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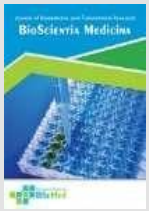

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Predictive Accuracy of the Placenta Accreta Index (PAI) for Histopathological Severity in Placenta Accreta Spectrum Disorders: A Prospective Cohort Study

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A B S T R A C T

Background: Placenta accreta spectrum disorder (PASD) represents a range of conditions characterized by abnormal placental adherence and invasion into the uterine wall, posing significant risks of maternal morbidity and mortality, primarily due to severe hemorrhage. The incidence has risen, largely attributed to increasing rates of cesarean deliveries. Prenatal diagnosis is crucial for optimal management. The Placenta Accreta Index (PAI), an ultrasound-based scoring system, was developed to aid in prenatal risk assessment. This study aimed to evaluate the predictive accuracy and correlation of PAI scores with final histopathological findings in patients with suspected PASD at a tertiary hospital in Riau, Indonesia. **Methods:** A descriptive-analytical study with prospective data collection was conducted over six months (July-December 2024) at Arifin Achmad Regional General Hospital Pekanbaru. The study included 29 pregnant women diagnosed with placenta previa totalis and suspected PASD based on clinical and initial ultrasound findings. Patients underwent transabdominal Doppler ultrasonography between 32-34 weeks of gestation to calculate the PAI score. Following delivery (primarily via cesarean hysterectomy), placental and uterine specimens underwent histopathological examination to determine the definitive PASD classification (accreta, increta, percreta). Correlation between PAI scores and pathological severity was assessed using the Spearman correlation test. Logistic regression was used to evaluate PAI as a predictor of pathological outcomes. Sensitivity and specificity were calculated using a PAI cut-off score of ≥6. Statistical significance was set at $p < 0.05$. **Results:** Of the 29 participants, the mean age was 32.83 ± 2.82 years, the mean parity was 3.21 ± 1.05, and a mean number of prior cesarean sections was 1.72 ± 0.70. Histopathology confirmed PASD in all cases: 23 (79.3%) were placenta accreta, 5 (17.2%) were placenta increta, and 1 (3.5%) was placenta percreta. A statistically significant positive correlation was found between PAI score and histopathological severity (Spearman's $R = 0.512$, $p = 0.012$). Logistic regression confirmed PAI score as a significant predictor of pathological outcome ($\beta = 3.64$, 95% CI 1.301–5.982, $p = 0.003$). Using a cut-off score of ≥6, PAI demonstrated a sensitivity of 88.6% and specificity of 83.3% for predicting PASD based on the abstract data. **Conclusion:** The Placenta Accreta Index (PAI) demonstrated a significant positive correlation with the histopathological severity of Placenta Accreta Spectrum Disorders. PAI serves as a valuable and accurate predictive tool for assessing the degree of placental invasion prenatally. Its use can significantly aid clinicians in risk stratification, surgical planning, and optimizing obstetric management to improve maternal outcomes in this high-risk population.

1. Introduction

Placenta accreta spectrum disorder (PASD) represents a critical area of concern in contemporary obstetrical practice. It is characterized by a range of pathological conditions where placental villi abnormally adhere to and invade the uterine

myometrium due to a defect in the decidua basalis layer. This spectrum of conditions includes placenta accreta, where the villi attach directly to the myometrium; placenta increta, where the villi invade into the myometrium; and placenta percreta, where the villi penetrate through the myometrium, potentially invading the uterine serosa and adjacent organs. PASD poses a significant threat to maternal health, being a leading cause of severe intrapartum and postpartum hemorrhage. The associated maternal morbidity can be substantial, with rates reaching up to 60%. Complications frequently include the need for massive blood transfusions, admission to the intensive care unit, and peripartum hysterectomy. In severe cases, maternal mortality has been reported to be as high as 7%. The incidence of PASD has increased dramatically in recent decades. This rise is strongly correlated with the increasing rates of cesarean deliveries performed worldwide. The historical incidence of PASD was approximately 1 in 30,000 pregnancies, but current estimates suggest a much higher occurrence, ranging from 1 in 533 to 1 in 1000 births, with notable regional variations. In Indonesia, PASD presents a considerable health burden, with estimates suggesting over 500,000 cases nationally and 49 cases recorded at RSUD Arifin Achmad Pekanbaru in 2023.[1-4]

