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ANTENATAL ULTRASOUND PREDICTORS OF HEMORRHAGE, ANESTHETIC COMPLICATIONS, AND MATERNAL OUTCOMES DURING CESAREAN DELIVERY FOR PLACENTA PREVIA: A PROSPECTIVE COHORT STUDY

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ABSTRACT

Background: Placenta previa is associated with substantial perioperative hemorrhage, anesthetic complications, and maternal morbidity during cesarean delivery. Antenatal ultrasonography provides important information regarding placental morphology, cervical anatomy, and abnormal vascularity, potentially facilitating preoperative risk stratification and multidisciplinary management.

Objective: To evaluate the associations of antenatal ultrasound markers with severe perioperative hemorrhage, anesthetic complications, and maternal outcomes among women undergoing cesarean delivery for placenta previa.

Methods: This prospective, two-center cohort study included 100 women undergoing cesarean delivery for placenta previa between January 2025 and February 2026 at Sandeman Provincial Hospital, Quetta, and Lahore General Hospital, Lahore, Pakistan. Antenatal ultrasound assessment included cervical length, placental location and overlap, abnormal placental lacunae, loss of the retroplacental clear zone, and bridging vessels. Severe perioperative hemorrhage was defined as cumulative blood loss ≥1,500 mL during cesarean delivery and within 24 hours postpartum. Associations were evaluated using comparative statistical analyses and multivariable logistic regression.

Results: Severe perioperative hemorrhage occurred in 32 women (32.0%), while 25 (25.0%) experienced clinically significant anesthetic complications. Cervical length ≤30 mm (adjusted odds ratio [aOR], 3.53; 95% confidence interval [CI], 1.33–9.41) and bridging vessels (aOR, 5.93; 95% CI, 2.17–16.21) were independently associated with severe hemorrhage. Bridging vessels were also significantly associated with anesthetic complications (aOR, 5.16; 95% CI, 1.85–14.37). Women experiencing severe hemorrhage had higher rates of blood transfusion, intensive care unit admission, and prolonged postoperative hospitalization.

Conclusion: Short cervical length and bridging vessels were independently associated with severe perioperative hemorrhage in women with placenta previa, while bridging vessels were additionally associated with anesthetic complications. These findings support the potential clinical value of antenatal ultrasound markers in preoperative risk assessment and multidisciplinary delivery planning. Further validation in larger prospective cohorts is warranted.

KEYWORDS: Placenta previa; Antenatal ultrasonography; Cesarean delivery; Perioperative hemorrhage; Anesthetic complications; Cervical length; Bridging vessels; Maternal outcomes.

INTRODUCTION

Placenta previa is one of the obstetric complications that is of major concern because it is defined by the placenta lying over the internal cervical os and carries significant maternal morbidity, especially during cesarean delivery [1]. It is a significant cause of antepartum and perioperative bleeding, which often requires emergency surgery, blood transfusion, and intensive monitoring after surgery. The increasing prevalence of previous cesarean deliveries has further contributed to the clinical burden of placenta previa and its association with placenta accreta spectrum (PAS). In such pregnancies, severe bleeding can occur due to abnormal attachment of the placenta, extensive vascularization of the lower uterine segment, and poor myometrial contractility after the placenta is separated. It is important to identify women at risk of haemorrhagic complications early in pregnancy, therefore, to ensure optimal surgical readiness, anaesthetic management and maternal outcomes [2–4].

Antenatal ultrasonography is still the most useful imaging tool for the diagnosis of placenta previa and assessment of characteristics of placenta associated with poor maternal outcomes. Transabdominal and transvaginal sonography with colour Doppler imaging is useful for assessing the location of the placenta, the length of the

cervix, placental overlap, and abnormalities in the uteroplacental vessels [5]. Sonographic characteristics like abnormal placental lacunae, loss of the retroplacental clear zone, and bridging vessels have been identified as significant findings of abnormal placentation and as indicators of suspected PAS. To better classify and interpret these abnormalities, Collins et al. [5] have introduced standard ultrasound descriptors. In addition, Watthanasathitnukun et al. [6] found that there were several grayscale and Doppler ultrasound parameters that correlated with large blood loss perioperatively in pregnancies complicated by placenta previa and suspected PAS [7].

