Experimental
&
Clinical Article

Obstetrics; *Maternal Fetal Medicine and Perinatology*

Predictive Value of the Delta Neutrophil Index for Placenta Accreta in Cases with Placenta Previa

Fikriye KARANFIL YAMAN[1], Sukran DOGRU[2], Huriye EZVECI[1], Fatih AKKUS[1], Emine ARSLAN[3], Elifsena Canan ALP[4], Ali ACAR[1]

Konya, Türkiye

ABSTRACT

OBJECTIVE: This study aimed to investigate the predictive value of the Delta Neutrophil Index (DNI) in detecting placenta accreta spectrum (PAS) in patients with placenta previa (PP).

STUDY DESIGN: retrospective cohort study was conducted on 735 patients diagnosed with PP. Demographic characteristics, laboratory results, and maternal and fetal outcomes were obtained from electronic medical records. DNI levels were assessed with other inflammatory markers, and logistic regression analysis was performed to identify predictors of the PAS. Receiver operating characteristic (ROC) analysis was used to determine the diagnostic accuracy of DNI in distinguishing PAS cases from non-PAS cases.

RESULTS: Logistic regression analysis revealed that the number of previous cesarean sections and DNI levels were significant predictors of the development of PAS (p=0.07). Elevated DNI levels were independently associated with an increased risk of PAS (p<0.05). The optimal cut-off value of DNI for diagnosing PAS was determined as 0.07 with a sensitivity of 67.5% and a specificity of 56.26%. The area under the ROC curve (AUC) for DNI was calculated as 0.639, indicating moderate diagnostic accuracy.

CONCLUSION: This study demonstrates that DNI is a potential predictor of PAS development in cases of PP. Integrating DNI assessment into routine prenatal care protocols in PP patients may facilitate early risk identification and inform clinical management strategies. Further research is needed to confirm these findings and explore the broader applicability of DNI in obstetric practice.

Keywords: Delta neutrophil index; Obstetric care; Placenta accreta; Placenta previa; Predictive biomarker

Gynecol Obstet Reprod Med 2025;31(1):1-8

[1] Necmettin Erbakan University Meram Faculty of Medicine, Clinic of Obstetrics and Gynecology Division of Maternal and Fetal Medicine, Konya, Türkiye
[2] Konya City Hospital, Clinic of Obstetrics and Gynecology Division of Maternal and Fetal Medicine, Konya, Türkiye
[3] Baskent University Istanbul Hospital, Clinic of Obstetrics and Gynecology, Istanbul, Türkiye
[4] Batman Education and Research Hospital, Clinic of Obstetrics and Gynecology, Batman, Türkiye

Address of Correspondence: Fikriye Karanfil Yaman
Hocacihan district, Abdülhamid han Street, no 3 Selcuklu, Konya, Türkiye
fikriyekaranfilyaman@gmail.com

Submitted for Publication: 09.01.2025 Revised for Publication: 05.02.2025
Accepted for Publication: 07.04.2025 Online Published: 11.04.2025

ORCID IDs of the authors:
FKY: 0000-0003-2773-7267
ŞD:0000-0002-3383-2837
HE: 0000-0002-7626-5799
FA:0000-0001-7037-9165
EA:0000-0003-2259-8376
ECA:0000-0002-1956-1014
AA:0009-0006-1474-3958

QR Code	Access this article online
	www.gorm.com.tr • gorm@medicalnetwork.com.tr full magazin: https://mndijital.medicalnetwork.com.tr
	DOI:10.21613/GORM.2025.1572

How to cite this article: *Karanfil Yaman F. Dogru S. Ezveci H. Akkus F. Arslan E. Alp EC. Acar A. Predictive Value of the Delta Neutrophil Index for Placenta Accreta in Cases with Placenta Previa. Gynecol Obstet Reprod Med. 2025;31(1):1-8*

Introduction

Placenta previa (PP) is the localization of the placenta in a way that covers the cervical os. This pathology poses significant risks to maternal and fetal health, especially during delivery. The prevalence of PP is estimated to be 4 to 5 per 1000 deliveries (1). In particular, the prevalence rate is higher in early pregnancy but decreases by delivery time, which is attributed to the resolution of most cases detected early before delivery (2). Major risk factors contributing to PP include a history of previous PP (3,4) and cesarean birth (5,6); 47-60 percent risk escalation is associated with increasing cesarean births (7). Furthermore, multiple gestations, particularly twin pregnancies, confer a 40 percent heightened risk, as evidenced by prevalence rates substantially higher than singleton pregnancies (8). In addition, multiple risk factors, such as maternal age, previous infertility treatment, male fetuses, and abortion, contribute to the complex pathogenesis of PP and necessitate a comprehensive risk assessment during prenatal care (9-11). Placenta accreta is a serious complication often associated with PP and involves the abnormal attachment of the placenta to the uterine wall, which can lead to potentially life-threatening bleeding and adverse outcomes (12). While these disor-

ders have been recognized by clinical science for over a century, recent epidemiological data suggest a concerning trend of increasing incidence, particularly over the last two decades. This rise in prevalence has been predominantly attributed to iatrogenic factors, marking a pivotal shift in the landscape of maternal-fetal health (13). Timely identification of placenta accreta in PP cases is critical to guide management decisions and optimize maternal and neonatal outcomes (14).

