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EVALUATION OF HEMATOLOGICAL PROFILE OF NEONATES BORN TO PREECLAMPTIC AND NORMOTENSIVE MOTHERS

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Abstract-

Introduction- Preeclampsia, a hypertensive disorder of pregnancy, can adversely affect neonatal outcomes. So this study aims to evaluate hematological parameters in neonates born to preeclamptic versus normotensive mothers to identify potential hematologic alterations linked to intrauterine hypoxia and placental insufficiency.

Material and method- The present study was a hospital-based, comparative cross-sectional study conducted on 200 term neonates, categorized into two groups. Group A constituted 100 neonates born to preeclamptic mothers diagnosed whereas group B had 100 neonates born to healthy, normotensive mothers. Umbilical cord blood was analyzed for hemoglobin, hematocrit, WBC, ANC, platelet count, and red cell indices. Data were analyzed using SPSS v20, with significance set at $p<0.05$.

Result- Neonates born to preeclamptic mothers had significantly lower gestational age, birth weight, RBC count, and platelet count, but higher hemoglobin, hematocrit, nRBCs, and reticulocytes (all $p<0.01$). Polycythemia (14% vs. 4%) and thrombocytopenia (46% vs. 12%) were significantly more frequent in the preeclamptic group. NICU admissions, IUGR, neonatal sepsis, and prematurity were also more common. No significant differences were observed in WBC, MCV, MCH, MCHC, or Apgar scores.

Conclusion- Maternal preeclampsia significantly impacts neonatal hematological profiles due to intrauterine hypoxia and placental insufficiency. Routine screening enables early detection and management of complications like thrombocytopenia or polycythemia, improving neonatal outcomes and guiding perinatal care in high-risk pregnancies.

Keywords- Neonates, hematological, preeclamptic, normotensive, group etc.

Introduction

Preeclampsia is a complex hypertensive disorder of pregnancy, typically presenting after 20 weeks of gestation with elevated blood pressure and proteinuria, and in some cases, signs of organ dysfunction.[1] It remains one of the leading causes of maternal and perinatal morbidity and mortality globally, accounting for significant obstetric complications and adverse neonatal outcomes.[2] Affecting approximately 5–8% of pregnancies, preeclampsia involves a multifactorial etiology, including abnormal placentation, oxidative stress, and systemic inflammation.[3] While the maternal implications of preeclampsia are widely studied, its impact on neonatal health, especially hematological parameters, remains an area warranting deeper investigation. Neonatal hematological parameters, including hemoglobin concentration, hematocrit, platelet count, white blood cell (WBC) count, and red blood cell (RBC) indices, are essential indicators of neonatal well-being and can reflect intrauterine conditions. Alterations in these parameters may point to fetal stress, hypoxia, inflammation, or impaired hematopoiesis. In pregnancies complicated by preeclampsia, the placenta often exhibits reduced perfusion due to shallow trophoblastic invasion and endothelial dysfunction, potentially resulting in chronic fetal hypoxia and growth restriction.[4] These changes may influence the neonatal hematological profile. Several studies have explored the association between maternal preeclampsia and neonatal hematologic abnormalities. Some findings suggest an increased risk of polycythemia, possibly due to hypoxia-driven erythropoietin stimulation in utero.[5] Others have reported thrombocytopenia and neutropenia in neonates, which may result from impaired megakaryocyte and myeloid cell production secondary to intrauterine inflammation or placental insufficiency.[6,7] Moreover, many available studies have limitations, including small sample sizes or lack of adequate controls, which may compromise the generalizability of their conclusions.[7] Hence the existing literature remains inconsistent, with some studies showing no significant differences between neonates of preeclamptic and normotensive mothers, highlighting the need for further, more comprehensive research.