In recent years, cervical length has become another sonographic parameter that could be of prognostic value in placenta previa. Cervical shortening may be indicative of changes in the lower uterine segment which can lead to placental separation and hemorrhage [8,9]. One study by Stafford et al. [10] found that there was a significant relationship between shortened cervical length and haemorrhage-related delivery. Likewise, Hessami et al. [7], in a systematic review and meta-analysis, showed that the risks of antenatal bleeding, emergency cesarean delivery, and postpartum hemorrhage were higher in women with cervical length ≤30 mm. Previous studies more recently emphasized the potential for use of clinical features with ultrasound markers in the prediction of severe postpartum hemorrhage. However, the relative importance of each ultrasound abnormality for the prognosis is still unclear, especially when taking into consideration previous uterine surgery and other known maternal risk factors [10-13].

In addition to the problem of hemorrhage, placenta previa poses significant issues for obstetric anesthesia [14]. If a lot of bleeding occurs during surgery, this can cause hemodynamic instability, require more blood transfusions, and mean that the patient can no longer have a spinal or epidural anesthesia [15]. Other considerations include the degree of urgency of the surgery, placental vascularity, and the suspicion of abnormal placental invasion. Previous investigations have examined anesthetic techniques and their associations with maternal outcomes in placenta previa [8,9,16]. Anesthetic choice, however, is often determined by the expected complexity and risk of bleeding at surgery, and so it can be challenging to separate the independent prognostic significance of ultrasound findings in pregnancy from the influence of the severity of the pregnancy [17].

Although significant improvements have been made in antenatal imaging and multidisciplinary obstetric management, few data have been published on the correlation between ultrasound findings and the degree of hemorrhage, complications of anesthesia, and postoperative maternal morbidity [18]. Previous research has mainly examined the diagnosis of PAS or prediction of obstetric hemorrhage, and there have been relatively few studies that have looked at association of specific sonographic parameters with clinically important anesthetic outcomes. Moreover, the additional prognostic information that ultrasound abnormalities could provide in addition to conventional clinical risk factors has yet to be investigated. A thorough study of these associations could help with individual risk assessment and coordinated obstetric, anesthetic and surgical management [19,20].

Therefore, the present prospective cohort study evaluated the association of antenatal ultrasound characteristics, including cervical length, placental location and overlap, abnormal placental lacunae, loss of the retroplacental clear zone, and bridging vessels, with severe perioperative hemorrhage, anesthetic complications, and maternal outcomes among women undergoing cesarean delivery for placenta previa. The study also examined the independent associations of sonographic markers with adverse perioperative outcomes and their potential relevance to preoperative risk stratification and multidisciplinary clinical decision-making.

MATERIALS AND METHODS

Study Design and Setting

This prospective, multicenter observational cohort study included 100 pregnant women diagnosed with placenta previa who underwent cesarean delivery. The study period extended from January 2025 to February 2026, with participation from two tertiary healthcare institutions in Pakistan: the Department of Gynaecology, Unit I, Sandeman Provincial Hospital Quetta (SPHQ), Quetta, Pakistan, and the Department of Obstetrics and Gynecology, Postgraduate Medical Institute (PGMI)/Ameer-Ud-Din Medical College (AMC)/Lahore General Hospital (LGH), Lahore, Pakistan. The main aim was to examine the relationship between antenatal ultrasound features and significant perioperative bleeding, anesthetic complications, and short-term maternal outcomes in women with placenta previa who underwent cesarean delivery. To achieve methodological transparency and standardized outcome reporting, the study framework was based on the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations.

Sample Size and Sampling Technique

A total of 100 pregnant women with sonographically confirmed placenta previa who underwent cesarean delivery were included through a nonprobability consecutive sampling approach. All the women who attended the two institutions were eligible to be included until the desired sample size was reached. Due to the sample size and the number of observed hemorrhagic events, it was decided to estimate the associations between the characteristics of the antenatal ultrasound and clinical outcomes and not to develop a validated clinical prediction model.

Inclusion and Exclusion Criteria

Pregnant women aged 18–45 years with singleton pregnancies, gestational age of at least 28 weeks, antenatally confirmed placenta previa, and planned or emergency cesarean delivery at either participating hospital were considered eligible. Placenta previa was diagnosed when placental tissue was lying over the internal cervical os on transvaginal ultrasound. The study included women with prior cesarean deliveries, women with recurrent antepartum bleeding, and women with suspected placenta accreta spectrum (PAS), as these factors are clinically

important determinants of obstetric hemorrhage. Patients with multiple gestations, placental abruption, low-lying placenta not covering the internal cervical os, known congenital or acquired bleeding disorders unrelated to pregnancy, or incomplete essential imaging and perioperative records were excluded. The same eligibility criteria were applied at both participating institutions to minimize selection bias.