The most significant risk factor for PASD is a history of prior uterine surgery, particularly cesarean section. The risk escalates with each subsequent cesarean delivery; it has been estimated to increase from 3% after one prior cesarean to over 60% after four or more. Additional risk factors include advanced maternal age (greater than 35 years), multiparity, a history of uterine curettage or other uterine surgeries such as myomectomy, and certain uterine anomalies. The pathophysiology of PASD is believed to involve defective decidualization, often at the site of a uterine scar. This defective decidua fails to adequately regulate trophoblast invasion, allowing placental villi to infiltrate abnormally deep into or through the myometrium. This abnormal implantation disrupts normal placental separation after delivery, leading to intractable hemorrhage when manual removal is attempted. Given the severe risks associated with PASD, accurate prenatal diagnosis is of utmost importance for optimizing management and improving maternal outcomes. Prenatal identification enables multidisciplinary team planning, scheduled delivery at a tertiary center equipped with adequate resources, and strategies to minimize hemorrhage. Such resources include experienced surgeons, anesthesiologists, blood bank facilities with massive transfusion protocols, and critical care support. Furthermore, prenatal diagnosis helps in avoiding attempts at placental removal, which can often precipitate severe hemorrhage.[5-7]

Ultrasonography, utilizing grayscale and color Doppler imaging, serves as the primary tool for prenatal screening and diagnosis of PASD. Several sonographic markers have been identified, including loss of the retroplacental clear zone, myometrial thinning, the presence of placental lacunae, bladder wall interruption, subplacental hypervascularity, and bridging vessels. However, the interpretation of these markers can be subjective, and the diagnostic accuracy of ultrasonography can vary. In an effort to standardize and enhance the predictive capability of ultrasound in the context of PASD, the Placenta Accreta Index (PAI) was developed. The PAI is a scoring system that integrates key ultrasound findings with clinical risk factors, such as the number of prior cesarean sections, to quantify the risk and potential severity of PASD. While initial results have been promising, ongoing validation is necessary to confirm the correlation of PAI scores with definitive histopathological findings, which remain the gold standard for diagnosis and severity grading, across diverse populations.[8-10] This study was conducted at RSUD Arifin Achmad Pekanbaru, a tertiary referral hospital in Riau Province, Indonesia, where a significant number of PASD cases are managed. The primary objective was to evaluate the predictive accuracy of the PAI score, calculated using prenatal Doppler ultrasonography, by comparing it with the final histopathological assessment of PASD severity

(accreta, increta, percreta) in patients undergoing surgery for suspected PASD.

2. Methods

This study employed a descriptive-analytical design with prospective data collection, structured as a cohort study. The research was conducted within the Division of Fetomaternal Medicine, Department of Obstetrics and Gynecology, Faculty of Medicine, Universitas Riau/Arifin Achmad Regional General Hospital in Pekanbaru, Riau, Indonesia. Arifin Achmad Regional General Hospital serves as a major tertiary referral center for the province. Data collection spanned a six-month period from July 1st, 2024, to December 31st, 2024.

The study population comprised all pregnant women diagnosed with placenta previa totalis who were suspected of having PASD based on clinical risk factors and preliminary ultrasound findings and who received care at the study institution during the research period. Participants were recruited using a consecutive sampling technique from the accessible population who met the study's eligibility criteria.

The required sample size was calculated using a formula for comparing two proportions, with the aim to detect a significant difference with an alpha of 0.05 and a power of 80% (beta=0.20). Based on assumed proportions (p1=0.12, p2=0.63), the initial calculation yielded approximately 20 participants per group. Adjusting for a potential 10% dropout rate resulted in a target sample size of 22 participants. A total of 29 participants were ultimately included in the final analysis.

The study utilized specific criteria to determine participant eligibility; Inclusion Criteria: Pregnant women diagnosed with placenta previa totalis who also had a clinical suspicion of PASD (based on risk factors like prior cesarean section and suggestive ultrasound signs) and who consented to participate in the study; Exclusion Criteria: Patients diagnosed with placenta previa totalis who were not suspected of having PASD.