Although the pathophysiology of the Placenta Accreta Spectrum (PAS) is not clearly known, it is based on irregular decidualization at the implantation site (15,16). However, it is recognized that processes such as inflammation, neovascularization, hyperperfusion, and apoptosis also play a significant role in the development of PAS cases (17,18). The molecular control of trophoblast cell invasion and the formation of blood vessels in the placenta are crucial for understanding the mechanisms behind PP. Research indicates that various angiogenic growth factors are increased in patients with PAS, implying that inflammation in the uterine endometrium could hinder the proper implantation of the placenta into the decidua (19). The role of inflammation in the pathophysiology suggests that inflammatory markers can be used in the diagnosis of PAS. Detection of PAS cases through these biomarkers may enable the early diagnosis of life-threatening PAS conditions, allowing the implementation of appropriate treatment plans and providing optimal health conditions for both mother and baby.

Recent advances in laboratory medicine have highlighted the potential utility of the Delta Neutrophil Index (DNI) as a predictive biomarker for various inflammatory and infectious conditions. DNI is an important parameter used to assess inflammatory responses and infections and can be affected by conditions such as infections, inflammation, and medication use. Infections can increase the DNI value by causing changes in the neutrophil count, which is considered an indicator of the body's immune response. In addition, treatments such as immunosuppressant drugs and steroids can alter neutrophil function and make DNI difficult to interpret, affecting the accurate assessment of inflammation and infection (20,21). DNI obtained from automated complete blood count (CBC) analysis reflects the proportion of immature granulocytes, especially band neutrophils (22). DNI has emerged as a promising inflammatory marker in various obstetric and gynecological diseases. Studies have investigated its use in polycystic ovary syndrome (PCOS) (23), intrahepatic cholestasis of pregnancy (ICP) (24), diagnosis of cesarean scar pregnancy (25), hyperemesis gravidarum (HEG) (26), gestational diabetes (27), and other pregnancy-related disorders. These findings highlight the importance of DNI in the diagnosis and prognosis prediction of obstetric diseases and require further investigation in clinical practice.

It was stated above that inflammation may play a role in PP and PAS cases, which led to the idea that DNI could be used in these cases. In this study, we aimed to evaluate the role of DNI in predicting PAS cases in PP cases and whether it can predict maternal-fetal outcomes.

Material and Method

This retrospective cohort study was carried out at the Necmettin Erbakan University Faculty of Medicine's Department of Obstetrics and Gynecology, spanning from January 2015 to January 2024. The study received ethical approval from the university's ethics committee (Number: 2024/4920, Application ID: 19067) and adhered to the principles outlined in the Declaration of Helsinki. Participants included pregnant women with PP who were monitored at our clinic, delivered their babies, and had access to complete electronic records. Exclusion criteria included autoimmune diseases, cancers, acute or chronic infections, chronic kidney or liver conditions, hematological issues, recent blood transfusions, fetal anomalies, insufficient data tracking during pregnancy, and deliveries that occurred at other facilities. Data collected comprised demographic information, treatment specifics, laboratory results, pregnancy monitoring details, and perinatal outcomes, all sourced from electronic medical records.

CBC parameters were obtained during the first-trimester assessment, utilizing an automatic cell analyzer to evaluate levels of hemoglobin, leukocytes (LEU), neutrophils (N), lymphocytes (L), platelets (P), platelet distribution width (PDW), mean platelet volume (MPV), and plateletcrit (PCT). Additionally, we computed the platelet-lymphocyte ratio (PLR) and the neutrophil-lymphocyte ratio (NLR).

Maternal age, number of pregnancies, parity, and previous miscarriage history were carefully recorded for each pregnant woman. Gestational age was determined based on the last menstrual period or first-trimester ultrasonography records. The evaluation involved a detailed examination of gestational age, delivery method, neonatal birth weight, APGAR scores at five minutes, rates of admission to the neonatal intensive care unit (NICU), and occurrences of stillbirth. Additional outcomes evaluated included preeclampsia (PE), placental abruption, uterine atony, small-for-gestational-age (SGA) neonates, preterm birth, and rates of premature rupture of membranes (PPROM).

Statistical analysis

Statistical analyses were performed using the SPSS program (Version 22). Continuous variables were reported as mean ± standard deviation (SD) or median (minimum-maximum) values, while categorical variables were presented as numbers and percentages (n (%)). The Kolmogorov-Smirnov test was used to evaluate data normality. To identify predictors of PAS, logistic regression analysis was employed, comparing PAS and non-PAS cases. Variables showing a significant association with PAS in univariate analyses were included in the multivariate model to adjust for confounders.

Results were reported as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). The diagnostic performance of DNI levels for PAS was assessed using receiver operating characteristic (ROC) curve analysis. The area under the ROC curve (AUC) was calculated to determine the diagnostic accuracy of DNI levels in distinguishing PAS cases from non-PAS cases. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated based on the optimal cut-off value identified by the Youden index from the ROC curve. All tests were two-tailed, and a p-value below 0.05 was deemed statistically significant.

