Am J Clin Exp Immunol 2026;15(4):269-276
www.ajcei.us /ISSN:2164-7712/AJCEI0175619

*Original Article*

# Association of early-pregnancy platelet-to-high-density lipoprotein cholesterol ratio with preeclampsia: a retrospective cohort study

Feifei Wang[1*], Andi Wang[2*], Dong Jiang[2], Chunhua Lin[2], Wenyu Fu[2], Longwei Qiao[2], Jian Sun[2]

*[1]Department of Nursing, Zhejiang Xinda Hospital, School of Medicine and Nursing, Huzhou Normal University, Huzhou 313000, Zhejiang, China; [2]School of Gusu, The Affiliated Suzhou Hospital of Nanjing Medical University, Nanjing Medical University, No. 26 Daoqian Street, Suzhou 215002, Jiangsu, China. [*]Equal contributors.*

Received July 25, 2026; Accepted August 16, 2026; Epub August 25, 2026; Published August 30, 2026

**Abstract:** Background: Preeclampsia (PE) is a major cause of poor maternal and perinatal outcomes. While a number of biophysical and biochemical markers have been explored for early prediction, there is a need for low-cost accessible markers. The platelet-to-high-density lipoprotein cholesterol ratio (PHR) might reflect the combined effects of impaired platelet function, inflammatory thrombosis and reduced protection against vascular injury. Methods: This retrospective cohort included 11,618 pregnancies assessed in early pregnancy. PHR, calculated from platelet count and high-density lipoprotein cholesterol, was analyzed per 10-unit increment. Logistic regression assessed associations with PE, subgroup analyses examined major phenotypes, and receiver operating characteristic analyses compared individual discrimination with mean arterial pressure multiples of the median (MAP MoM) and placental growth factor multiples of the median (PlGF MoM) values. Results: Among 11,618 pregnancies, 468 women (4.03%) developed PE. Median PHR per 10 was lower among women who developed PE than among those who did not (15.07 [IQR, 11.93-18.24] vs. 19.05 [IQR, 16.82-21.75]; P<0.001). In multivariable analyses controlling for maternal age, body mass index before pregnancy, parity, type of gestation, and conception by in vitro fertilization, every 10-point rise in PHR was linked to a reduced likelihood of PE (adjusted odds ratio, 0.69; 95% CI, 0.67-0.72; P<0.001). PHR values were significantly decreased in early-onset, preterm, and late-onset PE compared with pregnancies without PE (all P<0.01), but did not differ significantly across these three subtypes. Among participants with available Fetal Medicine Foundation (FMF) screening data, the AUCs were 0.732 (95% CI, 0.693-0.771) for PHR, 0.702 (95% CI, 0.669-0.738) for MAP MoM, and 0.606 (95% CI, 0.570-0.638) for PlGF MoM. Conclusion: Lower early-pregnancy PHR was independently associated with subsequent PE. PHR had the highest AUC point estimate among the three individual biomarkers evaluated.

**Keywords:** Preeclampsia, platelet count, high-density lipoprotein cholesterol, early pregnancy, risk stratification

## Introduction

Preeclampsia (PE) continues to be one of the major causes of maternal and perinatal morbidity and mortality worldwide, and early detection of high-risk pregnancies is a significant unsolved problem in obstetric practice. Though first-trimester prediction has been enhanced by adding maternal factors, mean arterial pressure, uterine artery Doppler indices, and placental angiogenic markers [1, 2], application has been inconsistent across clinical settings, and more straightforward biomarkers that could be measured with routine laboratory testing are still required [3].

PE is a clinically diverse gestational condition associated with defective placental development, immune-metabolic remodeling, defective decidualization, impaired trophoblast invasion, placental senescence, and dysregulated extracellular vesicle signaling [4-8]. Recent studies have identified several molecular changes that may contribute to these processes. Placenta-specific chimeric RNAs, for example, have been proposed as candidate diagnostic biomarkers, whereas FTO-mediated m6A modification has been linked to impaired decidualization in PE [9, 10]. Multi-omics analyses have further suggested that early- and late-onset PE share several placental stress pathways but differ in the

https://doi.org/10.62347/IHVE5947

relative contribution of inflammatory and metabolic disturbances. Clinical translation, however, remains slow. Most emerging biomarkers require specialized platforms, complex laboratory procedures, or further external validation before they can be incorporated into routine prenatal care. Thus, there remains a need for easy, cheap and accessible markers.