Data collection commenced after obtaining informed consent from eligible participants visiting the Fetomaternal outpatient clinic. Information regarding patient demographics (age), obstetric history (parity, number and type of previous uterine surgeries including cesarean sections, myomectomy, curettage), and smoking status was collected via patient interview and review of medical records. This information was recorded on a standardized questionnaire. All participants underwent a detailed transabdominal ultrasound examination with color Doppler assessment between 32 and 34 weeks of gestation. The examinations were performed by experienced operators in the Fetomaternal division. The PAI score was calculated based on specific predefined ultrasound parameters. These parameters included; Number of prior cesarean sections; Presence and grade of placental lacunae; Sagittal smallest myometrial thickness; Anterior placenta previa location; Presence of bridging vessels. The final PAI score was recorded. Patients were categorized based on PAI score probability ranges (5-19%, 33-69%, 83-96%). Following delivery, which typically involved planned cesarean hysterectomy for suspected PASD, the surgical specimen (uterus with placenta in situ) was sent for histopathological analysis. In the pathology laboratory, the specimen was processed according to standard protocols. Gross examination was performed, and representative tissue sections were taken from the placental-myometrial interface, particularly from suspected areas of abnormal adherence or invasion, often marked with sutures. Tissues were fixed in formalin, embedded in paraffin, sectioned, and stained with Hematoxylin and Eosin (H&E). Experienced pathologists, blinded to the PAI score, examined the slides microscopically to confirm the presence and determine the depth of placental villous invasion into the myometrium. The final diagnosis was classified according to the deepest level of invasion observed; Placenta Accreta: Villi attached directly to the myometrium with absent decidua, but without invasion into the muscle bundles; Placenta Increta: Villi invading into the myometrial muscle

fibers; Placenta Percreta: Villi penetrating through the entire myometrial thickness, reaching or breaching the uterine serosa, potentially involving adjacent organs. The definitive pathological diagnosis was recorded.

The study involved the following variables; Independent Variable: Placenta Accreta Index (PAI) score, treated as both a continuous variable and categorized based on probability ranges (Ordinal scale: 5-19%, 33-69%, 83-96%); Dependent Variable: Histopathological diagnosis of PASD severity (Nominal scale: Accreta, Increta, Percreta); Covariates: Maternal age (numeric), parity (numeric), history of cesarean section (ordinal: 1x, ≥2x), history of other uterine surgery (nominal: yes/no), smoking status (nominal: yes/no).

Data collected were checked for completeness (editing), coded according to predefined categories, and entered into SPSS software (Statistical Package for Social Sciences, Chicago, IL, USA) for Mac for analysis. Subject characteristics were summarized using means, standard deviations (SD), medians, and interquartile ranges (IQR) for continuous variables (age, parity, number of SCs), and frequencies and percentages for categorical variables (pathology type, PAI categories). The correlation between the continuous PAI score and the ordinal histopathological severity (treated as 1=Accreta, 2=Increta, 3=Percreta for analysis purposes) was assessed using the Spearman rank correlation coefficient (R), as data distribution assumptions for Pearson might not be met. Binary logistic regression analysis was performed to evaluate the association between the PAI score (as a continuous predictor) and the likelihood of a more severe pathological outcome (e.g., Increta/Percreta vs. Accreta). Coefficients (β), standard errors (SE), odds ratios (OR - implied by β), 95% confidence intervals (CI), and p-values were calculated. Sensitivity and specificity of the PAI score were reported based on a cut-off value of ≥6. A p-value less than 0.05 was considered statistically significant for all inferential tests.

The study protocol was submitted to and received ethical approval (ethical clearance) from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Riau /Arifin Achmad Provincial Hospital. Written informed consent was obtained from all participants (or legally authorized representatives) prior to enrollment and data collection. Patient confidentiality was maintained throughout the study. As the procedures involved (ultrasound, surgery, pathology) were part of standard clinical care for suspected PASD, direct research costs were covered by the patients' existing health insurance.

3. Results

Table 1 provides a summary of the key demographic and obstetric characteristics of the 29 participants included in the study. These characteristics are important as they can influence the risk and presentation of Placenta Accreta Spectrum Disorder (PASD), the focus of the research; Maternal Age (years): The average age of the participants was 32.83 years. This indicates that the study population consisted of women in their early to mid-30s on average. The standard deviation of 2.82 years shows the degree of variability or spread of ages around the mean. A smaller standard deviation suggests that the ages were relatively close to the average, indicating less spread. Most participants' ages are likely to fall within approximately 2.82 years of the mean (i.e., between roughly 30 and 36 years). The median age was 33.0 years. The median represents the middle value when the ages are arranged in ascending order. In this case, the mean (32.83) and median (33.0) are very close, suggesting a fairly symmetrical distribution of ages. This means the age distribution isn't heavily skewed towards younger or older ages. The IQR is 31.0 - 35.0 years. The IQR represents the range of the middle 50% of the data. It tells us that 50% of the participants were between 31 and 35 years old. This is another measure of spread, but it's less sensitive to extreme values than the standard deviation. The youngest participant was 27 years old. The oldest participant was 38 years old. The participants were