Results

This study was conducted on 735 patients diagnosed with PP. The average age of the participants was 36.14 ± 6.19 years, ranging from 20 to 51 years. The vast majority of the patients (97.3%) were of Turkish nationality; a small number were Syrian (2.4%), and patients from other nationalities made up 0.3%. The mean gravidity was 3.02 ± 1.68, mean parity was 1.51 ± 1.26, and the median number of cesarean sections was 0 (Min:0-Max:5). Approximately half of the patients (48.8%) had undergone a cesarean section previously (Table I).

Preoperative and postoperative mean hemoglobin (Hgb) levels were measured at 11.67 ± 1.44 g/dL and 10.90 ± 1.58 g/dL, respectively. The mean white blood cell (WBC) count was 11.94 ± 3.73, and the N count was 9.36 ± 3.68. Other significant parameters included L count, platelet count, RDW, MPV, PCT, and PDW (Table II).

The average operation time was 63.31 ± 26.24 minutes, and the average hospital stay was 2.67 ± 2.82 days. The most common indications for labor included contractions (71.0%), hemorrhage (14.1%), elective labor (9.9%), fetal distress (3.3%), and PE (1.6%). Among the types of anesthesia, general anesthesia (52.9%) was the most preferred, followed by spinal anesthesia (46.9%) and epidural anesthesia (0.1%) (Table III).

The average gestational week at birth was 35.46 ± 2.72, and the mean birth weight was 2752.7 ± 671.9 grams. The proportion of male infants (55.5%) was higher than that of female infants (44.5%). The rate of NICU admissions was 29.5%, with the proportion of newborns having an APGAR score <7 at the 1st minute being 46.3%, and at the 5th minute being 19.9% (Table III).

Table I: *Demographic and obstetric characteristics of placenta previa patients*

n=735		Mean ± SD / n(%)	Median [Min-Max]
Age		36.14 ± 6.19	36 [20-51]
Gravity		3.02 ± 1.68	3 [1-16]
Parity		1.51 ± 1.26	1 [0-9]
Number of C/S		0.86 ± 1.06	0 [0-5]
Nationality	Turkish	715 (97.3%)	
	Syria	18 (2.4%)	
	Other	2 (0.3%)	
Previous C/S History		359 (48.8%)	
Multiple pregnancy		14 (1.9%)	
Presence of PP in advance		3 (0.4%)	

C/S: cesarean section, PP: placenta previa

Table II: *Characteristics of laboratory hematological parameters of placenta previa patients*

n=735	Mean ± SD / n (%)	Median [Min-Max]
Preoperative Hgb	11.67 ± 1.44	11.80 [7.00-15.80]
Postoperative Hgb	10.90 ± 1.58	11.00 [6.60-15.00]
WBC	11.94 ± 3.73	11.30 [4.40-28.82]
Neutrophil	9.36 ± 3.68	8.56 [3.30-26.95]
Lymphocyte	1.83 ± 0.65	1.79 [0.40-4.80]
Platelet	212.75 ± 64.60	206.00 [51.00-669.00]
Immature granulocyte (DNI)	0.11 ± 0.12	0.05 [0.01-0.84]
RDW	14.93 ± 2.38	14.30 [10.80-30.30]
MPV	10.28 ± 1.65	10.30 [5.10-16.20]
PCT	0.24 ± 0.53	0.20 [0.03-14.50]
PDW	15.26 ± 3.17	16.00 [7.00-24.60]

Hgb: hemoglobin, WBC: white blood cell, DNI: Delta neutrophil index, RDW: red cell distribution width, MPV: Mean platelet volume, PCT: platecrit delta, PDW: platelet distribution width.

Table III: *Maternal clinical and operative characteristics and neonatal outcomes of placenta previa patients*

n=735		Mean ± SD / n(%)	Median [Min-Max]
Operation Time (min)		63.31 ± 26.24	60 [25-240]
TX Unit		0.59 ± 1.14	0 [0-6]
Hospitalisation (days)		2.67 ± 2.82	2 [1-59]
Indications for labor	Hemorrhage	104 (14.1%)	
	Contraction	522 (71.0%)	
	Elective labor	73 (9.9%)	
	Fetal distress	24 (3.3%)	
	Preeclampsia	12 (1.6%)	
Maternal DM		48 (6.5%)	
Maternal HT		6 (0.8%)	
Type of anesthesia	General	389 (52.9%)	
	Spinal	345 (46.9%)	
	Epidural	1 (0.1%)	
Transfusion rate		189 (25.7%)	
Maternal Intensive Care Hospitalisation Rate		1 (0.1%)	
PAS positivity		40 (5.4%)	
Birth Week		35.46 ± 2.72	36 [20-40]
Birth Weight (gr)		2752.7 ± 671.9	2840 [190-4680]
FGR		87 (11.8%)	
Gender	Female	327 (44.5%)	
Neonatal Apgar Score <7 (1st min)		340 (46.3%)	
Neonatal Apgar Score <7 (5th min)		146 (19.9%)	
NICU Hospitalisation Rate		217 (29.5%)	

TX: transfusion, DM: diabetes mellitus, HT: hypertension, PAS: placenta accreata spectrum, FGR: fetal growth restriction, NICU: neonatal intensive care unit

Logistic regression analysis identified the number of cesarean sections and the DNI as significant predictors of the PAS status. The odds ratio (OR) for the number of cesarean sections was 1.99 (p=0.001), and for DNI, it was 1.039 (p0.001). The model exhibited a high overall accuracy rate of 94.6% in predicting PAS status, with the area under the receiver operating characteristic (ROC) curve (AUC) calculated as 0.805 (Table IV) (Figure 1).