The neonatal hematological profile offers valuable insight into intrauterine adaptation and can predict both short- and long-term outcomes. Conditions like thrombocytopenia and polycythemia may lead to serious complications, highlighting the need for early detection. Maternal preeclampsia, a systemic disorder, may predispose neonates to such hematologic abnormalities, yet this aspect is often under-recognized in perinatal care, which typically focuses on maternal health. Many delivery units do not routinely perform neonatal blood counts unless prompted by clinical symptoms, risking delayed diagnosis and treatment in affected newborns. Understanding the hematological impact of preeclampsia could support the development of targeted screening protocols. This study aims to compare hematological parameters in neonates born to preeclamptic versus normotensive mothers to identify distinct patterns. The goal is to assess whether routine screening is warranted for neonates of preeclamptic mothers, thereby improving outcomes through timely intervention and surveillance.

Material and Methods-

This hospital-based, comparative, cross-sectional study was carried out at Department of Pathology, Phulo Jhano Medical College and Hospital, Dumka, Jharkhand, India, over a period of 1year from January 2024 to December 2024. The primary objective of the study was to compare hematological parameters in neonates born to mothers with preeclampsia and those born to normotensive mothers. The study was conducted after obtaining ethical clearance from the Institutional Ethics Committee. Informed written consent was obtained from all participating mothers prior to inclusion in the study. Confidentiality and privacy of all participants were ensured, and participation was voluntary. A total of 200 term neonates were enrolled and categorized into two groups i.e. study group or group A and control group or group B. Group A constituted 100 neonates born to mothers diagnosed with preeclampsia. Group B also constituted 100 neonates but born to healthy, normotensive mothers with no obstetric complications. Participants were recruited through purposive sampling at the time of delivery in the labor and maternity wards. The study included singleton pregnant mothers aged 18–40 years with term neonates (gestational age ≥37 weeks). Multiple pregnancies, preterm deliveries (<37 weeks gestation), neonates with congenital anomalies, intrauterine infections, Rh

isoimmunization, or evidence of perinatal asphyxia, mothers with history of chronic hypertension, diabetes mellitus, renal disorders, or systemic infections and the mothers on medications known to affect fetal hematological parameters were excluded from the study. Preeclampsia was diagnosis on the basis of ACOG (2020) guidelines.[8] Mothers with systolic blood pressure ≥140mmHg and/or diastolic blood pressure ≥90mmHg on two occasions at least four hours apart, with proteinuria ≥300mg in a 24-hour urine sample or equivalent dipstick or protein/creatinine ratio were enrolled into study group and the mothers with no clinical sign of preeclampsia and normal blood pressure were enrolled into control group. A pretested structured proforma was used to collect demographic and clinical details of the participants. Maternal information included age, parity, gestational age at delivery, booking status, and presence/severity of preeclampsia (mild or severe). Neonatal data included birth weight, sex, Apgar scores at 1 and 5 minutes, and need for neonatal intensive care unit (NICU) admission. For hematological Analysis, immediately after delivery and clamping of the umbilical cord, 2mL of cord blood was collected aseptically from the umbilical vein using a sterile syringe and transferred into an EDTA vial. All samples were processed within two hours using an automated hematology analyzer. The hematological parameters assessed were hemoglobin concentration (g/dL), hematocrit (%), total leukocyte count (TLC) (cells/mm³), absolute neutrophil count (ANC) (cells/mm³), platelet count (lakh/mm³), red cell indices i.e. mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). The results were interpreted using gestation-appropriate reference ranges as described by Christensen and Henry.[9] Thrombocytopenia was defined as platelet count <150,000/mm³, leukopenia as WBC <5,000/mm³, and polycythemia as hematocrit >65%. Subgroup analyses were performed based on the severity of preeclampsia (mild vs. severe) to assess whether the degree of maternal disease had a proportional effect on neonatal hematological outcomes. Data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) version 20. Quantitative data were expressed as mean±standard deviation (SD), and qualitative data were presented as frequencies and percentages. An independent sample t-test was used to compare means of hematological parameters between the two groups. The chi-square test or Fisher's exact test was employed for comparison of categorical variables such as incidence of thrombocytopenia or leukopenia. A p-value of <0.05 was considered statistically significant.

