (FIGO grade 3), 60/92 (65.2%); conversely, in 41/85 (48.2%) of emergent deliveries, the severity of PAS identified at delivery more commonly included milder grades (FIGO grades 1 and 2, $p=0.01$).

Antenatal bleeding, defined as any bleeding prior to delivery, regardless of severity, occurred in a total of 69 individuals (69/182, 38%), of whom 23/93 (25.8%) in the scheduled

delivery group vs. 46/89 (52.9%) in the emergent delivery group ($p < 0.001$).

Hemorrhage deemed by the local team to be sufficient to cause maternal deterioration or shock and to require "crash/stat" delivery occurred in 13/69 (18.8%) of those who had antenatal bleeding. In comparison, emergent delivery due to hemorrhage occurred in only 2/107 (1.9%) of women who did not experience any bleeding during the antenatal period ($p < 0.001$, Table 4).

Regarding US characteristics, the presence of placental lacunae, placental bulge, presence of bridging vessels, loss of the clear zone, and location of the placenta in proximity to or over a uterine scar were more common in the scheduled group. For MRI markers, only abnormal vascularization of the placental bed was statistically significant and was more common in the scheduled group compared to the emergent group (Table 2).

Univariate logistic regression estimated a probability of emergent CD (vs. scheduled CD) based on given independent variables. Significant variables were posterior placenta ($p = 0.003$), placenta located over a uterine scar ($p = 0.001$), vaginal bleeding prior to delivery ($p = 0.0003$), pregnancy complications (0.02), placental bulge on US ($p = 0.007$), presence of bridging vessels on US ($p = 0.08$), and abnormal vascularization of the placental bed on MRI ($p = 0.04$).

Multivariate modeling aimed to identify the best combination of all statistically significant parameters from the univariate models. Independent predictors for emergency delivery were then vaginal bleeding prior to delivery (OR 2.9, 95% CI 1.5–5.7, $p = 0.02$) and the placenta located not over a uterine scar area (placenta over the scar OR 0.38, 95% CI 0.2–0.8, $p = 0.001$) with AUC 0.68 (sensitivity 71%, specificity 65%). The model showed poor predictive accuracy in identifying women with emergent CD (Table 3; Figure 1).

No significant association was found between groups in perioperative maternal outcomes with regard to estimated blood loss, the number of blood units transfused, or the incidence of severe maternal morbidity (Table 5).

4 | DISCUSSION

We report in this cohort study the risk factors and maternal outcomes in emergent and scheduled deliveries in pregnancies with placenta accreta spectrum. Of the 182 patients, the number of women in the scheduled and emergent groups was distributed almost equally.

The principal finding of our study is that antenatal bleeding was the most significant predictor for emergent delivery, with a 2.9-fold (95% CI 1.51–5.69) higher risk. Placental location appeared to be another important parameter in the predictive model. If the placenta was placed over the cesarean scar, the risk of emergent delivery was lower (0.4-fold, 95% CI 0.17–0.82). Neither known risk factors (maternal characteristics and pregnancy complications) nor ultrasound/MRI markers improved the predictive value of the model, which overall was low. Finally, we found that emergent intervention was not associated with a higher occurrence of maternal complications after delivery. Interestingly, US/MRI markers and the final grade of PAS were more severe in the scheduled group than in the emergent group.

We confirmed the results from the previous IS-PAS database published in 2021, which showed that antenatal bleeding was the only independent predictor of emergency delivery, with an OR of 4.3.[9] This study's findings are generally in line with those reported by a recently published retrospective study by Thang MN et al. involving 255 patients, where the risk of emergency delivery was higher in the case of antenatal bleeding (OR 2.86)[11] and also with the other recent studies.[12–14] We found only one previous study, with a small sample size, in which no significant correlation was found between bleeding before 32 gestational weeks and emergency delivery (only multiple episodes of bleeding increased the risk of emergency delivery).[17] Consistent with previous results by Morlando et al.,[9] we did not find an association between the gestational age of the episode of prenatal bleeding and the later need for emergency delivery.