Antenatal Ultrasound Assessment

A standardized antenatal ultrasound assessment was used to evaluate placental morphology, cervical anatomy, and abnormal uteroplacental vascularity (UPV). Transabdominal ultrasound was performed for placental location, morphology, and obstetric parameters, while transvaginal ultrasound was performed to confirm placental coverage of the internal cervical os and measure cervical length. Abnormal placental vascular patterns were identified using color Doppler imaging, particularly those associated with suspected PAS. Ultrasound examinations were conducted by qualified obstetric sonographers or radiologists at the participating institutions.

Anterior or posterior placental location, degree of placental overlap of internal cervical os, cervical length, abnormal intraplacental lacunae, loss of retroplacental clear zone, and bridging vessels were the major ultrasound parameters. The cervical canal length was measured in millimeters at the closed endocervical canal, and a length of 30 mm or less was classified as short. Abnormal placental lacunae was defined as an irregular vascular space in the placental tissue, especially when Doppler flow was turbulent. Interruption or absence of the normal hypoechoic interface between the placenta and myometrium was defined as loss of the retroplacental clear zone. Bridging vessels were considered abnormal vascular structures that traversed the myometrial border from the placenta to the uterine serosa or neighboring structure. Data were analysed with the use of accepted sonographic terminology for abnormal placentation and accepted imaging descriptors for PAS.

Data Collection for Maternal and Obstetric Conditions

Structured data collection form was used for obtaining the maternal demographic and clinical data. The maternal age, parity, gravidity, gestational age at birth, number of previous cesarean section, previous surgery in the uterus, previous placenta previa, recurrent antepartum bleeding, pre-birth hemoglobin concentration, and obstetric comorbidities were noted. Patients who underwent surgery had their complete blood counts, blood grouping and cross matching done as per institutional protocol. Other data recorded were time of cesarean delivery, emergency or elective surgery, and clinically suspected PAS. Appropriate baseline data was obtained prior to delivery to continue the prospective evaluation of the relationships among maternal characteristics, ultrasound parameters, and perioperative outcomes.

Cesarean Delivery and Anesthetic Management

Cesarean delivery was conducted by the on-duty obstetric surgical team according to maternal and fetal indications and institutional protocols. The timing and urgency of delivery were determined by clinical presentation, including antepartum bleeding, maternal hemodynamic stability, gestational age, and fetal status. The anesthetist in charge individualized anesthetic management, and spinal, epidural, combined spinal–epidural, or general anesthesia was administered as clinically indicated. Study participation did not influence anesthetic choice. Preoperative preparation involved clinical evaluation, assessment of anticipated hemorrhagic risk, availability of appropriate blood products, and multidisciplinary consultation in cases involving extensive placental vascular abnormalities or suspected PAS.

Intraoperative variables included anesthetic technique, surgical duration, quantified blood loss, hemodynamic instability, vasoactive drug administration, blood transfusion, conversion from neuraxial to general anesthesia, and major surgical interventions. Perioperative complications were documented using anesthetic records, operative reports, and postoperative monitoring records.

Outcome Measures

The primary outcome was severe perioperative hemorrhage, defined as cumulative quantified blood loss ≥1,500 mL during cesarean delivery and within 24 hours postpartum. Estimated blood loss was measured by surgical suction volumes, gravimetric assessment of blood soaked surgical materials and subtraction of non-blood fluids if present. The patients were divided into two groups: severe hemorrhage group and nonsevere hemorrhage group. Clinically important anesthetic complications and adverse maternal outcomes were secondary outcome measures. Anesthetic complications included an anesthetic event that necessitated rescue treatment with vasopressors for hypotension, unplanned conversion from neuraxial to general anesthesia, difficult or failed airway management, and clinically documented major anesthetic events. Routine prophylactic vasopressor administration without an associated anesthetic complication was not classified as an adverse event. Maternal outcomes included packed red blood cell transfusion, major surgical injury, cesarean hysterectomy, intensive care unit (ICU) admission, postoperative hospital stay, and maternal mortality. Outcomes were assessed throughout the index hospitalization, while the primary hemorrhage endpoint was evaluated within 24 hours postpartum.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation or median with interquartile range according to their distribution, whereas categorical variables were presented as frequencies and percentages. Normality was evaluated using graphical methods and the Shapiro–Wilk test, when appropriate. Independent-samples t-tests or Mann–Whitney U tests were used to compare continuous variables, while Pearson's chi-square or Fisher's exact tests were applied to categorical comparisons between patients with and without severe hemorrhage. Associations between antenatal ultrasound characteristics and severe hemorrhage were initially examined through unadjusted