Result-

A total of 200 term neonates were included in the study, with 100 in the preeclampsia group (Group A) and 100 in the normotensive group (Group B). Table 1 summarizes the maternal characteristics of the two groups. The mean maternal age was similar between the groups, with the preeclamptic group having a mean age of 27.4±4.1years and the control group 26.9±3.8years (p=0.28). The mean gestational age at delivery was significantly lower in the preeclamptic group (38.1±1.2weeks) compared to the control group (39.0±1.1weeks, p<0.01). Blood pressure measurements showed significant differences between the groups. The mean systolic blood pressure was significantly higher in the preeclamptic group (150±12mmHg) compared to the control group (120±9mmHg, p<0.001). Similarly, the mean diastolic blood pressure was elevated in the preeclamptic group (95±8mmHg) compared to the control group (75±6mmHg, p<0.001). Mean proteinuria was also significantly higher in the preeclamptic group (2.5±1.2g/day) compared to the control group (0.5±0.2 g/day, p<0.001). The rate of operative deliveries was significantly higher in the preeclamptic group (62%) compared to the control group (30%, p<0.001). Additionally, maternal BMI was significantly higher in the preeclamptic group (27.4±5.3kg/m²) compared to the control group (25.6±4.2kg/m², p=0.02). The proportion of working mothers was higher in the preeclamptic group (65%) compared to the control group (58%), although this difference was not statistically significant (p=0.12). The proportion of educated mothers did not differ significantly between the groups (12% in the preeclamptic group and 18% in the control group, p=0.29).

Table 1- Baseline maternal characteristics

Parameter	Group A (Preeclampsia)	Group B (Control)	p-value
Maternal age (years)	27.4 ± 4.1	26.9 ± 3.8	0.28
Gestational age (weeks)	38.1 ± 1.2	39.0 ± 1.1	<0.01
Mean systolic BP (mmHg)	150 ± 12	120 ± 9	<0.001
Mean diastolic BP (mmHg)	95 ± 8	75 ± 6	<0.001
Mean proteinuria (g/day)	2.5 ± 1.2	0.5 ± 0.2	<0.001
Operative delivery (%)	62 (62%)	30 (30%)	<0.001
BMI of mothers (kg/m²)	27.4 ± 5.3	25.6 ± 4.2	0.02
Working mothers	65 (65%)	58 (58%)	0.12
Educated mothers	12 (12%)	18 (18%)	0.29

The sex distribution of neonates was similar between the two groups. In the preeclamptic group, 52.4% were male and 47.6% were female (male-to-female ratio 1.1:1), while in the control group, 51.2% were male and 48.8% were female (male-to-female ratio 1.05:1). This difference was not statistically significant (p = 0.71), indicating no meaningful variation in sex distribution between the groups.