Routine clinical phenotypes and data-driven approaches have been widely investigated as tools for precision risk management [11-14]. Recent studies have further shown that first-trimester blood count-derived inflammatory indices and routinely available hematological markers may contribute to early PE risk assessment [15, 16]. Integrating such laboratory variables with maternal characteristics and established screening parameters through machine-learning approaches may further improve risk stratification [16, 17]. Against this background, the platelet-to-high-density lipoprotein cholesterol (HDL-C) ratio (PHR) can be a convenient and readily available marker. Its biological relevance is supported by the concurrent involvement of platelet dysregulation and HDL-related vascular dysfunction in PE. Pooled analyses have shown that platelet counts are generally lower in affected pregnancies, with reductions detectable before clinical diagnosis in some cohorts [3]. In the meantime, increased platelet activation and modified platelet-associated transcriptional patterns have also been observed, which indicates that platelet activation and consumption can be concurrent [3, 18, 19]. HDL is also impacted. Its circulating concentration and vasoprotective activities could be compromised in PE, and Mendelian randomization studies suggest that high levels of HDL cholesterol could be associated with reduced disease susceptibility [20, 21]. Recent evidence has also linked early-pregnancy HDL-related inflammatory indices, including PHR, with subsequent PE risk [22]. PHR can potentially indicate the balance between thrombo-inflammatory activity and impaired vascular protection by combining 2 routinely measured parameters. However, evidence regarding its consistency across populations and PE phenotypes remains limited.

It is against this background that the relationship between early-pregnancy PHR and the subsequent occurrence of PE was assessed in a retrospective cohort of 11,618 pregnancies. Moreover, the distribution of PHR among major PE phenotypes and its separate discriminatory ability compared to mean arterial pressure multiples of the median (MAP MoM) and placental growth factor multiples of the median (PlGF MoM) were also evaluated, to determine the potential of PHR as an easily accessible additional marker to assess risk early on.

## Materials and methods

### *Study design and participants*

This retrospective cohort analysis enrolled pregnant individuals with documented pregnancy outcomes and available platelet count and HDL-C results measured at 8-14 gestational weeks. Eligible participants were required to have complete clinical information relevant to the analysis and platelet count and HDL-C measurements obtained during the same early-pregnancy assessment. Pregnancies were excluded if key exposure or outcome data were missing or if participants had preexisting chronic hypertension, pregestational diabetes, clinically significant cardiovascular disease, hematological disorders, lipid-lowering treatment, or other maternal conditions that could substantially affect platelet count or HDL-C levels. After eligibility assessment, 11,618 pregnancies were included in the final analysis, among which 468 pregnancies were subsequently complicated by PE and 11,150 served as the non-PE comparison group. PE was diagnosed according to the American College of Obstetricians and Gynecologists (ACOG) criteria. Briefly, PE was defined as new-onset hypertension after 20 weeks of gestation (systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg) accompanied by proteinuria or, in its absence, relevant maternal organ dysfunction. For phenotype analyses, PE cases were classified by gestational age at delivery as early-onset PE (<34 weeks), preterm PE (34 to <37 weeks), and late-onset PE (≥37 weeks). The primary exposure of interest was the PHR, selected because PE has been characterized by platelet dysregulation and abnormal vascular or lipid biology in contemporary mechanistic work.

### *Clinical variables and biomarker definitions*

Maternal demographic and obstetric characteristics were extracted from electronic health