Antenatal bleeding remained the most significant predictor even when combining more than 40 candidate predictive risk factors, including US and MRI PAS markers. The only other novel potential predictor was the localization of the placenta, especially in relation to the previous cesarean scar. Most (>90%) of the placentas were positioned anteriorly and/or laterally. In 74.7% of the cases, the placenta was located over the uterine scar, and this condition was significantly correlated with scheduled deliveries. In contrast, a posterior placenta located some distance from the scar was significantly associated with emergent delivery. Furthermore, in our study, milder PAS grades (FIGO stage 1 or 2) were also significantly correlated with emergent delivery ($p = 0.012$). These results are in concordance with previous observations by Morlando et al.,[9] and a recent study with 255 patients reached the same results (the planned delivery group demonstrated a higher rate of placenta increta, compared to the emergent groups, 59.2% vs. 32.2%, $p = 0.043$).[11] Therefore, it can

TABLE 3 Univariate and multivariate logistic regression analysis predicting emergent delivery.

	Univariate		Multivariate	
Characteristic	**OR (95% CI)**	***p*-value**	**OR (95% CI)**	***p*-value**
The posterior location of the placenta	4.78 (1.82–14.99)	**0.003**	2.69 (0.93–8.98)	0.08
The placenta located over a uterine scar	0.28 (0.13–0.56)	**0.001**	0.38 (0.17–0.82)	**0.02**
Antenatal vaginal bleeding	3.22 (1.72–6.15)	**0.0003**	2.91 (1.51–5.69)	**0.001**

Note: OR—Odds ratio, 95% LCI OR is the lower 95% confidence limit of OR, 95% UCI is the upper 95% confidence limit of OR. The bold emphasized variables show statistically significant (at a 5% significance level) differences in proportion between groups.

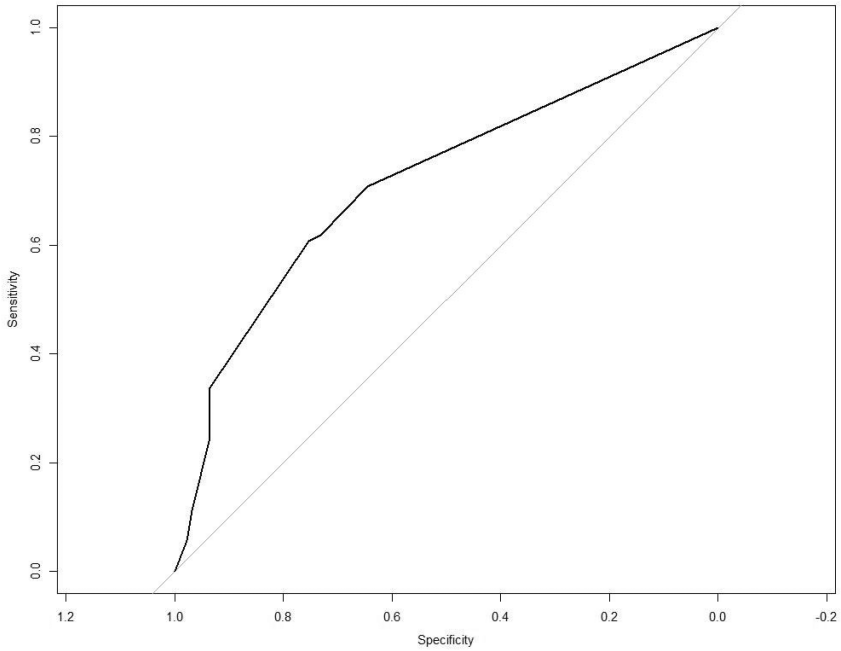

FIGURE 1 Predictive ability of the multivariate model.

Predictive value		Sensitivity	Specificity	Accuracy
positive %	negative %			
66 %	70 %	71 %	65 %	67.6 %

TABLE 4 Comparison of patients with and without antenatal vaginal bleeding.