The most effective cut-off value of DNI in the diagnosis of PAS was found to be 0.07. This value has a sensitivity of 67.5%, specificity of 56.26%, PPV of 8.16%, and NPV of 96.78% with an AUC of 0.639. These results suggest that a cut-off value of 0.07 is a reliable tool for predicting PAS (Figure 2).

Table IV: *Logistic Regression Analysis Results for the Prediction of PAS Status in Placenta Previa Patients*

Predictor	Estimate	SE	Z	p	Odds Ratio	95% CI Lower	95% CI Upper
Intercept	-3.18	1.14	-2.79	0.005	0.04	0.00	0.38
Number of C/S	0.68	0.14	4.88	0.001	1.99	1.51	2.62
Maternal DM	0.96	0.52	1.83	0.068	2.60	0.93	7.28
Maternal HT	1.77	1.13	1.57	0.116	5.88	0.65	53.56
SII	-0.00	0.00	-1.67	0.096	0.999	0.998	1.00
IG(DNI)	0.038	1.14	3.36	0.001	1.039	1.016	1.063
NLR	0.12	0.08	1.57	0.116	1.13	0.97	1.31
PLR	0.01	0.00	1.23	0.220	1.01	0.997	1.02
Age	-0.05	0.03	-1.52	0.128	0.96	0.90	1.01

The logistic regression model had a deviance of 263 and AIC of 281, McFadden R2:0.153, and Nagelkerke R2:0.182. The overall accuracy of the model was 94.6%, specificity 99.7%, and sensitivity 5.0%; AUC was 0.805. C/S: cesarean section, DM: diabetes mellitus, HT: hypertension, SII: systemic inflammatory index, IG(DNI): Immature granulocyte (Delta neutrophil index), NLR: neutrophil-lymphocyte ratio, PLR: platelet-lymphocyte ratio