**Table 1.** Baseline demographic and obstetric characteristics of the study population

| Variables | Total (n=11618) | Non-PE (n=11150) | PE (n=468) | Statistic | *P* |
|---|---|---|---|---|---|
| Age, year, M ($Q_1$, $Q_3$) | 31.00 (28.00, 34.00) | 31.00 (28.00, 34.00) | 32.00 (29.00, 35.00) | Z=-3.95 | <0.001 |
| BMI, kg/m$^2$, M ($Q_1$, $Q_3$) | 21.85 (20.20, 23.87) | 21.79 (20.20, 23.74) | 24.10 (21.47, 26.62) | Z=-12.70 | <0.001 |
| Gravidity, M ($Q_1$, $Q_3$) | 2.00 (1.00, 2.00) | 2.00 (1.00, 2.00) | 2.00 (1.00, 2.00) | Z=-0.65 | 0.519 |
| Gestational age, M ($Q_1$, $Q_3$) | 12.43 (11.86, 13.00) | 12.43 (11.86, 13.00) | 12.29 (11.71, 13.00) | Z=-1.83 | 0.067 |
| PHR per10, M ($Q_1$, $Q_3$) | 18.94 (16.67, 21.68) | 19.05 (16.82, 21.75) | 15.07 (11.93, 18.24) | Z=-18.64 | <0.001 |
| Parity, M ($Q_1$, $Q_3$) | 0.00 (0.00, 1.00) | 0.00 (0.00, 1.00) | 0.00 (0.00, 1.00) | Z=-3.54 | <0.001 |
| Pregnancy type, n (%) | | | | $\chi^2$=287.73 | <0.001 |
| Singleton | 11442 (98.49) | 11025 (98.88) | 417 (89.10) | | |
| Multifetal | 176 (1.51) | 125 (1.12) | 51 (10.90) | | |
| IVF, n (%) | | | | $\chi^2$=150.52 | <0.001 |
| No | 10552 (90.82) | 10202 (91.50) | 350 (74.79) | | |
| Yes | 1066 (9.18) | 948 (8.50) | 118 (25.21) | | |

Z: Mann-Whitney test, $\chi^2$: Chi-square test, M: Median, $Q_1$: 1st Quartile, $Q_3$: 3rd Quartile.

records, comprising age, body mass index (BMI), number of pregnancies and births, type of gestation, conception method, and gestational week at evaluation. Pregnancy type was classified as singleton versus multifetal gestation. In vitro fertilization (IVF) conception was analyzed as a binary variable. PHR was calculated as platelet count (×10$^9$/L) divided by HDL-C concentration (mmol/L), with both measurements obtained during the same early-pregnancy assessment. PHR was treated as a continuous variable. For logistic regression, PHR was scaled per 10-unit increment to facilitate interpretation because the absolute PHR values were relatively large. Accordingly, the reported odds ratio (OR) represents the change in PE odds associated with each 10-unit increase in the original PHR value.

For analyses involving established first-trimester screening biomarkers, only participants with available Fetal Medicine Foundation (FMF) screening data were included (n=6454). MAP and PlGF were assessed at 8-14 weeks of gestation as part of early-pregnancy screening and converted to multiples of the median (MoM) to account for gestational-age-related variation. MAP MoM and PlGF MoM were subsequently used as comparator biomarkers in the ROC analysis.

*Statistical analysis*

Continuous data were described using medians and interquartile ranges, whereas categorical measures were presented as frequencies and proportions. Univariable and adjusted logistic regression models were fitted to derive OR with 95% confidence intervals (CIs). PHR distributions were also compared across controls and PE phenotypes, with pairwise contrasts reported where applicable. The discriminative ability of PHR, MAP MoM, and PlGF MoM was assessed by receiver operating characteristic (ROC) analysis, and the corresponding area under the curves (AUCs) and 95% CIs were estimated. The AUC of PHR was compared with those of MAP MoM and PlGF MoM using DeLong's test. Statistical analyses were conducted in R software, version 4.3.3. Statistical significance was defined as a 2-tailed *P* value <0.05.

## Results

*Baseline characteristics of the study population*

The final analytic cohort comprised 11,618 pregnant participants, of whom 468 developed PE, corresponding to an incidence of 4.03% (**Table 1**). The remaining 11,150 women were included in the non-PE group. Women who developed PE were slightly older than those without PE, with median ages of 32 years (interquartile range [IQR], 29-35) and 31 years (IQR, 28-34), respectively (P<0.001). Pregestational BMI was likewise significantly elevated among women with PE compared with those without PE [24.10 (IQR, 21.47-26.62) vs. 21.79 (IQR, 20.20-23.74) kg/m$^2$, P<0.001].