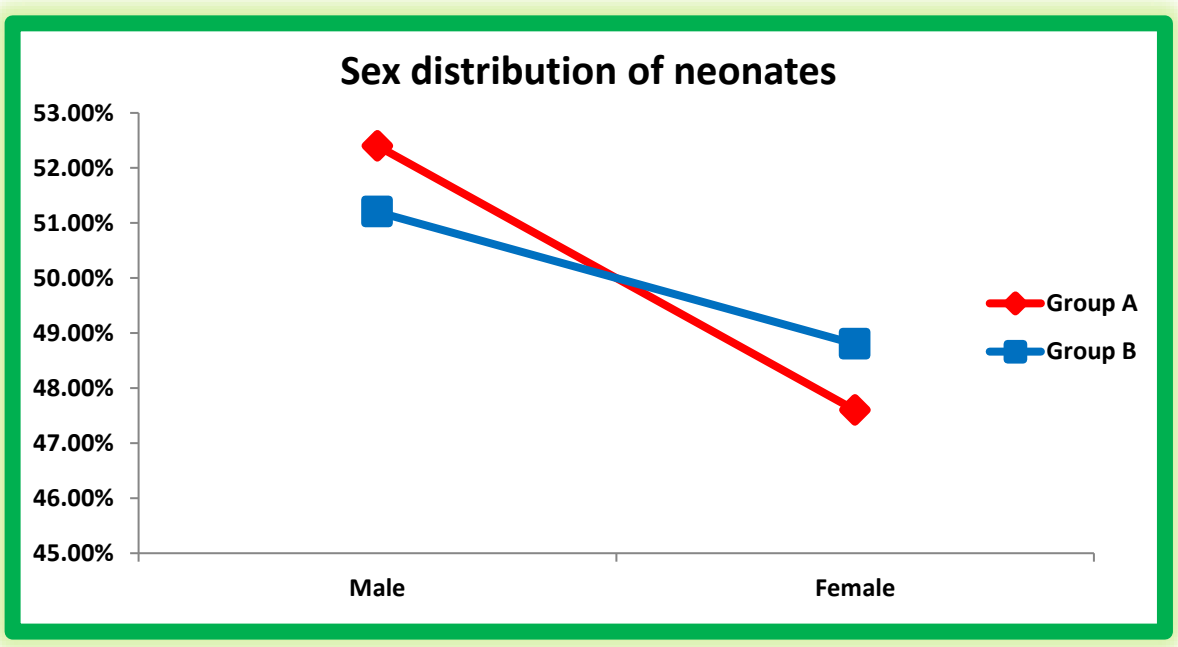

Figure 1- Sex distribution of neonates among the preeclamptic and normotensive groups.

Neonatal characteristics of the preeclamptic and control groups are summarized in Table 2. The mean birth weight was significantly lower in the preeclamptic group (2.64±0.35 kg) compared to the control group (2.89±0.42 kg, p<0.01). The mean Apgar score at 5 minutes did not differ significantly between the groups, with the preeclamptic group scoring 8.2±0.5 and the control group scoring 8.3 ± 0.4 (p=0.11). A higher proportion of neonates in the preeclamptic group required NICU admissions (18%) compared to the control group (8%), though this difference was not statistically significant (p=0.06). Intrauterine growth restriction (IUGR) was significantly more prevalent in the preeclamptic group (40%) compared to the control group (12%, p<0.001). Neonatal sepsis was also significantly more common in the preeclamptic group (15%) compared to the control group (5%, p=0.04).

Table 2-: Baseline neonatal characteristics.

Parameter	Group A (Preeclampsia)	Group B (Control)	p-value
Birth weight (kg)	2.64 ± 0.35	2.89 ± 0.42	<0.01
Apgar score at 5 min (mean)	8.2 ± 0.5	8.3 ± 0.4	0.11
NICU admissions (%)	18 (18%)	8 (8%)	0.06
Mean Birth weight (g)	2640 ± 350	2890 ± 420	<0.01
IUGR (%)	40 (40%)	12 (12%)	<0.001
Sepsis (%)	15 (15%)	5 (5%)	0.04