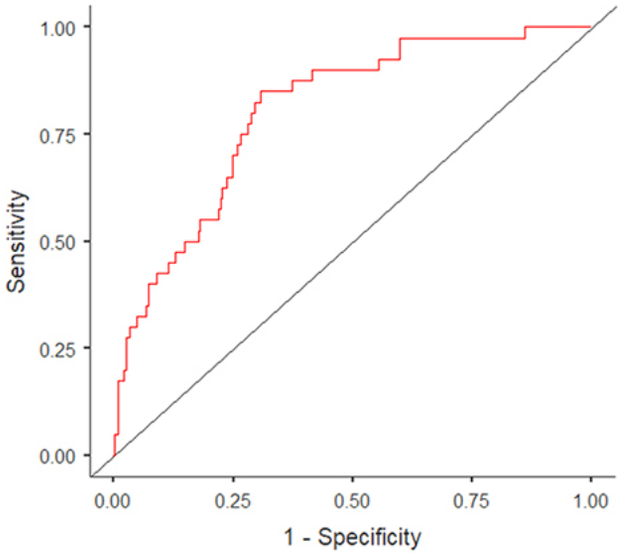

Figure 1: *Showing the performance of the regression model with ROC Curve*

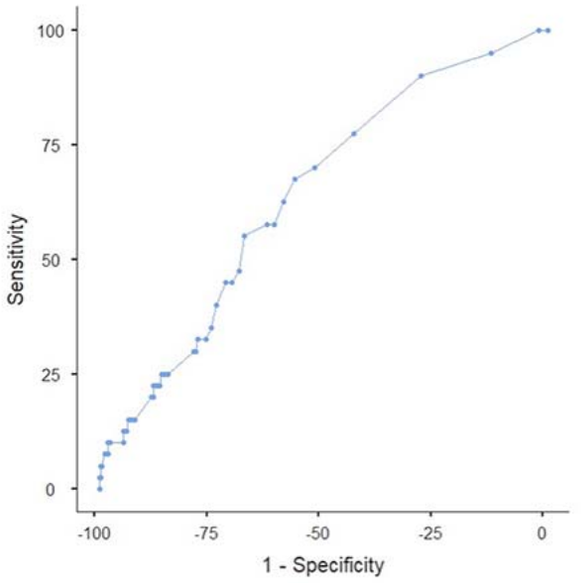

Figure 2: *ROC Curve Analysis of DNI Cut-off Value in the Diagnosis of PAS*

Discussion

Our research results highlight several important insights. Initially, the logistic regression analysis demonstrated that the frequency of cesarean deliveries and DNI levels were notable indicators of PAS condition in patients with PP. This highlights the necessity of taking into account obstetric history, especially the total number of previous cesarean deliveries when evaluating the risk of placenta accreta. This research examines the predictive value of the DNI, an immunological marker that can be easily derived from routine complete blood count (CBC) tests, in forecasting instances of PAS in patients with PP. In this study, the optimal cut-off value for DNI in diagnosing PAS was determined to be 0.07. Furthermore, higher DNI levels were found to be independently linked to a greater risk of placenta accreta, underscoring the potential of this inflammatory marker as a valuable predictive tool in obstetric practice. These results endorse the predictive significance of DNI in forecasting PAS, further validating the conclusions of the earlier study that explored the prognostic value of DNI about PAS. Management of PAS is a complex process in which surgical and conservative strategies are used together. In such cases, uterine protection protocols and conservative approaches should be determined according to the patient's stable condition and bleeding level. Prophylactic endovascular interventions, especially balloon catheter placement and arterial embolization, can be effective in bleeding management, and surgical intervention can be rendered unnecessary (28). Intraoperative interventional radiology use and applications such as angiographic embolization performed on deep pelvic vessels are important to control the risk of postoperative bleeding. In cases of severe bleeding, a planned cesarean hysterectomy is considered the safest option for placental removal (29,30). However, conservative treatments for uterine protection should be carefully evaluated and implemented, especially in patients who wish to have children in the future (29,31). Management of such complex situations should be meticulously performed in hospitals with experienced teams and the necessary medical resources.

PP and its related complications, especially placenta accreta, represent serious threats to both maternal and fetal well-being, highlighting the need for prompt detection and effective management (32). Recent research has indicated a possible link between placenta accreta and the DNI, an emerging biomarker that represents the percentage of circulating immature granulocytes, which serve as an indicator of inflammation (33). The goal of our research was to investigate this relationship and its potential impact on clinical practice. Our results demonstrate a significant correlation between elevated DNI levels and placenta accreta. Patients with a diagnosis of placenta accreta exhibited markedly elevated DNI levels in comparison to the control group, indicating a potential connection between abnormal placental implantation and a systemic inflammatory response. The increased DNI levels seen in patients with placenta accreta highlight the possible value of this biomarker for predicting and diagnosing the condition. As a readily accessible and affordable marker, DNI could provide healthcare professionals with an important tool for identifying patients at risk for placenta accreta, enabling prompt intervention. Timely identification of placenta accreta is crucial for improving maternal outcomes and minimizing related complications, including severe hemorrhage and the necessity for emergency cesarean delivery.

A prospective observational cohort study conducted over four years at 19 academic centers involving 30,132 women undergoing cesarean deliveries without labor demonstrates a significant link between the frequency of cesarean sections and heightened maternal morbidity. The rate of placenta acc-

reta rose steadily with each additional cesarean delivery: 0.24% for the first, 0.31% for the second, 0.57% for the third, 2.13% for the fourth, 2.33% for the fifth, and 6.74% for six or more cesarean deliveries. This underscores a troubling trend of increasing risk associated with multiple procedures (34). In line with the previously mentioned study, our research shows a clear link between the number of cesarean deliveries and the occurrence of placenta accreta.

In a previous study by Tokalioglu et al., the ability of hematological systemic inflammation markers, specifically the NLR, PLR, and SII, to predict the combined adverse outcomes of peripartum hemorrhage and fibrinogen therapy was examined, and it was concluded that they may be helpful to clinicians (35).

A study conducted by Cho et al. found that the severe PE group had significantly elevated DNI levels compared to normal pregnancies (36). The research developed by Yakiştiran et al. also revealed that several inflammatory markers, including NLR, derived NLR, and DNI, were higher in the PE group when compared with healthy controls (37). The study conducted by Eroğlu et al. compared maternal serum DNI levels in cases of intrahepatic pregnancy cholestasis (ICP) with levels observed in healthy pregnancies and showed that DNI levels were significantly higher in women with ICP compared to the control group (24).

The research carried out by Keles A. and colleagues focused on evaluating the effectiveness of the SII in conjunction with various inflammatory parameters for diagnosing PAS and its histological variants (38).

In a retrospective case-control study with 273 participants, significant variations in the SII and additional inflammatory markers were observed between the PAS and PP groups. The findings suggest that the SII could be a valuable predictor of PAS in pregnant individuals diagnosed with PP (38). The study carried out by Farisoğullari et al. aimed to differentiate between individuals with PAS and those experiencing PP by measuring maternal serum concentrations of vascular endothelial growth factor (VEGF), tumor necrosis factor-alpha (TNF-alpha), interleukin-4 (IL-4), and interleukin-10 (IL-10). Results indicated that patients with PAS exhibited significantly higher levels of VEGF, TNF-alpha, and IL-4, along with lower levels of IL-10 when compared to those with PP. The research suggests that assessing IL-10 levels, alongside factors such as a history of prior cesarean deliveries, preoperative hemoglobin levels, and TNF-alpha, could improve the clinical diagnosis of PAS in cases of PP, highlighting the potential utility of cytokines as additional biomarkers for this condition (39). The Aggregate Systemic Inflammation Index (AISI) can be used to predict the risk of chorioamnionitis and NICU admission in cases of premature rupture of membranes according to a study by Tokalioglu et al (40). Finding dependable biomarkers for PAS is essential for enhancing prenatal care and improving outcomes for both mothers and newborns. Conventional diagnostic methods for PAS, such as ultrasound and magnetic resonance imaging (MRI), are useful but can be restricted by factors such as accessibility, cost, and the level of expertise available. In contrast, the DNI, derived from routine complete blood count (CBC) analysis offers a readily available, cost-effective, and non-invasive alternative for PAS risk stratification in obstetric practice.