In contrast, PHR per 10 was lower among women who developed PE [15.07 (IQR, 11.93-

**Table 2.** Univariable and multivariable logistic regression analyses of factors associated with PE

| Variables | Univariable | | | | | Multivariable | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | β | S.E | Z | *P* | OR (95% CI) | β | S.E | Z | *P* | OR (95% CI) |
| Parity | -0.31 | 0.10 | -3.12 | 0.002 | 0.73 (0.60-0.89) | -0.60 | 0.12 | -4.84 | <0.001 | 0.55 (0.43-0.70) |
| Pregnancy type | | | | | | | | | | |
| Singleton | | | | | 1.00 (Reference) | | | | | 1.00 (Reference) |
| Multifetal | 2.38 | 0.17 | 13.71 | <0.001 | 10.79 (7.68-15.16) | 1.94 | 0.22 | 8.64 | <0.001 | 6.94 (4.47-10.76) |
| IVF | | | | | | | | | | |
| No | | | | | 1.00 (Reference) | | | | | 1.00 (Reference) |
| Yes | 1.29 | 0.11 | 11.53 | <0.001 | 3.63 (2.91-4.52) | 0.91 | 0.14 | 6.48 | <0.001 | 2.48 (1.88-3.27) |
| Age | 0.05 | 0.01 | 4.19 | <0.001 | 1.05 (1.03-1.08) | 0.03 | 0.02 | 2.22 | 0.027 | 1.03 (1.01-1.06) |
| BMI | 0.20 | 0.01 | 15.71 | <0.001 | 1.23 (1.20-1.26) | 0.28 | 0.02 | 17.76 | <0.001 | 1.32 (1.28-1.36) |
| Gravidity | 0.03 | 0.04 | 0.82 | 0.415 | 1.03 (0.95-1.12) | | | | | |
| Gestational age | -0.07 | 0.05 | -1.36 | 0.175 | 0.93 (0.84-1.03) | | | | | |
| PHR per10 | -0.34 | 0.02 | -20.90 | <0.001 | 0.71 (0.69-0.74) | -0.37 | 0.02 | -21.10 | <0.001 | 0.69 (0.67-0.72) |

OR: Odds Ratio, CI: Confidence Interval.

18.24)] than among those without PE [19.05 (IQR, 16.82-21.75); P<0.001]. IVF conception was more frequent in the PE group than in the non-PE group (25.21% vs. 8.50%, P<0.001). Multiple gestation was likewise more common among women with PE (10.90% vs. 1.12%, P<0.001). Although the median parity was 0 in both groups, the overall distribution of parity differed significantly (P<0.001). Gravidity and gestational age at evaluation were comparable between the two groups (P=0.519 and P=0.067, respectively).

*Factors associated with PE*

In univariable logistic regression analyses, parity, pregnancy type, IVF conception, maternal age, BMI, and PHR per 10 were associated with the occurrence of PE (**Table 2**). Higher parity was associated with lower odds of PE (OR, 0.73; 95% CI, 0.60-0.89; P=0.002). Women with multifetal gestations had substantially higher odds of PE than those with singleton pregnancies (OR, 10.79; 95% CI, 7.68-15.16; P<0.001). IVF conception was also associated with an increased likelihood of PE (OR, 3.63; 95% CI, 2.91-4.52; P<0.001). The odds of PE increased with maternal age (OR per year, 1.05; 95% CI, 1.03-1.08; P<0.001) and BMI (OR per kg/m$^2$, 1.23; 95% CI, 1.20-1.26; P< 0.001), whereas a higher PHR per 10 was inversely associated with PE (OR, 0.71; 95% CI, 0.69-0.74; P<0.001). Neither gravidity nor gestational age showed a significant association with PE (P=0.415 and P=0.175, respectively).

In the multivariable model, parity remained inversely associated with PE (adjusted OR [aOR], 0.55; 95% CI, 0.43-0.70; P<0.001). Multifetal pregnancy was independently associated with higher odds of PE (aOR, 6.94; 95% CI, 4.47-10.76; P<0.001), as was IVF conception (aOR, 2.48; 95% CI, 1.88-3.27; P<0.001). Maternal age showed a modest independent association with PE (aOR per year, 1.03; 95% CI, 1.01-1.06; P=0.027), whereas the association with BMI was more pronounced (aOR per kg/m$^2$, 1.32; 95% CI, 1.28-1.36; P<0.001). PHR per 10 remained inversely associated with PE after adjustment (aOR, 0.69; 95% CI, 0.67-0.72; P<0.001).

*Distribution of PHR across PE subtypes*

PHR per 10 differed significantly across the four study groups (**Figure 1**). Relative to unaffected pregnancies, 10-unit-scaled PHR values were significantly reduced in early-onset, preterm, and late-onset PE (all P<0.01). However, PHR did not differ significantly across the three PE phenotypes. These findings indicate that the reduction in PHR was consistently present across different PE phenotypes rather than being restricted to a particular gestational subtype.