The hematological parameters of neonates born to preeclamptic and normotensive mothers are presented in Table 3. Hemoglobin levels were significantly higher in the preeclamptic group (16.9±1.5g/dL) compared to the control group (15.8±1.4g/dL, $p<0.001$). Similarly, the mean hematocrit was significantly elevated in neonates from the preeclamptic group (52.3±4.1%) compared to those from the control group (48.5±3.9%, $p<0.001$). The mean total leukocyte count was slightly lower in the preeclamptic group (11,800±2,100/mm³) than in the control group (12,400±2,300/mm³), though the difference was not statistically significant ($p=0.06$). Likewise, the absolute neutrophil count did not show a significant difference between the two groups (6,100±1,400/mm³ vs. 6,500±1,600/mm³, $p=0.08$). Platelet counts were significantly lower in the preeclamptic group (138±28×10⁹/L) compared to the control group (176±30×10⁹/L, $p<0.001$), indicating a higher risk of neonatal thrombocytopenia in this group. The red blood cell (RBC) count was significantly lower in the preeclamptic group (4.8±0.4×10⁶/mm³) compared to the control group (5.1±0.3×10⁶/mm³, $p<0.01$). The number of nucleated red blood cells (nRBCs) was markedly higher in neonates born to preeclamptic mothers (11.2 ± 4.6 per 100 WBC) compared to those born to normotensive mothers (4.5±2.3 per 100 WBC, $p<0.001$), suggesting increased erythropoietic stress or hypoxia. Reticulocyte counts were also significantly elevated in the preeclamptic group (5.1±1.2%) versus the control group (3.8±1.0%, $p<0.01$), reinforcing the evidence of increased red cell production in response to hypoxic conditions. There were no significant differences between the two groups in mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), or mean corpuscular hemoglobin concentration (MCHC).

Table 3- Comparison of neonatal hematological parameters between preeclamptic and normotensive pregnancies.

Hematological Parameter	Group A (Preeclampsia)	Group B (Control)	p-value
Hemoglobin (g/dL)	16.9 ± 1.5	15.8 ± 1.4	<0.001
Hematocrit (%)	52.3 ± 4.1	48.5 ± 3.9	<0.001
Total leukocyte count (/mm³)	11,800 ± 2,100	12,400 ± 2,300	0.06
Absolute neutrophil count (/mm³)	6,100 ± 1,400	6,500 ± 1,600	0.08
Platelet count (×10⁹/L)	138 ± 28	176 ± 30	<0.001
MCV (fL)	100.1 ± 4.5	99.4 ± 4.3	0.22
MCH (pg)	33.0 ± 1.6	32.7 ± 1.7	0.27
MCHC (g/dL)	33.0 ± 1.5	32.9 ± 1.4	0.61
RBC (×10⁶/mm³)	4.8 ± 0.4	5.1 ± 0.3	<0.01
nRBC (/100 WBC)	11.2 ± 4.6	4.5 ± 2.3	<0.001
Reticulocytes (%)	5.1 ± 1.2	3.8 ± 1.0	<0.01

Figure 2 shows that the prevalence of hematological abnormalities was higher among neonates born to preeclamptic mothers compared to those born to normotensive mothers. Polycythemia was significantly more frequent in the preeclamptic group (14%) than in the control group (4%, $p=0.02$). Thrombocytopenia was also markedly more common in the preeclamptic group, affecting 46% of

neonates, compared to only 12% in the control group (p<0.001). Although leukopenia was observed slightly more in the preeclamptic group (5%) than in controls (3%), the difference was not statistically significant (p=0.47). Similarly, anemia was present in 10% of neonates from the preeclamptic group versus 6% in the control group (p=0.28), and neutropenia was found in 8% of neonates from the preeclamptic group compared to 3% in the control group (p=0.12); both differences were not statistically significant.