Limitations and strengths: This was a retrospective analysis conducted at a single tertiary facility, the findings may not be generalizable to broader populations. Furthermore, the sample size of placenta accreta cases was comparatively small, which could have influenced the statistical power of our analyses. Future prospective research involving larger cohorts is necessary to confirm our findings and to further clarify the clinical usefulness of DNI in forecasting placenta accreta.

It is crucial to acknowledge the strengths of our study DNI as a predictive biomarker for detecting PAS in cases of PP. With a large sample size and robust statistical analysis, the research demonstrates DNI's diagnostic accuracy in predicting PAS. The study's findings suggest that integrating DNI into routine prenatal care can improve early risk identification and guide management strategies. Additionally, DNI offers a non-invasive and cost-effective method, making it a practical tool in obstetric practice.

Conclusion

This research offers initial evidence that suggests DNI may serve as a predictive biomarker for placenta accreta in cases of PP. Incorporating DNI into standard prenatal care procedures could enhance the early detection of high-risk pregnancies, inform suitable management approaches, and ultimately lead to better outcomes for both mothers and their babies. Further research is needed to validate these results and explore the wider relevance of DNI in obstetric practice and clinical applications.

Declarations
Funding: None declared.
Ethical approval: Research with human subjects complies with all relevant national regulations and institutional policies and the principles of the Declaration of Helsinki (revised in 2013) and was approved by the NEU Ethics Committee with the decree numbered 2024/4920(19067).
Authors' contributions: Fikriye Karanfil Yaman and Sukran Dogru planned and designed the study on the effect of parity on perinatal outcomes in patients with placenta previa. Fatih Akkuş and Huriye Ezveci processed the data, contributed to the data analysis, and interpreted them. Fikriye Karanfil Yaman was responsible for preparing and developing the first draft of the manuscript. Elif Sena Canan Alp processed the data and Emine Arslan contributed to the writing of the article. All authors contributed to the writing of the article, and

the final draft was collected. All authors participated in data analysis, interpretation, and editing of the manuscript. All authors took part in data collection and interpretation of the results. Sukran Dogru, Huriye Ezveci, and Fikriye Karanfil Yaman critically reviewed the manuscript. Ali Acar contributed at all stages. All authors read and collected the final manuscript. All authors have accepted responsibility for the entire content of this manuscript and approved its submission.
Acknowledgements: Thanks to all colleagues. Informed consent was obtained from all parents included in this study.
Disclosure: Authors state no conflict of interest.