predominantly in their early to mid-30s, with a relatively narrow age range. This is important because advanced maternal age is a known risk factor for PASD; Parity (number): The average parity (number of previous births) was 3.21. This indicates that, on average, the women in the study had given birth three times prior to the current pregnancy. The standard deviation of 1.05 suggests a moderate amount of variability in parity. The median parity was 3.0. Again, the mean and median are close, suggesting a reasonably symmetrical distribution. The IQR was 2.0 - 4.0. This means that 50% of the women had between 2 and 4 previous births. The lowest number of previous births was 2. The highest number of previous births was 5. The participants were multiparous (having given birth more than once), with most having between 2 and 4 previous births. Higher parity can be associated with uterine changes that might influence PASD; Number of Prior Cesarean Sections: The average number of prior cesarean sections was 1.72. This is a crucial factor, as prior cesarean delivery is a major risk factor for PASD. The standard deviation of 0.70 is relatively small, indicating that the number of prior cesareans was fairly consistent among participants. The median number of prior cesarean sections was 2.0. This suggests that half of the participants had at least 2 prior cesarean deliveries. Note that the mean is lower than the median, indicating a slight negative skew (more women with fewer cesareans). The IQR was 1.0 - 2.0. This means that 50% of the participants had between 1 and 2 prior cesarean sections. The minimum number of prior cesarean sections was 1. The maximum number of prior cesarean sections was 3. A significant proportion of the study population had a history of prior cesarean sections. The fact that the median is 2 and the minimum is 1 highlights the importance of this risk factor in this cohort.

Table 1. Demographic and obstetric characteristics of study participants (N=29).

Characteristic	Mean	Standard deviation (SD)	Median	Interquartile range (IQR)	Minimum	Maximum
Maternal age (years)	32.83	2.82	33.0	31.0 – 35.0	27	38
Parity (number)	3.21	01.05	3.0	2.0 – 4.0	2	5
Number of prior cesarean sections	1.72	0.70	2.0	1.0 – 2.0	1	3

Table 2 summarizes the distribution of PAI scores among the 29 study participants, categorized by their final histopathological diagnosis of PASD severity. The majority of cases (79.31%, representing 23 out of 29 participants) were classified as placenta accreta. Placenta increta was found in 17.24% of cases (5 participants), and placenta percreta was the least common, occurring in only 3.45% of cases (1 participant). This distribution aligns with the general understanding that accreta is the most frequent form of PASD, while increta and percreta represent more severe but less common forms. A key finding is the trend of increasing PAI scores with increasing severity of PASD. Placenta accreta cases had a mean PAI score of 70.91, with a median of 69.0. Placenta increta cases showed a lower mean PAI score of 57.20, with a median of 51.0. The single case of placenta percreta had a PAI score of 83.0 (mean and median are the same in this instance). The standard deviation of PAI scores was relatively high for both accreta (28.74) and increta (28.20), indicating a fair amount of variability in scores within each group. This suggests that while there's a general trend, PAI scores can vary considerably, even within the same histopathological classification. The percreta group had no standard deviation reported, likely due to it being a single case. The data suggests that PAI scores tend to correlate with the severity of placental invasion. Higher PAI scores are generally associated with more severe forms of PASD. However, the variability within each group highlights that PAI scores are not absolute predictors of histopathological severity and should be interpreted in conjunction with other clinical and ultrasound findings.

Table 2. Placenta accreta index (PAI) scores (N=29).