group comparisons, followed by multivariable logistic regression to estimate adjusted odds ratios (aORs) with 95% confidence intervals (CIs).

Given the cohort size of 100 participants and the observed number of outcome events, parsimonious multivariable logistic regression models were fitted separately for severe perioperative hemorrhage and anesthetic complications. The severe hemorrhage model consisted of previous cesarean delivery, cervical length ≤30 mm, and bridging vessels, while the anesthetic complication model consisted of previous cesarean delivery and bridging vessels. To estimate the apparent discriminative performance of both models, receiver operating characteristic (ROC) curve analysis was used, and results are reported as the area under the curve (AUC). The discrimination estimates were considered exploratory results due to no external model validation being attempted. A two-sided p-value <0.05 was considered statistically significant, with emphasis also placed on effect sizes, confidence intervals, and clinical relevance.

Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the relevant Institutional Review Board before study initiation. Written informed consent was obtained from all participants. Confidentiality, anonymity, and voluntary participation were maintained throughout the study.

RESULTS

Baseline Maternal, Obstetric, and Antenatal Ultrasound Characteristics

The study population consisted of 100 pregnant women diagnosed with placenta previa who underwent cesarean delivery. Of these, 52 (52.0%) were obtained from Sandeman Provincial Hospital, Quetta; and 48 (48.0%) from Lahore General Hospital. The median (interquartile range [IQR]) age of the mothers was 30.7 years (26.6–35.2 years), and the median (IQR) gestational age at delivery was 35.9 weeks (34.9–36.7 weeks). Previous cesarean delivery was reported in 52 women (52.0%), recurrent antenatal bleeding in 21 (21.0%), and preoperative hemoglobin <10 g/dL in 28 (28.0%). Unscheduled cesarean delivery was carried out in 38 women (38.0%) and there were plans to use general anesthesia in 32 (32.0%).

As far as the ultrasound features of the pregnancy are concerned, anterior placenta was found in 51 women (51.0%), and placenta overlap ≥20 mm was recorded in 36 women (36.0%). The parameters cervical length ≤30 mm were observed in 31 women (31.0%), abnormal placental lacunae in 41 (41.0%), retroplacental clear zone loss in 26 (26.0%) and bridging vessels in 28 (28.0%). Baseline maternal, obstetric, and sonographic characteristics are summarized in Table 1.

Table 1. Baseline Maternal, Obstetric, and Antenatal Ultrasound Characteristics (n = 100)

Characteristics	Total cohort (n = 100)
Maternal age, years, mean ± SD	30.7 ± 5.2
Gestational age at delivery, weeks, median (IQR)	35.9 (34.9–36.7)
Sandeman Provincial Hospital Quetta	52 (52.0%)
Lahore General Hospital	48 (48.0%)
Previous cesarean delivery	52 (52.0%)
Recurrent antenatal bleeding	21 (21.0%)
Preoperative hemoglobin <10 g/dL	28 (28.0%)
Unscheduled cesarean delivery	38 (38.0%)
Planned general anesthesia	32 (32.0%)
Anterior placental location	51 (51.0%)
Placental overlap ≥20 mm	36 (36.0%)
Cervical length ≤30 mm	31 (31.0%)
Abnormal placental lacunae	41 (41.0%)
Loss of retroplacental clear zone	26 (26.0%)
Bridging vessels	28 (28.0%)

Association Between Antenatal Ultrasound Findings and Severe Perioperative Hemorrhage

Severe perioperative hemorrhage, defined as cumulative quantified blood loss ≥1,500 mL, occurred in 32 patients (32.0%), whereas 68 (68.0%) experienced blood loss below this threshold. The median quantified blood loss was 1,985.5 mL (IQR, 1,736.5–2,169.8 mL) in the severe hemorrhage group compared with 782.0 mL (IQR, 612.8–1,005.0 mL) among patients without severe hemorrhage (p<0.001).