References

1. Faiz AS, Ananth CV. Etiology and risk factors for placenta previa: an overview and meta-analysis of observational studies. J Matern Fetal Neonatal Med. 2003; 13(3): 175-90. Doi: 10.1080/jmf.13.3.175.190. PMID:12820840.
2. Sinclair S, Masters HR, DeFranco E, Rountree S, Warshak CR. Universal transvaginal cervical length screening during pregnancy increases the diagnostic incidence of low-lying placenta and placenta previa. Am J Obstet Gynecol MFM. 2021;3(1):100255. Doi: 10.1016/j.ajogmf.2020.100255. PMID: 33451594.
3. Roberts CL, Algert CS, Warrendorf J, Olive EC, Morris JM, Ford JB. Trends and recurrence of placenta praevia: a population-based study. Aust N Z J Obstet Gynaecol. 2012;52(5):483-6. Doi: 10.1111/j.1479-828X.2012.01470.x. PMID: 22862285.
4. Yaman FK, Dogru S, Ezveci H, Akkus F, Acar A. Parity-driven disparities in placenta previa: a comprehensive analysis of obstetric and perinatal factors. Gynecol Obstet Reprod Med. 2024;30(3):174-9. Doi: 10.21613/GORM.2023.1524.
5. Downes KL, Hinkle SN, Sjaarda LA, Albert PS, Grantz KL. Previous prelabor or intrapartum cesarean delivery and risk of placenta previa. Am J Obstet Gynecol. 2015; 212(5):669.e1-6. Doi: 10.1016/j.ajog.2015.01.004. PMID: 25576818, PMCID: PMC4416991.
6. Doğru Ş, Akkuş F, Atci AA, Metin Ü S, Uyar M, Acar A. Fetal and maternal outcomes of segmental uterine resection in emergency and planned placenta percreta deliveries. Obstet Gynecol Sci. 2024;67(1):58-66. Doi: 10.5468/ogs.23154. PMID: 38044617, PMCID: PMC107 92304.
7. Klar M, Michels KB. Cesarean section and placental disorders in subsequent pregnancies-a meta-analysis. J Perinat Med. 2014;42(5):571-83. Doi: 10.1515/jpm-2013-0199. PMID: 24566357.
8. Ananth CV, Demissie K, Smulian JC, Vintzileos AM. Placenta previa in singleton and twin births in the United States, 1989 through 1998: a comparison of risk factor profiles and associated conditions. Am J Obstet Gynecol. 2003;188(1):275-81. Doi: 10.1067/mob.2003.10. PMID: 12548229.
9. King LJ, Dhanya Mackeen A, Nordberg C, Paglia MJ. Maternal risk factors associated with persistent placenta previa. Placenta. 2020;99:189-92. Doi: 10.1016/j.placenta.2020.08.004. PMID: 32854040.
10. Long SY, Yang Q, Chi R, Luo L, Xiong X, Chen ZQ. Maternal and neonatal outcomes resulting from antepartum hemorrhage in women with placenta previa and its associated risk factors: a single-center retrospective study. Ther Clin Risk Manag. 2021;17:31-8. Doi: 10.2147/tcrm.S288461. PMID: 33469297, PMCID: PMC7811482.
11. Ezveci H, Doğru Ş, Yaman Fk, Ali A. Effects of timing of delivery on maternal and neonatal outcomes in pregnant women with placenta previa: case control research in a single tertiary center. JCOG. 2024;34(4):141-8. Doi: 10.5336/jcog.2024-105820.
12. Liu X, Wang Y, Wu Y, Zeng J, Yuan X, Tong C, et al. What we know about placenta accreta spectrum (PAS). Eur J Obstet Gynecol Reprod Biol. 2021;259:81-9. Doi: 10.1016/j.ejogrb.2021.02.001. PMID: 33601317.
13. Jauniaux E, Moffett A, Burton GJ. Placental Implantation Disorders. Obstet Gynecol Clin North Am. 2020;47(1): 117-32. Doi:10.1016/j.ogc.2019.10.002. PMID:32008663.
14. Kingdom JC, Hobson SR, Murji A, Allen L, Windrim RC, Lockhart E, et al. Minimizing surgical blood loss at cesarean hysterectomy for placenta previa with evidence of placenta increta or placenta percreta: the state of play in 2020. Am J Obstet Gynecol. 2020;223(3):322-9. Doi: 10.1016/j.ajog.2020.01.044. PMID: 32007492, PMCID: PMC8725207.
15. Jauniaux E, Ayres-de-Campos D, Langhoff-Roos J, Fox KA, Collins S. FIGO classification for the clinical diagnosis of placenta accreta spectrum disorders. Int J Gynaecol Obstet. 2019;146(1):20-4. Doi:10.1002/ijgo.12761. PMID: 31173360.
16. Tantbirojn P, Crum CP, Parast MM. Pathophysiology of placenta creta: the role of decidua and extravillous trophoblast. Placenta. 2008;29(7):639-45. Doi: 10.1016/j.placenta. 2008.04.008. PMID: 18514815.
17. Bartels HC, Postle JD, Downey P, Brennan DJ. Placenta accreta spectrum: a review of pathology, molecular biology, and biomarkers. Dis Markers. 2018;2018:1507674. Doi: 10.1155/2018/1507674. PMID: 30057649, PMCID: PMC6051104.
18. Ernst LM, Linn RL, Minturn L, Miller ES. Placental pathologic associations with morbidly adherent placenta: potential insights into pathogenesis. Pediatr Dev Pathol. 2017;20(5):387-93. Doi: 10.1177/1093526617698600. PMID: 28812469.
19. Jauniaux E, Alfirevic Z, Bhide AG, Belfort MA, Burton GJ, Collins SL, et al. Placenta praevia and placenta accreta: diagnosis and management: Green-top Guideline No. 27a. BJOG. 2019;126(1):e1-e48. Doi:10.1111/1471-0528.15306. PMID: 30260097.
20. Kim MJ, Choi WH, Cheong JC, Choi SY, Kim JW, Park

JH. Delta neutrophil index and symptomatic time are effective factors for predicting perforated appendicitis. Medicine (Baltimore). 2021;100(20):e25935. Doi:10.1097/md.0000000000025935. PMID: 34011068, PMCID: PMC8137091.

