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A STUDY OF COMPARISON OF HAEMATOLOGICAL INDICES WITH SEVERITY OF PRE-ECLAMPSIA AND MATERNAL OUTCOME IN PRE-ECLAMPTIC WOMEN

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ABSTRACT **Background:** Pre-eclampsia is a pregnancy-specific systemic hypertensive disorder developing after 20 weeks of gestation and remains a premier etiology behind global maternal morbidity and mortality. Widespread endothelial dysfunction, vascular instability, and intense pro-inflammatory activation characterize its pathogenesis, reflecting severe hematological alterations. Cost-effective, accessible, and reproducible cellular markers are vital for timely risk stratification, particularly across low-resource tertiary centers. **Objective:** To evaluate baseline hematological indices in women presenting with pre-eclampsia and validate their objective statistical correlation with clinical disease severity and immediate adverse maternal outcomes. **Methods:** A prospective hospital-based observational registry was instituted over a two-year timeline at the Department of Obstetrics and Gynaecology, Saraswathi Institute of Medical Sciences, Hapur. A total cohort of 120 singleton gestations beyond 28 weeks of gestation exhibiting pre-eclampsia were consecutively enrolled. Venous EDTA profiles obtained within 1 hour of labor admission quantified hemoglobin (Hb), packed cell volume (PCV), absolute red blood cell (RBC) indices, platelet counts, red cell distribution width (RDW), and derived neutrophil-to-lymphocyte ratios (NLR). Statistical cross-tabulation and significance testing were completed via SPSS version 29.0. **Results:** Out of 120 patients, 91% presented without severe features, whereas 9% were verified with severe pre-eclampsia. Widespread thrombocytopenia (<100×10⁹/L) manifested in 32% of the overall population, while hemoconcentration (PCV ≥36%) appeared in 83%. Severe pre-eclampsia demonstrated rigorous statistical correlation with profound thrombocytopenia (p=0.00017), elevated packed cell volume (p=0.000012), diminished mean corpuscular hemoglobin concentration (p=0.0003), and advanced neutrophil-lymphocyte ratios (p=0.029). Regarding adverse outcomes, preterm delivery occurred in 49%, excessive post-delivery hemorrhage (≥1000 mL) in 51%, and eclamptic convulsions in 15% of cases. Elevated baseline Hb, hemoconcentration, marked thrombocytopenia, and high NLR metrics were critically linked with premature labor, hemorrhage scales, and neurological eclamptic episodes (p<0.05). **Conclusion:** Baseline automated hematological parameters exhibit intense prognostic alignment with pre-eclampsia severity tracks and downstream maternal complications. Given their absolute cost-effectiveness and rapid generation, regular adoption of platelet indices, hemoconcentration screens, and cellular ratios offers excellent objective risk modeling in contemporary obstetric medicine.

KEYWORDS : Pre-eclampsia; Hematological indices; Thrombocytopenia; Neutrophil-lymphocyte ratio; Maternal outcome.

INTRODUCTION

Hypertensive conditions complicating gestation are primary causes of maternal and perinatal mortality worldwide. Pre-eclampsia is a multi-system, pregnancy-specific condition defined by new-onset hypertension evolving after the 20th week of pregnancy in a previously normotensive individual. This elevation in systemic pressure is accompanied by proteinuria or objective clinical criteria indicating acute end-organ impairment. Far from a basic vascular presentation, pre-eclampsia features systemic vascular instability, profound endothelial damage, and microvascular lesions. These core structural dysfunctions account for its heterogeneous and unpredictable clinical trajectory, causing rapid progression toward eclamptic seizures, hepatic rupture, or acute kidney injury.

In low- and middle-income nations, the clinical management of pre-eclampsia faces issues like late presentations, inadequate antenatal monitoring, and restricted access to novel biochemical profiling tools, including soluble fms-like tyrosine kinase-1 (sFlt-1) or placental growth factor (PIGF). Consequently, identifying simple, highly reproducible, and inexpensive laboratory parameters remains an important clinical priority for risk stratification. Automated complete blood count (CBC) screenings provide access to standard parameters that parallel the systemic inflammatory and prothrombotic state seen in pre-eclampsia. Widespread endothelial damage enhances microvascular platelet consumption, leading to relative thrombocytopenia. Simultaneously, increased capillary permeability triggers a shift of intravascular volume into tissue compartments, manifesting as relative hemoconcentration. This study evaluates hematological metrics—specifically platelet counts, red cell indices, and derived leucocyte ratios—to determine their diagnostic association with disease severity and immediate maternal outcomes in a North Indian tertiary hospital population.