Histopathological result	Number of cases (N)	Percentage (%)	Mean PAI score	Standard deviation (SD)	Median PAI score
Placenta accreta	23	79.31	70.91	28.74	69.0
Placenta increta	5	17.24	57.20	28.20	51.0
Placenta percreta	1	3.45	83.00	-	83.0
Total	29	100.00			

Table 3 presents the results of a Spearman rank correlation analysis, a statistical test used to assess the relationship between two ordinal or ranked variables. In this case, the variables are the Placenta Accreta Index (PAI) score and the histopathological severity grade of PASD; Variable 1: Placenta Accreta Index (PAI) Score. This is a continuous score derived from ultrasound measurements and clinical risk factors, used to predict the severity of PASD; Variable 2: Histopathological Severity Grade. This is an ordinal variable representing the severity of PASD as determined by pathological examination of tissue samples. It was coded as: 1 = Accreta, 2 = Increta, and 3 = Percreta. This means the grades have a natural order from least to most severe; Test Used: Spearman's rank correlation. This test was chosen because it doesn't assume a linear relationship between the variables and is suitable for ordinal data. It assesses whether there is a monotonic relationship (i.e., as one variable increases, the other tends to increase or decrease, but not necessarily at a constant rate); Correlation Coefficient (Spearman's R): The Spearman's R value is 0.512. This value indicates the strength and direction of the monotonic relationship. The positive sign (+) indicates a positive correlation, meaning that as the PAI score increases, the histopathological severity grade also tends to increase (i.e., higher PAI scores are associated with more severe PASD). The magnitude of 0.512 suggests a "moderate" correlation. While there's a noticeable trend, it's not a very strong or perfect relationship. There is scatter; p-value: The p-value is 0.012. This value represents the probability of observing the obtained correlation (or a stronger one) if there were actually no relationship between the PAI score and histopathological severity grade in the population. Since the p-value (0.012) is less than the conventional significance level of 0.05, it is considered statistically significant. This means that the observed correlation is unlikely to have occurred by chance, and we can conclude that there is a statistically significant association between the PAI score and the severity of PASD; Interpretation: The table concludes with the interpretation: "Significant moderate positive correlation." "Significant" refers to the statistical significance ($p < 0.05$), indicating that the correlation is unlikely due to random variation. "Moderate" describes the strength of the correlation ($R = 0.512$). "Positive correlation" specifies the direction of the relationship (as PAI score increases, PASD severity tends to increase).

Table 3. Spearman correlation analysis between placenta accreta index (PAI) score and histopathological severity grade (N=29).

Variable 1	Variable 2	Test Used	Correlation Coefficient (Spearman's R)	p-value	Interpretation
Placenta Accreta Index (PAI) Score	Histopathological Severity Grade*	Spearman's rank correlation	0.512	0.012	**Significant moderate positive correlation**
*Histopathological Severity Grade treated as ordinal: 1=Accreta, 2=Increta, 3=Percreta.					

Table 4 presents a cross-tabulation of the histopathological results of PASD (Placenta Accreta Spectrum Disorder) against categories of the Placenta Accreta Index (PAI) score. This allows us to examine how PAI score categories relate to the actual severity of PASD as determined by pathology; PAI Score Categories: The PAI scores are grouped into three categories: 5-19%, 33-69%, and 83-96%. These categories likely represent increasing levels of risk or likelihood of more severe PASD; Histopathological Results: The histopathological results represent the definitive diagnosis of PASD severity: Placenta Accreta (least severe), Placenta Increta, and Placenta Percreta (most severe); Distribution of Cases: The majority of the 29 cases fall into the 83-96% PAI score category (18 cases), followed by the 33-69% category (10 cases), and only 1 case in the 5-19% category. Overall, Placenta Accreta is the most common histopathological finding (23 cases), followed by Increta (5 cases), and Percreta (1 case); Trends Between PAI and Histopathology: As the PAI score category increases, there's a general trend toward a higher proportion of more severe PASD cases. In the lowest PAI category (5-19%), only Placenta Accreta was observed. In the middle PAI category (33-69%), most cases were Accreta, but one case of Increta was also present. In the highest PAI category (83-96%), while Accreta was still the most frequent, Increta and the single case of Percreta were also found; Row Percentages: Row percentages show the distribution of histopathological results within each PAI category. For example, in the 83-96% PAI category, 72.2% of cases were Accreta, 22.2% were Increta, and 5.6% were Percreta; Column Percentages: Column percentages show the distribution of PAI categories for each histopathological result. For instance, 56.5% of Accreta cases were in the highest PAI category, while 100% of Percreta cases were in the highest PAI category; Overall Association: The overall association between PAI score category and histopathological result is statistically significant, with a p-value of 0.047 (Chi-square or Fisher's Exact test). This suggests that there's a relationship between the PAI score category and the severity of PASD. It is unlikely that the observed distribution occurred by chance.