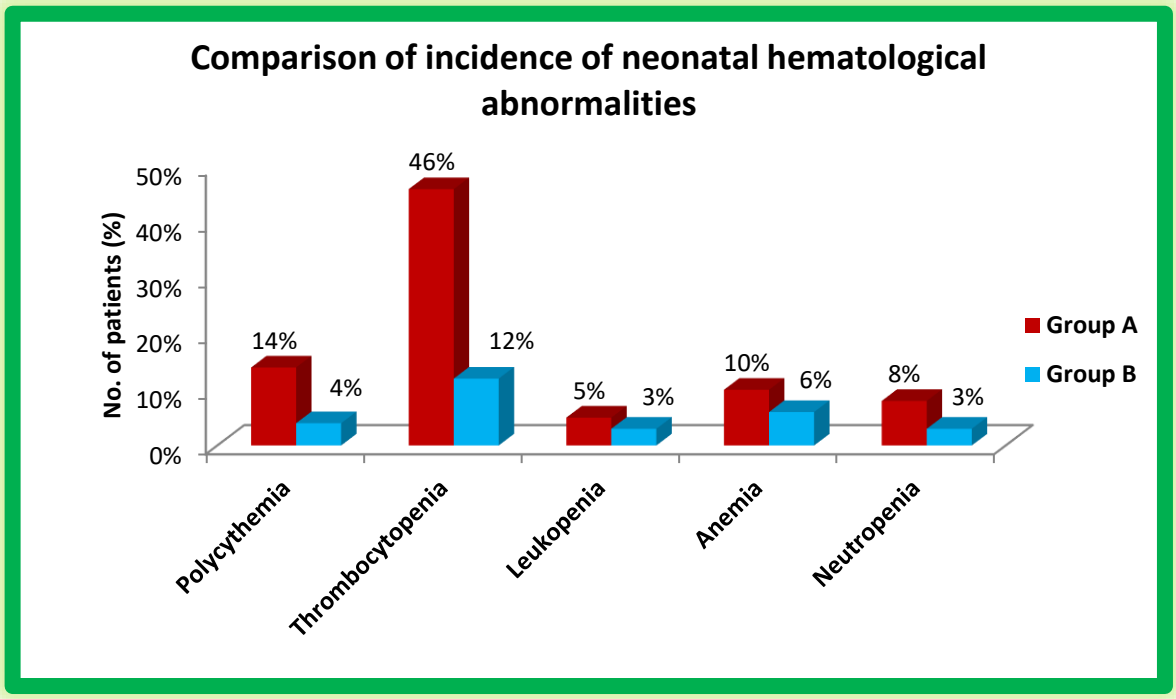

Figure 2- Comparison of incidence of neonatal hematological abnormalities between preeclamptic and normotensive groups.

Discussion-

This study evaluated the hematological profiles of neonates born to preeclamptic mothers compared to those born to normotensive mothers. The findings reveal significant differences in several hematological parameters, aligning with previous research and underscoring the impact of maternal preeclampsia on neonatal hematology. Neonates in the preeclamptic group had a significantly lower mean gestational age and birth weight compared to controls, consistent with previous reports that associate preeclampsia with uteroplacental insufficiency and intrauterine growth restriction (IUGR). In our study, IUGR was observed in 40% of neonates in the preeclamptic group, significantly higher than the 12% observed in controls. This finding is in agreement with the study by KalavaKuru Mouna et al.,[10] who reported that IUGR is a frequent neonatal complication of preeclampsia, emphasizing the role of impaired placental perfusion.

The total leukocyte and absolute neutrophil counts were slightly lower in the preeclamptic group, the differences were not statistically significant, although neutropenia was more frequently observed in the preeclamptic group. However, other studies have reported significant reductions in these counts, suggesting variability that may be influenced by factors such as the severity of preeclampsia and timing of delivery. For instance, Mulatie et al.[11] found lower neutrophil counts in neonates born to preeclamptic mothers, highlighting the impact of maternal hypertension on neonatal immune function. Similarly, KalavaKuru Mouna et al.[10] also reported decreased leukocyte counts in their cohort of neonates from preeclamptic pregnancies, noting that these variations might be tied to the degree of placental insufficiency and the timing of delivery. The study observed a significant increase in nucleated red blood cells (nRBCs) (11.2± 4.6 per 100 WBC) and reticulocyte counts (5.1±1.2%) in the preeclamptic group. This elevation indicates enhanced erythropoietic activity, likely a compensatory mechanism to chronic fetal hypoxia. Similar findings have been reported by