Materials and Methods

Study Design and Institutional Setting:

This prospective, hospital-based observational study was conducted in the Department of Obstetrics and Gynaecology at the Saraswathi Institute of Medical Sciences, Hapur, Uttar Pradesh, India. The clinical investigation spanned an active 18-month recruitment and follow-up timeline following institutional review and clearance from the Institutional Ethics Committee (Ref: EC/NEW/INST/2022/UP/0125).

Participant Cohort Selection:

A total sample size of 120 pregnant women was established based on sequential screening. The selection criteria targeted singleton gestations with verified pre-eclampsia presenting past 28 weeks of gestation who provided written informed consent. Diagnosis followed standard guidelines from the American College of Obstetricians and Gynecologists (ACOG). Exclusion criteria were precisely defined to eliminate confounding variables: multiple gestations, structural or chromosomal fetal anomalies, intrauterine fetal death at baseline, a confirmed history of pre-gestational diabetes mellitus, chronic essential hypertension, chronic kidney disease, intrinsic hepatic disorders, or preexisting autoimmune diseases. Patients with deep blood dyscrasias, baseline severe nutritional anemia (Hb <8 g/dL), or those using low-dose aspirin or systemic corticosteroids were excluded.

Clinical and Laboratory Workup:

Standardized blood pressure measurements were documented in a sitting position with an appropriate cuff size, defining hypertension as systemic readings >140/90 mmHg on two distinct sessions at least 4 hours apart. Urinalysis via automated dipstick testing or 24-hour protein excretion screens established proteinuria profiles. Upon admission, a clean 3 mL venous sample was drawn into an EDTA vacuum tube and analyzed within 1 hour using an automated hematology analyzer. Quantified markers included Hemoglobin (Hb), Packed Cell Volume (PCV), Total Red Blood Cell Count (RBC), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), Red Cell Distribution Width (RDW), and absolute Platelet Counts. The absolute Neutrophil Count divided by the absolute Lymphocyte Count provided

the Neutrophil-Lymphocyte Ratio (NLR). Participants were categorized into two cohorts: Pre-eclampsia without severe features and Pre-eclampsia with severe features based on criteria like severe blood pressure thresholds (≥160/110 mmHg), severe thrombocytopenia, or renal/hepatic impairment.

Maternal Outcome Definition:

Maternal trajectories were carefully tracked until hospital discharge. Primary clinical outcome variables included: (a) Gestational age at delivery, distinguishing premature labor (<37 completed weeks); (b) Immediate mode of delivery, categorized into normal vaginal delivery (NVD) or lower segment cesarean section (LSCS); (c) Measured peripartum blood loss, indexing significant postpartum hemorrhage at a cutoff >1000 mL; (d) Manifestation of eclamptic convulsions; and (e) Measured maternal mortality.

Statistical Computation:

Collected analytical fields were cataloged within Microsoft Excel and computed via SPSS Version 29.0. Continuous numeric lines were reported as Mean ± Standard Deviation (SD), and categorical arrays as counts and percentages. Distribution comparisons were evaluated using the standard Chi-square test or Fisher's Exact test. Statistical significance was defined by a p-value <0.05.

RESULTS

Demographic baseline mapping demonstrated that the majority of pre-eclamptic women belonged to the primary reproductive age class of 19-29 years (53%), followed by women aged 30 and above (33%), while adolescent pregnancies below 18 years constituted 14%. Educational stratification showed that 70% of the sample possessed primary education or below. Rural residences accounted for 60% of the registry. Parity tracking confirmed that 49% were primigravidae, emphasizing the risk profile in first pregnancies. Gestational age at presentation was nearly evenly split: 49% presented prematurely (<37 weeks) and 51% at term.