Table 4. Cross-tabulation of histopathological severity and placenta accreta index (PAI) score category (N=29).

PAI score category	Histopathological result	Count (N)	Row %	Column %
5-19%	Placenta Accreta	1	100.0%	4.3%
(N=1)	Placenta Increta	0	0.0%	0.0%
	Placenta Percreta	0	0.0%	0.0%
	Category Total	**1**	**100.0%**	**3.4%**
33-69%	Placenta Accreta	9	90.0%	39.1%
(N=10)	Placenta Increta	1	10.0%	20.0%
	Placenta Percreta	0	0.0%	0.0%
	Category Total	**10**	**100.0%**	**34.5%**
83-96%	Placenta Accreta	13	72.2%	56.5%
(N=18)	Placenta Increta	4	22.2%	80.0%
	Placenta Percreta	1	5.6%	100.0%
	Category Total	**18**	**100.0%**	**62.1%**
Overall total	**Placenta Accreta**	**23**	**79.3%**	**100.0%**
(N=29)	**Placenta Increta**	**5**	**17.2%**	**100.0%**
	Placenta Percreta	**1**	**3.5%**	**100.0%**
	Grand Total	**29**	**100.0%**	**100.0%**
Overall association p-value = 0.047 (Chi-square or Fisher's Exact).				
Row % indicates the distribution of pathology types within each PAI category.				
Column % indicates the distribution of PAI categories for each pathology type.				

Table 5 displays the output of a logistic regression model. This statistical technique is used when the outcome variable is binary (two categories), as is the case here where the outcome is "Severe Pathology" (Increta/Percreta) versus "Accreta." The table assesses if the PAI score can predict the likelihood of a more severe form of PASD. The outcome being predicted is a binary variable: "Severe Pathology" is coded as 1 (representing Increta or Percreta), and "Accreta" is coded as 0. This means the model is predicting the probability of having Increta or Percreta compared to having Accreta. The variable used to predict the outcome is the PAI Score, treated as a continuous variable. This means the model examines how each unit increase in the PAI score affects the likelihood of severe pathology. The coefficient for the PAI Score is 3.64. This positive coefficient indicates that as the PAI score increases, the predicted log-odds of having Severe Pathology (Increta/Percreta) also increase. In simpler terms, higher PAI scores are associated with a higher likelihood of more severe PASD. The standard error for the PAI Score's coefficient is 1.19. This measures the precision of the coefficient estimate. A smaller SE indicates a more precise estimate. The Wald statistic is 9.30. This statistic tests the null hypothesis that the coefficient is zero (i.e., the PAI Score has no effect on the likelihood of Severe Pathology). A larger absolute z-value suggests stronger evidence against the null hypothesis. The p-value is 0.003. This is the probability of observing the obtained results (or more extreme results) if there were actually no association between the PAI Score and Severe Pathology. Since the p-value (0.003) is less than the common significance level of 0.05, we reject the null hypothesis. This means the PAI Score is a statistically significant predictor of Severe Pathology. The odds ratio is 38.1. The odds ratio is calculated by exponentiating the coefficient. It represents how the odds of having Severe Pathology change for each one-unit increase in the PAI Score. An odds ratio of 38.1 means that for every one-unit increase in the PAI Score, the odds of having Increta or Percreta are 38.1 times higher than the odds of having Accreta. This is a substantial increase. The 95% confidence interval for the odds ratio is 3.67 - 396.2. This interval provides a range within which we are 95% confident that the true odds ratio lies. Since the interval does not include 1, this further supports the statistical significance of the finding. If it included 1, it would suggest that the effect could be null.

Table 5. Logistic regression analysis predicting likelihood of severe pathological outcome (Increta/Percreta vs. Accreta) based on PAI score (N=29).

Predictor variable	**Coefficient (β)**	**Standard error (SE)**	**Wald statistic (z-value)**	**p-value**	**Odds Ratio (OR = exp(β))**	**95% CI for Odds Ratio**
PAI score	3.64	1.19	9.30	**0.003**	38.1	3.67 – 396.2
Constant	1.64	0.75	4.77	0.837	5.15	1.18 – 22.46
Dependent Variable: Binary outcome (Severe Pathology [Increta/Percreta] = 1, Accreta = 0).						
PAI Score treated as a continuous predictor.						