Characteristic	Overall $N = 176$	Without bleeding $N = 107$	With bleeding $N = 69$	p-value
Suspected PAS as an indication of CD	119 (67.6)	86 (80.4)	33 (47.8)	**<0.001**
Severe vaginal bleeding as an indication of CD	15 (8.5)	2 (1.9)	13 (18.8)	**<0.001**
Gestational age at delivery (weeks)	33.78 (2.79)	34.48 (2.32)	32.71 (3.12)	**<0.001**

Note: The bold emphasized variables show statistically significant (at a 5% significance level) differences in proportion between groups.

be hypothesized that less severe PAS cases (FIGO 1 and 2) and placentas implanted away from the area of significant uterine scarring are at higher risk of partial separation and bleeding during the antenatal period, with a subsequent higher risk of emergency delivery.[18]

Prenatal diagnosis of PAS is crucial to improving perinatal outcomes, as it allows the planning of the most appropriate management. Specific ultrasound and MRI markers are described for screening and characterizing the severity of PAS.[5–7,19,20] In our study, we tried to improve the ability to predict emergency deliveries using US and MRI markers. The following were significantly less often observed in the emergency deliveries: loss of clear zone, placental lacunae, placental bulge, bridging vessels for US markers, and abnormal vascularization of the placental bed for MRI. None of these markers could improve the predictive value of the model. Our observation remained correlated with a lower PAS grade final diagnosis, which was consistent with the hypothesis of prenatal bleeding condition.

Our results revealed that the scheduled delivery group had a significantly higher gestational age at birth (34.7 ± 1.9 vs. 32.9 ± 3.2, $p < 0.001$, "crash/stat" 31.5 ± SD 4.5) than the emergent group. In a Canadian study, gestational age at birth was also lower in the emergency group (31.55 [4.75] vs. 35.19 [2.77], $p = 0.001$).[21] Similar findings were shown in a Vietnamese study (emergency group gestational age 35.1 ± 0.27 vs. scheduled group gestational age 38.0 ± 0.10 $p < 0.001$).[11]

Considering that PAS US/MRI markers and final FIGO grades were milder in the emergent group in our study, it could be hypothesized that physicians could have scheduled delivery for the most severe cases at later gestational ages within the ranges included in most guidelines. Our results showed that emergent deliveries occurred very early in pregnancy and most often before the earliest gestational ages advocated in the various guidelines, highlighting the need for caution and surveillance throughout pregnancy, even when placentation appears less severe.

According to several studies, a scheduled delivery is associated with lower blood loss, shorter operative time, and fewer intensive care unit admissions compared with emergent delivery. The principal finding of the Canadian study[21] was that patients with PAS disorders and emergent CD, even those managed in an expert center

TABLE 5 Maternal outcomes and major morbidity.

Characteristic	Overall ($n=182$)	Scheduled ($n=93$)	Emergency ($n=89$)	p-value
Estimated blood loss[2]	2000 [1421, 3242]	2000[1400, 3000]	2000 [1485, 3500]	0.46
Blood units transfused[2]	2 [0, 4]	2 [0, 4]	2 [0, 4]	0.94
ICU admission[3]	92 (50.8)	41 (44.1)	51 (58.0)	0.09
Bowel damage[3]	1 (0.5)	0 (0.0)	1 (1.1)	0.98
Urinary tract damage[3]	33 (18.1)	17 (18.3)	16 (18.0)	1.00
Vesicovaginal fistula[3]	4 (2.2)	3 (3.2)	1 (1.1)	0.65
Thrombotic event[3]	4 (2.2)	1 (1.1)	3 (3.4)	0.58
Cardiac arrest[3]	0 (0.0)	0 (0.0)	0 (0.0)	NaN
Cerebrovascular accident[3]	1 (0.5)	0 (0.0)	1 (1.1)	0.98
Pulmonary edema[3]	1 (0.5)	1 (1.1)	0 (0.0)	1.00
Renal failure[3]	4 (2.2)	2 (2.2)	2 (2.2)	1.00
Sepsis[3]	2 (1.1)	0 (0.0)	2 (2.2)	0.46
Ventilation required[3]	5 (2.7)	1 (1.1)	4 (4.5)	0.34
Maternal mortality[3]	1 (0.5)	0 (0.0)	1 (1.1)	0.98
Cesarean hysterectomy[3]	126 (69.2)	64 (68.8)	62 (69.7)	1.00

Note: Numerical variables are reported as [1]mean (standard deviation-SD) or [2] median [lower quartile-p25, upper quartile-p75]. Categorical variables are reported as frequency [3]*n* (%). NAN, Not available for statistical analysis.