*Discriminative performance of individual biomarkers*

Among the 6,454 participants with available FMF screening data, ROC analysis yielded an AUC of 0.732 (95% CI, 0.693-0.771) for PHR,

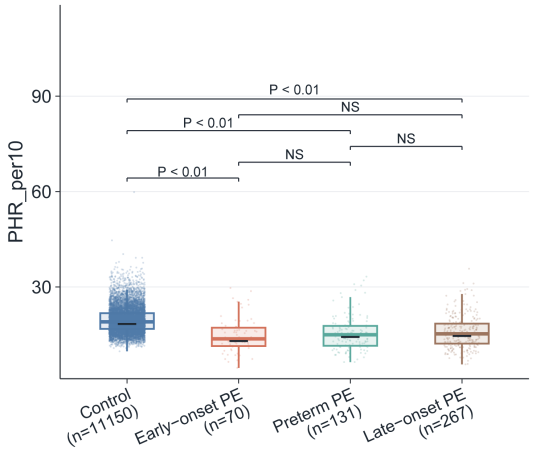


**Figure 1.** Distribution of PHR per 10 among controls and women with different preeclampsia (PE) subtypes. PE subtypes were classified according to gestational age at delivery as early-onset PE (<34 weeks), preterm PE (34 to <37 weeks), and late-onset PE (≥37 weeks).

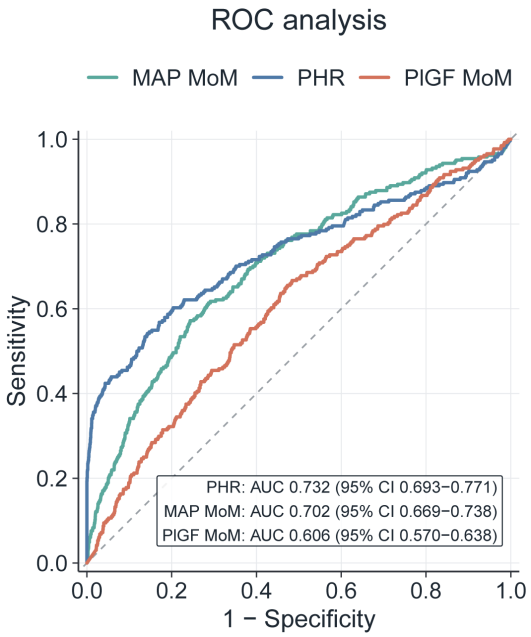


**Figure 2.** Receiver operating characteristic curves for PHR, MAP MoM, and PIGF MoM.

0.702 (95% CI, 0.669-0.738) for MAP MoM, and 0.606 (95% CI, 0.570-0.638) for PIGF MoM (**Figure 2**). Pairwise comparisons using DeLong's test showed that the AUC of PHR did not differ significantly from that of MAP MoM (P=0.258), whereas it was significantly higher than that of PIGF MoM (P<0.001). Thus, PHR showed the highest AUC point estimate among the three individual biomarkers, with significantly greater discrimination than PIGF MoM but not MAP MoM.

## Discussion

Within this cohort, lower PHR during early gestation was independently associated with subsequent PE, and the negative relationship remained robust after controlling for recognized maternal and pregnancy-related covariates. Importantly, the reduction in PHR was observed not only in the overall PE group but also across early-onset, preterm, and late-onset PE phenotypes, whereas no significant differences were detected among the PE subgroups themselves. In addition, among the 3 individual biomarkers assessed, PHR showed the highest point estimate for discrimination, with an AUC of 0.732, compared with 0.702 for MAP MoM and 0.606 for PIGF MoM. Collectively, these results indicate that PHR may reflect a biological signal shared across PE phenotypes rather than a feature confined to a specific gestational subtype [23].

The overall clinical profile of women who developed PE in this study was consistent with the contemporary understanding of PE risk architecture. Advanced maternal age, higher prepregnancy BMI, IVF conception, and multiple gestation were all more frequent among PE cases, whereas higher parity was inversely associated with risk [24-27]. This concordance with current guideline-based risk stratification supports the internal plausibility of the cohort and strengthens the interpretation that the PHR signal is not occurring in isolation. Current ISSHP and ACOG/SMFM recommendations emphasize that PE risk assessment should begin at the booking visit and, when feasible, combine maternal characteristics with biophysical and biochemical indicators in the first trimester [28-30]. Recent studies similarly support the use of routinely available hematological and inflammatory markers, either alone or integrated with maternal characteristics and machine-learning models, for early PE risk assessment [15-17, 31, 32]. Our results align with that framework and suggest that PHR may add clinically relevant information within a broader maternal-risk context.