Table 6 provides two key metrics that evaluate how well the PAI score performs in identifying cases of Placenta Accreta Spectrum Disorder (PASD); PAI Cut-off: The PAI score cut-off used for this analysis is ≥ 6. This means that a PAI score of 6 or higher is considered a positive test result, indicating a higher likelihood of PASD; Sensitivity: Sensitivity is defined as the proportion of actual PASD cases that are correctly identified by the PAI. In other words, it's the test's ability to correctly identify individuals who truly have the condition. The sensitivity of the PAI at the chosen cut-off (≥ 6) is 88.6%. This means that the PAI correctly identifies 88.6% of patients who actually have PASD. A high sensitivity is important because it indicates that the test is good at minimizing false negatives (i.e., not missing true cases of PASD); Specificity: Specificity is defined as the proportion of non-PASD cases that are correctly identified by the

PAI. It's the test's ability to correctly identify individuals who do not have the condition. The specificity of the PAI at the cut-off (≥ 6) is 83.3%. This means that the PAI correctly identifies 83.3% of patients who do not have PASD. High specificity is important because it indicates that the test is good at minimizing false positives (i.e., not incorrectly labeling someone as having PASD when they don't).

Table 6. Diagnostic accuracy of placenta accreta index (PAI) for detecting PASD (N=29).

Diagnostic metric	Definition	PAI Cut-off	Value (%)
Sensitivity	Proportion of actual PASD cases correctly identified by PAI	≥ 6	88.6%
Specificity	Proportion of non-PASD cases correctly identified by PAI*	≥ 6	83.3%

4. Discussion

The demographic and obstetric profiles of the participants provide a crucial context for interpreting the study's findings. The mean maternal age in this study was approximately 33 years, with a median of two prior cesarean sections. These characteristics are clinically relevant as they align with well-established risk factors for PASD. Advanced maternal age is independently associated with an increased risk of PASD. Several studies have demonstrated that older mothers have a higher likelihood of developing PASD, potentially due to age-related changes in the uterus and placenta. However, the most prominent risk factor for PASD is a history of prior uterine surgery, particularly cesarean section. The risk of PASD increases with each subsequent cesarean delivery, demonstrating a dose-response relationship. The risk is particularly elevated when placenta previa is present in a pregnancy following a cesarean section. Our study's finding of a median of two prior cesarean sections underscores the significance of this risk factor in our cohort and is consistent with the global trend of rising PASD incidence alongside increasing cesarean delivery rates. Furthermore, high parity, with a median of 3.0 in our study, has been identified as a risk factor for PASD. The association between parity and PASD risk might be attributed to cumulative damage and alterations in the uterine wall resulting from multiple pregnancies and deliveries.[11,12]

The distribution of PASD subtypes observed in this study is consistent with established epidemiological patterns. Placenta accreta was the most common form, accounting for 79.3% of cases, followed by increta at 17.2%, and percreta at 3.5%. This distribution mirrors findings in larger studies, where placenta accreta typically represents the majority (75-80%) of PASD cases. This distribution is clinically important. While accreta is the most common, increta and percreta represent more severe forms of PASD with a higher risk of complications. These severe forms are associated with increased risks of massive hemorrhage, uterine perforation, damage to adjacent organs, and maternal morbidity and mortality. Therefore, accurate prenatal identification of these severe forms is crucial for optimal management and planning.[13,14]

The central finding of this study is the significant positive correlation between the PAI score and the histopathologically determined severity of PASD. The Spearman correlation coefficient of 0.512 ($p = 0.012$) indicates a moderate positive correlation, suggesting that higher PAI scores are associated with deeper placental invasion into or through the myometrium. This finding aligns with the intended purpose of the PAI, which is to provide a quantitative assessment of PASD risk and severity based on ultrasound markers and clinical risk factors. The PAI score incorporates

several ultrasound parameters known to be indicative of abnormal placental invasion, such as the loss of the retroplacental clear zone, myometrial thinning, the presence of placental lacunae, and abnormal placental vasculature. By combining these ultrasound findings with clinical risk factors, particularly the number of prior cesarean sections, the PAI aims to provide a more objective and standardized assessment of PASD risk. The logistic regression analysis in our study further supports the predictive capability of the PAI score. The analysis demonstrated that the PAI score is a significant predictor of pathological severity ($p = 0.003$). This finding is consistent with other studies that have evaluated ultrasound-based scoring systems for PASD. These studies have also reported significant correlations between higher ultrasound scores and adverse maternal outcomes, such as increased need for hysterectomy, massive blood transfusion, and prolonged hospital stay. These adverse outcomes are directly related to the severity of placental invasion, highlighting the importance of accurate prenatal prediction of PASD severity.[15,16]