by a multidisciplinary team, had increased maternal morbidity and worse perinatal outcomes than those with scheduled delivery. In contrast, as in the previous IS-PAS study,[9] we reported no difference between emergency and elective deliveries regarding blood loss, transfusion rates, or significant maternal morbidity. The authors of the Canadian study argued that in the IS-PAS database, emergent births were associated with a lower PAS grade (however, these were only cesarean sections for the indication of acute bleeding). In contrast, there were pathologically confirmed severe PAS cases diagnosed in their cohort; however, individual PAS grades were not listed. In our study, we did not evaluate the neonatal outcomes. Still, according to the previous study by Morlando et al., the most relevant factor affecting neonatal outcomes in women with PAS was gestational age at delivery. That means that maternal advantages expected from avoiding emergent delivery by scheduling delivery in the early or late-preterm period must be weighed against the neonatal risks of iatrogenic prematurity. Our data demonstrate that women with a history of antenatal bleeding have an increased risk of emergent birth across all gestational ages. Still, our model's predictive value remains low, with a high risk of false-positive prenatal prediction.

Whenever possible, our data support scheduling delivery between 34 and 36 weeks, with early patient relocation nearby or admission to a PAS referral center, rather than routinely scheduling all patients with risk for preterm before 34 weeks. Centers must be able to deliver emergently, should heavy bleeding or maternal-fetal deterioration occur; therefore, individualization of care based on patient characteristics, access to the referral center and team resources may still be required and may drive delivery timing.

Our study is a large international multicenter cohort study assessing maternal/pregnancy characteristics and the performance of antenatal imaging in predicting emergency delivery. The main strengths of the study are its multicenter nature and the use of a standardized approach to collecting and evaluating ultrasound markers. The data reported there are of high quality and reliability with high external validity. Furthermore, in addition to exploring the associations of maternal, pregnancy, and US characteristics with emergency CD, we also compared the maternal outcomes in emergency and scheduled delivery.

The limitations of this study are that we included only patients from referral centers of expertise, and retrospective analysis was done from an international IS-PAS database. Therefore, there may be some bias in the accuracy and interpretation of PAS severity and obstetrical management in each center. The lack of some essential data also led to exclude 78 patients.

5 | CONCLUSION

Our study revealed that antenatal bleeding and the location of the placenta remote from the uterine scar are independent risk factors for emergent delivery among patients with PAS disorders. There appears to be little benefit of a predictive model for emergency CD in PAS. An individualized approach (and the immediate proximity of an expert center) in patients with suspected PAS and antenatal bleeding is essential. Cesarean delivery should not be scheduled earlier in pregnancy due to antenatal bleeding alone because of the low predictive value of these risk factors. Emergent deliveries were

not associated with severe adverse maternal outcomes, likely because cases were treated in expert centers with around-the-clock support.

AUTHOR CONTRIBUTIONS

Petra Hanulikova: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, visualization, writing—original draft. Egle Savukyne, Mina Mhallem, Heleen J. van Beekhuizen, Vedran Stefanovic, Karin A. Fox, Charline Bertholdt, and Thorsten Braun: Resources, validation, writing—review and editing. Lukas Sobisek: Conceptualization, data curation, formal analysis, investigation, methodology, resources, validation, writing—review and editing. Olivier Morel: Conceptualization, methodology, project administration, supervision. All IS-PAS Group collaborators contributed by filling the forms with own cases, giving suggestions during preparation of manuscript and approved the final version.

ACKNOWLEDGMENTS

I am thankful to Prof. Krofta and Prof. Feyereisl, who led me to the issue of placenta accreta spectrum. Thanks also go to the entire team and our patients, for whom we always try to improve our care. The graphical abstract has been designed using images from Flaticon.com.

CONFLICT OF INTEREST STATEMENT

None.

ETHICS STATEMENT

All participating IS-PAS centers were responsible for contributing to clinical and scientific research under local IRB/ethics committee approval and operated under Data Use Agreements between individual centers and the IS-PAS. Details of these have been published previously.[10]

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How to cite this article: Hanulikova P, Savukyne E, Fox KA, et al. Emergency delivery in case of suspected placenta accreta spectrum: Can it be predicted? *Acta Obstet Gynecol Scand*. 2024;00:1-9. doi:10.1111/aogs.14931

APPENDIX A

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