A biologically plausible explanation for the inverse association observed here is that PHR reflects the balance between two PE-related

processes that may not evolve in parallel: platelet activation/consumption and HDL-related vascular protection. Meta-analytic evidence indicates that platelet counts are, on average, lower in women with PE, including before clinical diagnosis and during the second trimester, while mechanistic work shows that platelet activation is increased in both early- and late-onset disease [3, 18]. At the same time, higher HDL appears to be protective against PE, and women with PE exhibit lower HDL levels together with impaired HDL composition and function [20, 21]. Maternal lipid metabolism has also been associated with fetal fraction and screening failure in non-invasive prenatal testing, highlighting the potential influence of metabolic status on prenatal biomarker profiles [33]. In this setting, the direction of the composite PHR signal is likely determined by the relative magnitude of change in its numerator and denominator. Our findings suggest that, in this cohort, the reduction in platelet count or platelet availability may have outweighed the decrease in HDL-C, resulting in a lower overall PHR among women who developed PE. This interpretation is inferential, but it is supported by the current platelet and lipid literature. A recent cohort study also linked early-pregnancy PHR to PE risk, although the direction of association differed from that observed in our cohort [22]. Differences in population characteristics and analytical approaches may partly explain this discrepancy, highlighting the need for further external validation.

Taken together, these results support PHR as a potential, accessible clinical marker of PE risk, but also caution against over-interpretation. Prior to clinical use, it is important to establish whether PHR provides incremental value over existing first-trimester models, whether the direction of association is consistent across different PE phenotypes and populations, and whether standardized laboratory definition and scaling can enhance portability.

## Disclosure of conflict of interest

None.

**Address correspondence to:** Dr. Jian Sun, School of Gusu, The Affiliated Suzhou Hospital of Nanjing Medical University, Nanjing Medical University, No. 26 Daoqian Street, Suzhou 215002, Jiangsu, China. E-mail: sunjiangoal@163.com

## References

[1] Cuenca-Gómez D, De Paco Matallana C, Rolle V, Mendoza M, Valiño N, Revello R, Adiego B, Casanova MC, Molina FS, Delgado JL, Wright A, Figueras F, Nicolaides KH, Santacruz B and Gil MM. Comparison of different methods of first-trimester screening for preterm pre-eclampsia: cohort study. Ultrasound Obstet Gynecol 2024; 64: 57-64.

[2] Torres-Torres J, Villafan-Bernal JR, Martinez-Portilla RJ, Hidalgo-Carrera JA, Estrada-Gutierrez G, Adalid-Martinez-Cisneros R, Rojas-Zepeda L, Acevedo-Gallegos S, Camarena-Cabrera DM, Cruz-Martínez MY and Espino-Y-Sosa S. Performance of machine-learning approach for prediction of pre-eclampsia in a middle-income country. Ultrasound Obstet Gynecol 2024; 63: 350-357.

[3] Woldeamanuel GG, Tlaye KG, Wang X, Nguyen-Hoang L, Zhou Q, Wang Y, Leung BW, Wang Y, Poon LC and Wang CC. Platelets in preeclampsia: an observational study of indices associated with aspirin nonresponsiveness, activation and transcriptional landscape. BMC Med 2025; 23: 346.

[4] Li C, Wang S, Tang J, Luo X, Ge L, Xie Y, Fu L, Ruan L, Adu-Gyamfi EA, Li F, Wang Y, Qi H and Ding Y. Unraveling the role of the WIPF1/ACTN4 complex in podosome formation of human placental EVTs: insights into recurrent spontaneous abortion. Genes Dis 2025; 12: 101665.

[5] Liu S, Chen W, Chen J, Liu T, Deng M, Xia L, Li Z, Shi J, Li Y, Peng Y, Ren Q, Miao Z, Wu G, Cao X, Xiao S, Zhang J, Zhong M, Wang L and Xia L. m(6)A deficiency impairs uterine spiral artery remodeling to induce preeclampsia-like symptoms via FGF2. Sci China Life Sci 2025; 68: 3138-3150.