Comparative analysis showed that the presence of the cervical shortening and bridging vessels were significantly associated with severe perioperative hemorrhage. Cervical length ≤ 30 mm was found in 16 (50.0%) patients with severe hemorrhage and 15 (22.1%) patients without severe hemorrhage (p=0.010). Similarly, bridging vessels were detected in 17 patients (53.1%) in the severe hemorrhage group compared with 11 (16.2%) in the nonsevere group (p<0.001).

Abnormal placental lacunae were more frequent among women with severe hemorrhage than among those without severe hemorrhage (46.9% versus 38.2%), although this difference was not statistically significant (p=0.514). Anterior placental location was observed in 56.2% and 48.5% of patients in the respective groups (p=0.524).

Likewise, placental overlap ≥20 mm and loss of the retroplacental clear zone were not significantly associated with severe hemorrhage. The associations between antenatal ultrasound characteristics and hemorrhage severity are presented in Table 2.

Table 2. Association of Antenatal Ultrasound Findings With Severe Perioperative Hemorrhage

Ultrasound characteristics	Severe hemorrhage (n = 32)	No severe hemorrhage (n = 68)	*p* value
Anterior placental location	18 (56.2%)	33 (48.5%)	0.524
Placental overlap ≥20 mm	9 (28.1%)	27 (39.7%)	0.372
Cervical length ≤30 mm	16 (50.0%)	15 (22.1%)	**0.010**
Abnormal placental lacunae	15 (46.9%)	26 (38.2%)	0.514
Loss of retroplacental clear zone	10 (31.2%)	16 (23.5%)	0.467
Bridging vessels	17 (53.1%)	11 (16.2%)	**<0.001**

Anesthetic Complications and Maternal Outcomes

Clinically significant anesthetic complications were recorded in 25 patients (25.0%). Intraoperative hemodynamic instability requiring rescue vasoactive treatment was the most frequently observed complication, affecting 22 patients (22.0%). Unplanned conversion from neuraxial to general anesthesia occurred in two patients (2.0%), while airway or intubation-related complications were documented in two (2.0%). Some patients experienced more than one complication.

Anesthetic complications were significantly more frequent among women with severe perioperative hemorrhage than among those without severe hemorrhage (43.8% versus 16.2%; p=0.006). Hemodynamic instability requiring vasoactive support occurred in 13 patients (40.6%) with severe hemorrhage compared with nine (13.2%) without severe hemorrhage (p=0.004). Unplanned conversion to general anesthesia occurred in two patients (6.2%) in the severe hemorrhage group and none in the comparison group (p=0.100).

Severe hemorrhage was also associated with increased maternal morbidity. Packed red blood cell transfusion was required in 26 patients (81.2%) with severe hemorrhage compared with 12 (17.6%) without severe hemorrhage (p<0.001). Cesarean hysterectomy was performed in four patients (12.5%) with severe hemorrhage and two (2.9%) without severe hemorrhage (p=0.081). ICU admission occurred in 12 patients (37.5%) in the severe hemorrhage group compared with two (2.9%) in the nonsevere group (p<0.001).

Major operative injury occurred in three patients (9.4%) with severe hemorrhage compared with one (1.5%) without severe hemorrhage (p=0.095). The median postoperative hospital stay was significantly longer among women experiencing severe hemorrhage, at six days (IQR, 6–8 days), compared with four days (IQR, 3–5 days) among those without severe hemorrhage (p<0.001). The distribution of anesthetic complications and postoperative maternal outcomes is presented in Table 3.