Clinical classification revealed that 91% (n=109) presented with pre-eclampsia without severe features, while 9% (n=11) exhibited severe features. Evaluation of laboratory findings identified thrombocytopenia (<100×10⁹/L) in 32% of the overall population, while hemoconcentration with a packed cell volume ≥36% was present in 83% of the participants.

Table 1: Baseline Frequencies of Hematological Parameters Across the Total Cohort (n=120)

Haematological Index Category	Cohort Frequency (n=120)	Cohort Percentage (%)
Platelet Count (10⁹/L): <100 (Thrombocytopenia)	38	32.0%
≥100 (Normal)	82	68.0%
Packed Cell Volume (PCV %): <36	20	17.0%
≥36 (Hemoconcentration)	100	83.0%
Red Blood Cell Count (million/µL): <3.5	20	17.0%
3.5-4.5	92	77.0%
>4.5	8	6.0%
Mean Corpuscular Volume (MCV fL): <80	47	39.0%
≥80	73	61.0%
Mean Corpuscular Hemoglobin (MCH pg): <26	55	46.0%
≥26	65	54.0%
MCHC (g/dL): <32	6	5.0%
≥32	114	95.0%
Hemoglobin Concentration (g/dL): 8.0-11.0	41	34.0%
>11.0	79	66.0%
Red Cell Distribution Width (RDW %): Normal/Low	18	15.0%
Increased	102	85.0%
Neutrophil-Lymphocyte Ratio (NLR): Low (<2)	5	4.0%
Normal (2)	71	59.0%
High (>2)	44	37.0%

Cross-tabulation separating pre-eclampsia severity groups demonstrated highly significant associations. Severe pre-eclampsia was strongly linked with thrombocytopenia (p=0.00017), where 9 out of 11 severe cases exhibited counts below 100×10⁹/L. Similarly, elevated PCV levels (p=0.000012), lower MCHC values (p=0.0003), and high derived NLR scores (p=0.029) demonstrated significant statistical relationships with severe disease. Conversely, absolute hemoglobin scales, MCV, MCH, and RDW distributions did not show significant differentiation between the severity cohorts.

Table 2: Cross-tabulation of Hematological Variables by Pre-eclampsia Severity

Haematological Variable	Without Severe Features (n=109)	With Severe Features (n=11)	p-value
Platelets (10⁹/L): <100	29	9	0.00017
>100	80	2	
RBC Count	16	4	3.698
3.5-4.5	86	6	
>4.5	7	1	
PCV (%): <36	13	7	0.000012
>36	96	4	
MCV (fL): <80	41	6	0.272
>80	68	5	
MCH (pg): <26	49	6	0.540
≥26	60	5	
MCHC (g/dL): <32	3	3	0.00030
≥32	106	8	
Hemoglobin (g/dL): 8.0-11.0	37	4	0.871
>11.0	72	7	
RDW (%): Normal/Low	16	2	0.756
Increased	93	9	
NLR: Low/Normal (≤2)	70	6	0.02900
High (>2)	39	5	

Adverse maternal outcomes were common across the study cohort: premature labor occurred in 49% of cases, cesarean delivery was performed in 58%, severe peripartum hemorrhage (≥1000 mL) occurred in 51%, and eclamptic convulsions manifested in 15%. There was 1 maternal death (1%) during the hospital timeline. Statistical correlation models evaluating baseline hematological variables against premature labor revealed highly significant links with elevated hemoglobin (p=0.001), hemoconcentration (p=0.014), increased RDW metrics (p=0.010), thrombocytopenia (p=0.0004), and high NLR indicators (p=0.0003). Similarly, excessive blood loss ≥1000 mL was significantly linked with hemoconcentration (p=0.0001), high NLR (p=0.0001) and thrombocytopenia (p=0.017). Eclamptic convulsions were also significantly associated with thrombocytopenia (p<0.001) and high NLR (p=0.001).