[6] Zhang J, Xue M, Huang J, He S, Zhu L, Zhao X, Wang B, Jiang T, Zhang Y, Miao C and Zhou G. Deficiency of UCHL1 results in insufficient decidualization accompanied by impaired dNK modulation and eventually miscarriage. J Transl Med 2024; 22: 478.

[7] Hosking SL, Moldenhauer LM, Tran HM, Chan HY, Groome HM, Lovell EA, Green ES, O'Hara SE, Roberts CT, Foyle KL, Davidge ST, Robertson SA and Care AS. Treg cells promote decidual vascular remodeling and modulate uterine NK cells in pregnant mice. JCI Insight 2024; 10: e169836.

[8] Liang Y, Zhang Y, Zhang Y, Cao J, Qiao L and Jin Z. Inflammatory cytokines, metabolites, and pre-eclampsia: a two-sample Mendelian randomization study. Am J Transl Res 2025; 17: 9128-9138.

[9] Xu J, Shi X, Lin S, Singh S, Haddox S, Phung C, Manley T, Huang N, Wu P and Li H. Chimeric RNA landscape in the placenta: a transcriptomic analysis revealing novel diagnostic biomarkers forpreeclampsia. Genes Dis 2024; 12: 101242.
[10] Tong J, Zhang L, Bai J and Zhang C. Exploring the role of FTO in preeclampsia pathogenesis: insights into m(6)A modification and decidualization. Genes Dis 2024; 12: 101504.
[11] Wei J, Chen H, Yao L, Hou X, Zhang R, Shi L, Sun J, Hu C, Wei X and Jia W. BioCompNet: a deep learning workflow enabling automated body composition analysis toward precision management of cardiometabolic disorders. Cyborg Bionic Syst 2025; 6: 0381.
[12] Chen S, Li J, Zhang X, Xu W, Qiu Z, Yan S, Zhao W, Zhao Z, Tian P, Zhao Q, Zhang Q, Chen W, Li H, Ruan X, Xiao G, Zhang S, Hu L, Qin J, Huang W, Li Z, Wang S, Zhang R, Huang S, Wang X, Yao Y, Ran J, Cheng D, Luo Q, Pan T, Gao R, Zheng J, Wang Y, Liu C, Cao X, Zhou X, Xu N, Zhang L, Han X, Wang H, Feng S, Li S, Zhang J, Zhao L and Wei F. Predicting preeclampsia in early pregnancy using clinical and laboratory data via machine learning model. BMC Med Inform Decis Mak 2025; 25: 178.
[13] Cai L, Liu Y, Li K, Xing C, Xu Z, Zhao L, Lv K, Li Z, Wang H, Wang L, Luo D, Yuan L, Qu L, Li Y, Wang Z and Ren P. Multimodal imaging-based cerebral blood flow prediction model development in simulated microgravity. Cyborg Bionic Syst 2025; 6: 0448.
[14] Liu Y, Hou C, Dong X, Wu D, Chu X, Luo J, Zhang W, Yu E, Li C, Zhou C, Wu C and Ji X. Sex-related difference in outcomes of remote ischemic conditioning for symptomatic intracranial atherosclerotic stenosis. Cyborg Bionic Syst 2025; 6: 0275.
[15] Özkan S, Dereli ML, Firatligil FB, Kurt D, Kurt A, Sucu ST, Sucu S, Celen S and Engin-Ustun Y. Role of systemic immune-inflammation index, systemic inflammation response index, and pan-immune inflammation value in the prediction of preeclampsia: a retrospective cohort study. Am J Reprod Immunol 2024; 92: e70029.
[16] Qiao L, Zhang Y, Wang J, Wu X, Zhang C, Xue Y, Cao J, Jin J, Wang T, Li J and Liang Y. Machine learning-based prediction of preeclampsia using first-trimester inflammatory markers and red blood cell indices. BMC Pregnancy Childbirth 2025; 25: 1083.
[17] Zhu Y, Zhang Y, Huang C, Zhang S, Cao J, Miranda N, Zhao S, Peng Y, Yu C, Feng B, Jin J, Tang Q, Fan J, Qiao L and Liang Y. First-trimester preeclampsia prediction model via integrative machine learning of maternal risk profiles and laboratory markers. Genes Dis 2026; 13: 102075.
[18] Agbani EO, Chow L, Nicholas J, Skeith L, Schneider P, Gregory A, Mahe E, Yamaura L, Young D, Dufour A, Paul PP, Walker AM, Mukherjee PG, Poole AW, Poon MC and Lee A. Overexpression of facilitative glucose transporter-3 and membrane procoagulation in maternal platelets of preeclamptic pregnancy. J Thromb Haemost 2023; 21: 1903-1919.
[19] de Moreuil C, Mehic D, Nopp S, Kraemmer D, Gebhart J, Schramm T, Couturaud F, Ay C and Pabinger I. Hemostatic biomarkers associated with postpartum hemorrhage: a systematic review and meta-analysis. Blood Adv 2023; 7: 5954-5967.
[20] Stadler JT, Scharnagl H, Wadsack C and Marsche G. Preeclampsia affects lipid metabolism and HDL function in mothers and their offspring. Antioxidants (Basel) 2023; 12: 795.
[21] Hosier H, Lipkind HS, Rasheed H, DeWan AT and Rogne T. Dyslipidemia and risk of preeclampsia: a multiancestry Mendelian randomization study. Hypertension 2023; 80: 1067-1076.
[22] Zhang H, Bao JL, Li QN, Xiao KD and Peng JQ. Early-pregnancy HDL-related inflammatory indices and risk of preeclampsia: a retrospective cohort study. PLoS One 2025; 20: e0339322.
[23] Magee LA, Nicolaides KH and von Dadelszen P. Preeclampsia. N Engl J Med 2022; 386: 1817-1832.
[24] Gu Y, Chen Y, Cao X, Hu L, Fu Y, Li J, Pan Y and Chen Q. Chronic hypertension diagnosed in a previous pregnancy is associated with recurrent preeclampsia. Clin Hypertens 2026; 32: e16.
[25] Chatzakis C, Magee LA, Castello R, Miranda G, von Dadelszen P, Nicolaides KH and Charakida M. Vascular assessment stratifying preeclampsia risk in overweight/obese women. Hypertension 2025; 82: 1433-1442.
[26] Jenabi E, Salimi Z, Ayubi E, Bashirian S and Salehi AM. The environmental risk factors prior to conception associated with placental abruption: an umbrella review. Syst Rev 2022; 11: 55.
[27] Wheeler SM, Myers SO, Swamy GK and Myers ER. Estimated prevalence of risk factors for preeclampsia among individuals giving birth in the US in 2019. JAMA Netw Open 2022; 5: e2142343.
[28] Zhou W, Li X, Li X, Liu Y, Song W and Yang Q. The role of circular RNA in preeclampsia: from pathophysiological mechanism to clinical application. Life Sci 2024; 338: 122407.
[29] Society for Maternal-Fetal Medicine (SMFM). Electronic address: pubs@smfm.org; Louis JM, Parchem J, Vaught A, Tesfalul M, Kendle A and