Table 3. Perioperative Anesthetic Complications and Maternal Outcomes According to Hemorrhage Severity

Outcomes	Severe hemorrhage (n = 32)	No severe hemorrhage (n = 68)	*p* value
Planned general anesthesia	8 (25.0%)	24 (35.3%)	0.363
Unscheduled cesarean delivery	15 (46.9%)	23 (33.8%)	0.270
Any anesthetic complication	14 (43.8%)	11 (16.2%)	**0.006**
Vasopressor-requiring hemodynamic instability	13 (40.6%)	9 (13.2%)	**0.004**
Unplanned conversion to general anesthesia	2 (6.2%)	0 (0.0%)	0.100
Airway or intubation complication	0 (0.0%)	2 (2.9%)	1.000
Packed red blood cell transfusion	26 (81.2%)	12 (17.6%)	**<0.001**
Cesarean hysterectomy	4 (12.5%)	2 (2.9%)	0.081
ICU admission	12 (37.5%)	2 (2.9%)	**<0.001**
Major operative injury	3 (9.4%)	1 (1.5%)	0.095
Postoperative hospital stay, days, median (IQR)	6 (6–8)	4 (3–5)	**<0.001**

Multivariable Analysis of Predictors of Severe Hemorrhage and Anesthetic Complications

Multivariable logistic regression was used to investigate independent associations between clinical and selected antenatal ultrasound characteristics and severe perioperative hemorrhage. The primary model included previous cesarean delivery, cervical length ≤30 mm, and bridging vessels. After adjustment, cervical length ≤30 mm remained significantly associated with severe hemorrhage (adjusted odds ratio [aOR], 3.53; 95% confidence interval [CI], 1.33–9.41; p=0.012). Bridging vessels were most strongly independently associated, with about six times higher odds of severe hemorrhage (aOR, 5.93; 95% CI, 2.17–16.21; p<0.001). After adjustment, previous

cesarean delivery was not independently associated with severe hemorrhage (aOR, 0.91; 95% CI, 0.35-2.37; p=0.846).
A separate multivariable logistic regression model was used to assess factors associated with clinically significant anesthetic complications. Bridging vessels were also independently associated with anesthetic complications (aOR, 5.16; 95% CI, 1.85–14.37; p=0.002). Previous cesarean delivery, in contrast, was not independently associated (aOR, 0.47; 95% CI, 0.17–1.28; p=0.139). The adjusted associations for the two outcomes are summarized in Table 4.

Table 4. Multivariable Logistic Regression Analysis of Severe Hemorrhage and Anesthetic Complications

Predictors	Adjusted OR	95% CI	*p* value
Model A: Severe perioperative hemorrhage			
Previous cesarean delivery	0.91	0.35–2.37	0.846
Cervical length ≤30 mm	3.53	1.33–9.41	**0.012**
Bridging vessels	5.93	2.17–16.21	**<0.001**
Model B: Anesthetic complications			
Previous cesarean delivery	0.47	0.17–1.28	0.139
Bridging vessels	5.16	1.85–14.37	**0.002**

Apparent Discriminative Performance of Antenatal Ultrasound Markers
The discriminative performance of selected clinical and antenatal ultrasound characteristics was assessed using receiver operating characteristic (ROC) curve analysis. The multivariable regression model incorporating previous cesarean delivery, cervical length ≤30 mm, and bridging vessels yielded an apparent area under the ROC curve (AUC) of 0.765 for severe perioperative hemorrhage. The separate model for anesthetic complications, incorporating previous cesarean delivery and bridging vessels, yielded an apparent AUC of 0.702.
These discrimination estimates demonstrated apparent discriminatory ability within the study cohort, suggesting that antenatal ultrasound characteristics may contribute additional information to preoperative clinical assessment. However, the limited number of outcome events and absence of external validation restricted the precision and generalizability of these model estimates.
Overall, cervical length ≤30 mm and bridging vessels demonstrated the strongest adjusted associations with severe perioperative hemorrhage among the assessed antenatal ultrasound characteristics. Bridging vessels were additionally associated with clinically significant anesthetic complications. Severe hemorrhage was associated with increased blood transfusion requirements, intraoperative hemodynamic instability, ICU admission, and prolonged postoperative hospitalization. These findings support further evaluation of standardized antenatal ultrasound assessment as a component of multidisciplinary risk stratification for cesarean delivery in women with placenta previa.