Table 3: Statistical Correlation Breakdown Between Hematological Markers and Immediate Maternal Outcomes

Hematological Marker	Premature Labor (p-value)	Blood Loss ≥1000 mL (p-value)	Convulsions (p-value)
Hemoglobin (g/dL)	0.001 (Higher >11)	0.0004 (Higher >11)	0.0001 (Linked 8-11)
Packed Cell Volume (PCV)	0.014 (Linked ≥36)	0.0001 (Linked ≥36)	1.000 (No Association)
Mean Corpuscular Volume (MCV)	0.144 (No Association)	0.038	0.118 (No Association)
Red Cell Distribution Width (RDW)	0.010 (Linked High RDW)	0.027	0.258 (No Association)

Platelet Count	0.0004 (Linked <100)	0.017 (Linked <100)	<0.001 (Linked <100)
Neutrophil-Lymphocyte Ratio (NLR)	0.0003 (Linked NLR >2)	0.0001 (Linked NLR >2)	0.001 (Linked NLR >2)
MCH (pg)	0.349 (No Association)	0.016	0.157 (No Association)
MCHC (g/dL)	0.025	0.003	0.001 (Linked <32)
RBC Count	0.547 (No Association)	0.012	0.015

DISCUSSION

Pre-eclampsia remains an intricate clinical challenge within modern obstetrics, especially across low-resource settings where late diagnosis and high disease burden amplify risks. This investigation highlights the practical value of complete blood count parameters as reliable indicators of disease severity and immediate maternal risk. Our findings demonstrate a significant link between severe pre-eclampsia and primigravid status, which aligns with classic physiological paradigms of immunological maladaptation at the decidual-trophoblastic interface, causing defective vascular remodeling of the spiral arteries.

The patterns identified in hemoglobin concentration and packed cell volume highlight the vascular dynamics characteristic of pre-eclampsia. Progressive increases in PCV reflect intravascular volume contraction driven by increased capillary permeability. Widespread endothelial activation compromises the structural integrity of the microvasculature, causing plasma fluid shifts into interstitial spaces. This phenomenon presents as relative hemoconcentration rather than actual erythrocytosis. Our findings align with work by Abbassi-Ghanavati et al., which documented matching hematocrit shifts in advanced pre-eclampsia. However, contextual factors like baseline nutritional status can influence these markers. In regions with highly prevalent iron deficiency anemia, baseline values may be lower, which highlights the need for careful clinical interpretation of hemoconcentration parameters.

The inverse relationship between absolute platelet counts and pre-eclampsia severity represents a crucial finding. Platelet destruction increases as platelets adhere to areas of microvascular endothelial damage, which accelerates consumption. This pathophysiological process accounts for the significant correlation found between thrombocytopenia and severe disease, eclamptic episodes, and post-delivery hemorrhage metrics. This finding matches classic studies by Donimath et al. and Gupta et al., which established a progressive fall in platelet parameters as hypertensive gestations advance. Regular monitoring of platelet counts is vital for early risk management, helping clinicians anticipate complications like HELLP syndrome or disseminated intravascular coagulation.

Similarly, the elevations found in derived inflammatory indices like the neutrophil-to-lymphocyte ratio provide insight into the systemic inflammatory state of pre-eclampsia. Widespread endothelial stress activates leukocyte lines, causing neutrophil proliferation alongside relative lymphopenia. Our statistical correlation models confirm that advanced NLR scores are strongly associated with higher rates of premature labor, eclamptic convulsions, and excessive blood loss. This supports the systemic inflammatory model of pre-eclampsia described by Brown et al. and Levine et al. Furthermore, our analysis demonstrated a significant relationship between high RDW values and adverse maternal outcomes, confirming that erythrocyte size variability reflects severe oxidative stress and altered erythropoiesis. These widely accessible cellular markers can help clinicians identify high-risk cases and optimize care pathways in resource-limited tertiary environments.

CONCLUSION

This study demonstrates that baseline automated hematological parameters have a strong predictive alignment with pre-eclampsia severity and adverse maternal outcomes. Advanced hemoconcentration, progressive thrombocytopenia, elevated red cell distribution width, and an increased neutrophil-lymphocyte ratio are reliably linked to severe disease trajectories, preterm labor, hemorrhage risks, and eclamptic seizures. Because these basic CBC markers are highly reproducible, inexpensive, and universally accessible, their systematic adoption for risk stratification is highly recommended, particularly in resource-limited settings where novel angiogenic profiling is unavailable. Early identification of these hematological anomalies can optimize care pathways, guide timely interventions, and help reduce maternal morbidity in hypertensive pregnancies.

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