Tsigas E. Preeclampsia: a report and recommendations of the workshop of the Society for Maternal-Fetal Medicine and the Preeclampsia Foundation. Am J Obstet Gynecol 2022; 227: B2-B24.

[30] Gumilar KE, Priangga B, Lu CH, Dachlan EG and Tan M. Iron metabolism and ferroptosis: a pathway for understanding preeclampsia. Biomed Pharmacother 2023; 167: 115565.

[31] Liang Y, Zhang Y, Li Y, Cao J, Feng B, Jin J, Zhang S, Tang Q, Qiao L and Jin Z. CRP-triglyceride-glucose index (CTGI) as a predictor of preeclampsia: a population-based study of risk stratification. Lipids Health Dis 2025; 25: 17.

[32] Zhu Y, Zhang Y, Hu W, Cao J, Feng B, Jin J, Zhang S, Tang Q, Qiao L and Liang Y. First-trimester pan-immune-inflammation value predicts preeclampsia in a dose-dependent linear pattern. BMC Pregnancy Childbirth 2025; 25: 1250.

[33] Cao J, Qiao L, Jin J, Zhang S, Chen P, Tang H, Yu Z, Shi J, Wang T and Liang Y. Lipid metabolism affects fetal fraction and screen failures in non-invasive prenatal testing. Front Med (Lausanne) 2022; 8: 811385.