The ability to accurately predict PASD severity prenatally has profound clinical implications for patient management. Prenatal diagnosis allows for appropriate risk stratification, enabling clinicians to tailor their management plans based on the predicted severity of PASD. One of the most critical benefits of prenatal PASD diagnosis is the opportunity for timely referral to specialized tertiary care centers. These centers are equipped with the necessary resources and multidisciplinary teams to manage the complex and potentially life-threatening complications of PASD. A multidisciplinary team typically includes obstetricians, gynecologic oncologists, urologists, anesthesiologists, interventional radiologists, and neonatologists. The involvement of such a team ensures comprehensive care and optimizes maternal and neonatal outcomes. Prenatal diagnosis also allows for adequate preparation for potential massive hemorrhage, a leading cause of maternal morbidity and mortality in PASD. This preparation includes ensuring the availability of blood products, implementing massive transfusion protocols, and having access to interventional radiology services for uterine artery embolization if needed. Furthermore, prenatal knowledge of PASD severity informs the planning of the optimal surgical approach. In many cases of PASD, particularly increta and percreta, a planned cesarean hysterectomy without attempting placental removal is the safest approach. Attempting to remove the placenta in cases of PASD can lead to catastrophic hemorrhage, necessitating emergency hysterectomy and increasing the risk of complications. The PAI score, by providing a quantitative estimate of risk and potential severity, plays a crucial role in guiding these clinical decisions. For instance, a very high PAI score might prompt more extensive preoperative preparations, such as the placement of ureteric stents to prevent ureteral injury during surgery or planning for more complex pelvic surgery.[17,18]

The diagnostic accuracy of the PAI score in our study, with a sensitivity of 88.6% and specificity of 83.3% (using a cut-off ≥6), suggests that it is a valuable tool for detecting PASD. Sensitivity, the ability of the test to correctly identify women with PASD, is particularly important in clinical practice. A high sensitivity minimizes the risk of false-negative results, which could lead to inadequate preparation and increased maternal morbidity. The 88.6% sensitivity observed in our study indicates that the PAI is effective in identifying most cases of PASD. Specificity, the ability of the test to correctly identify women without PASD, is also important to avoid unnecessary interventions and anxiety. The 83.3% specificity in our study suggests that the PAI has a relatively low false-positive rate. It's important to note that while these results are promising, the optimal PAI cut-off score for predicting PASD may vary across different populations and clinical settings. Further research is needed to validate the PAI and determine the most appropriate cut-off values in diverse populations. Our findings are consistent with a growing body of evidence supporting the use of ultrasound-based scoring systems, including the PAI,

for prenatal PASD assessment. Several studies have demonstrated the clinical utility of these scoring systems in improving prenatal diagnosis and guiding management decisions.[19,20]

5. Conclusion

The Placenta Accreta Index (PAI) demonstrates potential as a valuable clinical tool for the prenatal assessment of Placenta Accreta Spectrum Disorder (PASD). Our study reveals a significant positive correlation between PAI scores and the histopathological severity of PASD, confirming that higher PAI scores are associated with more severe forms of the condition. This correlation supports the use of PAI in predicting the degree of placental invasion, which is critical for effective clinical management. The logistic regression analysis further reinforces the PAI score's utility as a significant predictor of PASD severity. With a sensitivity of 88.6% and specificity of 83.3% at a cut-off of ≥6, the PAI exhibits strong diagnostic accuracy in identifying PASD cases. This level of accuracy can significantly aid clinicians in prenatal risk stratification, surgical planning, and the optimization of obstetric management. The findings of this study contribute to the growing body of evidence supporting the use of ultrasound-based scoring systems like the PAI in the prenatal evaluation of PASD. Implementing PAI in clinical practice can improve the precision of prenatal diagnosis, facilitate timely referrals to tertiary care centers, and enhance preparedness for potential complications such as massive hemorrhage. Ultimately, this leads to better maternal and neonatal outcomes in these high-risk pregnancies.

6. References

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