DISCUSSION

This study assessed the associations of antenatal ultrasound parameters with severe perioperative bleeding, anesthetic complications, and maternal outcomes in 100 women undergoing cesarean delivery for placenta previa [1,2]. Severe hemorrhage was observed in 32.0% of patients, and anesthetic complications were observed in 25.0% of patients. Cervical length ≤30 mm and the presence of bridging vessels were identified as independent factors associated with severe hemorrhage, and the presence of bridging vessels was also associated with anesthetic complications. These findings highlight the potential clinical relevance of antenatal ultrasonography in identifying high-risk pregnancies and supporting perioperative preparedness [4-6].
There was a significant association between shorter cervical length and severe hemorrhage (aOR, 3.53; 95% CI, 1.33–9.41). Stafford et al. [10] also noted an association between cervical shortening and hemorrhage-related delivery in placenta previa. In the systematic review and meta-analysis by Hessami et al. [7], cervical length ≤30 mm was associated with increased risks of antenatal bleeding, emergency cesarean delivery, and postpartum hemorrhage. Shortening of the cervix may reflect anatomical changes in the lower uterine segment associated with increased susceptibility to placental separation and hemorrhage.
Bridging vessels were the most strongly independent association with severe hemorrhage (aOR, 5.93; 95% CI, 2.17–16.21) and were independently associated with anesthetic complications (aOR, 5.16; 95% CI, 1.85–14.37) [5]. These anomalies may suggest that there is greater uteroplacental vascularity and placenta accreta spectrum. Similarly Watthanasathitnukun et al. [6] reported a correlation between vascular sonographic abnormality and significant peri-operative blood loss. Cao et al. [15] highlighted the need for integration of ultrasound features and maternal clinical parameters for hemorrhage risk assessment. In this study, none of the abnormal placental lacunae or loss of retroplacental clear zone were significantly associated with severe hemorrhage. These differences may be explained by differences in the prognostic value of the sonographic features or by small numbers of outcome events, or by differences in underlying placental pathology [6-10].
Severe perioperative bleeding was significantly associated with greater blood transfusion requirements, intraoperative hemodynamic instability, intensive care unit (ICU) admission, and longer hospital stay in the postoperative period. These results are in line with Gibbins et al. [3] who reported high rates of maternal morbidity due to haemorrhage in association with placenta previa. The clinical significance of anesthetic management in

these patients was also highlighted by Fan et al. [8] and Ismail and Rashid [9]. It is important to interpret the observed relationship between ultrasound abnormalities and anesthetic complications in the light of the severity of the hemorrhage, the complexity of the surgery and the anesthetic technique used, all of which may have an impact on the anesthetic outcome [11].

The strengths of this study were the prospective, multicenter design and the combined evaluation of ultrasound, anesthetic and maternal outcomes. When interpreting the results, however, the relatively small sample size, limited number of outcome events, potential interobserver variability in ultrasound assessment and residual confounding should be taken into account, especially in relation to placenta accreta spectrum. Future larger prospective studies with standardized imaging and external validation would help to determine the generalizability and clinical applicability of these associations [14-17].

The results showed that there was a significant relationship between cervical length ≤30 mm and bridging vessels with severe perioperative bleeding which supported their potential value in the assessment of risk of placenta previa before surgery. These sonographic parameters could help distinguish those who may need more hemorrhage preparation and monitoring during surgery. But their role as clinical prediction tools in a validated clinical prediction rule needs to be further assessed [18-20].

CONCLUSION

Among women with placenta previa undergoing cesarean delivery, antenatal ultrasound features, particularly cervical length ≤30 mm and bridging vessels, demonstrated significant associations with severe perioperative hemorrhage. Clinically relevant anesthetic complications were also found to correlate with the presence of bridging vessels, and severe hemorrhage with more blood transfusions, hemodynamic support, prolonged postoperative hospital stay and admission to intensive care unit. These data may be the basis for a clinically relevant systematic evaluation of cervical anatomy and abnormal placental vascularity in the identification of women at high peri-partum risk. These ultrasound features could be used in the multidisciplinary evaluation of obstetrics and anaesthesia to help with individualised surgical preparations, transfusion readiness and peri-operative management. These markers need to be further studied in terms of prospective validation before they are used in definitive clinical prediction protocols.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

ZB: Study conceptualization, research design, clinical supervision, and manuscript preparation. **LA:** Methodology development, data interpretation, critical revision, and scientific oversight. **HB:** Patient recruitment, clinical data collection, and data organization. **AS:** Radiological assessment, interpretation of imaging findings, and manuscript review. **H:** Assessment of anesthetic outcomes, interpretation of clinical findings, and manuscript review. **AA:** Radiological evaluation, interpretation of diagnostic findings, and critical manuscript revision. All authors reviewed and approved the final manuscript and agreed to be accountable for the accuracy and integrity of the work.

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