21. Park SY, Lee JS, Oh J, Park JY. Delta neutrophil index as a predictive and prognostic factor for Candidemia patients: a matched case-control study. BMC Infect Dis. 2020;20(1):396. Doi: 10.1186/s12879-020-05117-0. PMID: 32503442, PMCID: PMC7275408.
22. Soh JS, Lim SW. Delta neutrophil index as a prognostic marker in emergent abdominal surgery. J Clin Lab Anal. 2019;33(6):e22895. Doi: 10.1002/jcla.22895. PMID: 30985959, PMCID: PMC6642298.
23. Günday ÖK, Yılmazer M. Delta neutrophil index in obese and non-obese polycystic ovary syndrome patients. Obstet Gynecol Sci. 2023;66(5):441-8. Doi: 10.5468/ogs.22310. PMID: 37500074; PMCID: PMC10514584.
24. Eroğlu H, Şahin Uysal N, Sarsmaz K, Tonyalı NV, Codal B, Yücel A. Increased serum delta neutrophil index levels are associated with intrahepatic cholestasis of pregnancy. J Obstet Gynaecol Res. 2021;47(12):4189-95. Doi: 10.1111/jog.15028. PMID: 34532934.
25. Dogru S, Atci AA, Akkus F, Erdogan AC, Acar A. Predictability of hematological parameters in the diagnosis of cesarean scar pregnancy. J Lab Physicians. 2023; 15(3): 425-30. Doi: 10.1055/s-0043-1761929. PMID: 37564226, PMCID: PMC10411160.
26. Dal Y, Akkuş F, Karagün Ş, Çolak H, Coşkun A. Are serum delta neutrophil index and other inflammatory marker levels different in hyperemesis gravidarum? J Obstet Gynaecol Res. 2023;49(3):828-34. Doi: 10.1111/jog.15542. PMID: 36627732.
27. Şahin Uysal N, Eroğlu H, Özcan Ç, Şahin D, Yücel A. Is the serum delta neutrophil index level different in gestational diabetic women? J Matern Fetal Neonatal Med. 2020;33(19):3349-54. Doi: 10.1080/14767058.2020.1760833. PMID:32366136.
28. Cali G, Forlani F, Giambanco L, Amico ML, Vallone M, Puccio G, et al. Prophylactic use of intravascular balloon catheters in women with placenta accreta, increta and percreta. Eur J Obstet Gynecol Reprod Biol. 2014;179:36-41. Doi: 10.1016/j.ejogrb.2014.05.007. PMID: 24965977.
29. Clausen C, Lönn L, Langhoff-Roos J. Management of placenta percreta: a review of published cases. Acta Obstet Gynecol Scand. 2014;93(2):138-43. Doi: 10.1111/aogs.12295. PMID: 24266548.
30. Overton E, Wen T, Friedman AM, Azad H, Nhan-Chang CL, Booker WA, et al. Outcomes associated with peripartum hysterectomy in the setting of placenta accreta spectrum disorder. Am J Obstet Gynecol MFM. 2023;5(12): 101174. Doi: 10.1016/j.ajogmf.2023.101174. PMID:37802412.
31. Acar A, Ercan F, Pekin A, Elci Atilgan A, Sayal HB, Balci O, et al. Conservative management of placental invasion anomalies with an intracavitary suture technique. Int J Gynaecol Obstet. 2018;143(2):184-90. Doi: 10.1002/ijgo.12593. PMID: 29989156.
32. Silver RM. Abnormal placentation: placenta previa, vasa previa, and placenta accreta. Obstet Gynecol. 2015;126(3):654-68. Doi: 10.1097/aog.0000000000001005. PMID: 26244528.
33. Karakoç G, Yalcin SE, Yavuz A, Sarsmaz K, Şengül M, Yucel A. Delta Neutrophil Index as a promising biomarker for placental implantation disorders. Z Geburtshilfe Neonatol. 2021;225(5):412-7. Doi: 10.1055/a-1509-3676. PMID: 34256391.
34. Silver RM, Landon MB, Rouse DJ, Leveno KJ, Spong CY, Thom EA, et al. Maternal morbidity associated with multiple repeat cesarean deliveries. Obstet Gynecol. 2006;107(6):1226-32. Doi: 10.1097/01.Aog. 0000219750.79480.84. PMID: 16738145.
35. Tokalioglu EO, Tanacan A, Agaoglu MO, Özkavak O, Atalay A, Uzuner P, et al. The role of systemic inflammatory indices in predicting composite adverse outcomes of peripartum hemorrhage treated with fibrinogen concentrate. Indian J Hematol Blood Transfus. 2024. Doi:10.1007/s12288-024-01905-9.
36. Cho HY, Jung I, Kim SJ, Park YW, Kim YH, Kwon JY. Increased delta neutrophil index in women with severe preeclampsia. Am J Reprod Immunol. 2017;78(3): e12705. Doi: 10.1111/aji.12705. PMID: 28497869.
37. Yakiştiran B, Tanaçan A, Altinboğa O, Erol A, Şenel S, Elbayiyev S, et al. Role of derived neutrophil-to-lymphocyte ratio, uric acid-to-creatinine ratio and Delta neutrophil index for predicting neonatal outcomes in pregnancies with preeclampsia. J Obstet Gynaecol. 2022;42(6):1835-40. Doi: 10.1080/01443615.2022.2040968. PMID: 35290156.
38. Keles A, Dagdeviren G, Yucel Celik O, Karatas Sahin E, Obut M, Cayonu Kahraman N, et al. Systemic immune-inflammation index to predict placenta accreta spectrum and its histological subtypes. J Obstet Gynaecol Res. 2022;48(7):1675-82. Doi: 10.1111/jog.15254. PMID: 35365935.
39. Farisoğullari N, Tanaçan A, Sakcak B, Denizli R, Baştemur AG, Başaran E, et al. Evaluation of maternal serum VEGF, TNF-alpha, IL-4, and IL-10 levels in differentiating placenta accreta spectrum from isolated placenta previa. Cytokine. 2024;176:156513. Doi: 10.1016/j.cyto.2024.156513. PMID: 38262117.
40. Tokalioglu EO, Tanacan A, Agaoglu MO, Özbebek ÜG, Okutucu G, Kayaalp H, et al. Aggregate index of systemic inflammation: A novel systemic inflammatory index for prediction of neonatal outcomes and chorioamnionitis in women with preterm premature rupture of membranes. Int J Gynaecol Obstet. 2025;168(2):640-9. Doi: 10.1002/ijgo.15868. PMID: 39157934.