KalavaKuru Mouna et al.,[10] and Mulatie et al.,[11] highlighting the association between preeclampsia and increased nRBCs and reticulocytes in neonates. Many other studies are also in harmony with our study further supporting the role of intrauterine hypoxia as a key driver of these hematological changes. These changes underscore the body's attempt to compensate for reduced oxygen supply due to placental dysfunction, which is a hallmark of preeclampsia. Neonates in the preeclamptic group exhibited significantly higher hemoglobin (16.9±1.5g/dL) and hematocrit levels (52.3±4.1%) compared to the control group. These findings are consistent with prior studies that reported elevated hemoglobin and hematocrit in neonates born to preeclamptic mothers, suggesting a response to intrauterine hypoxia due to placental insufficiency stimulating erythropoiesis, as reflected by the significantly higher reticulocyte counts and nRBC values in our study.[10] This further aligns with the observations by Mulatie et al.,[11] who also reported elevated hemoglobin and hematocrit levels in neonates of preeclamptic mothers, indicating fetal compensatory mechanisms to hypoxia.

Despite the increased hemoglobin levels, 10% of neonates in the preeclamptic group exhibited anemia. A similar paradox was described by GhasemMiriAliabad and Dahmardeh[12] who suggested that the variability in hemoglobin levels might result from fluctuations in erythropoietic responses and blood volume alterations due to placental insufficiency. Although the incidences of anemia (10%) and neutropenia (8%) were higher in the preeclamptic group, these differences were not statistically significant. This contrasts with some the study by Noreen A, Abro F et al.,[13] that have reported significant associations between preeclampsia and these hematological abnormalities, suggesting that other factors may modulate these outcomes ._Study by KalavaKuru Mouna et al.,[10] found a significant association between preeclampsia and anemia in neonates, attributing it to placental insufficiency and maternal hypertension Similarly, Mulatie et al.,[11] observed a higher prevalence of neutropenia in neonates of preeclamptic mothers, suggesting a potential immune-mediated effect The variability in these findings may be due to differences in sample size, population characteristics, or the severity of preeclampsia._A significantly higher incidence of thrombocytopenia was noted in neonates born to preeclamptic mothers (46%) compared to controls (12%). This aligns with studies by Mohammad A. A. Bayoum et al[14] and Mahmoud M Elgari et al.[15] as they documented increased rates of neonatal thrombocytopenia associated with maternal preeclampsia, potentially due to platelet consumption or impaired platelet production in the fetus. KalavaKuru Mouna et al.,[10] found thrombocytopenia to be the most common hematological abnormality among neonates of preeclamptic mothers. The pathophysiology may involve fetal consumption of platelets in response to placental insufficiency or immune-mediated mechanisms. The prevalence of polycythemia was higher in the preeclamptic group (14%) compared to controls (4%). This finding is in line with previous research by Helen C. Okoye et al[16] and Zewudu Mulatie et al[17], indicating that chronic intrauterine hypoxia in preeclamptic pregnancies can stimulate erythropoiesis, leading to polycythemia in neonates. Similar results were observed by Ghasem Miri Aliabad and Dahmardeh,[12] who reported a higher incidence of polycythemia in neonates born to preeclamptic mothers, attributing this to the hypoxic environment caused by placental insufficiency. Additionally, Mulatie et al.,[11] also documented an increased incidence of polycythemia among neonates in preeclamptic pregnancies, reinforcing the role of fetal compensatory mechanisms in response to oxygen deprivation

Our findings also highlighted a higher rate of NICU admissions and preterm deliveries in the preeclampsia group, though not all differences reached statistical significance. These trends reflect the systemic impact of preeclampsia on neonatal outcomes, corroborating the broader literature that positions preeclampsia as a significant contributor to neonatal morbidity. Overall, our study findings are largely consistent with previous research, demonstrating that preeclampsia significantly affects neonatal hematological parameters, likely due to chronic intrauterine stress, hypoxia, and placental dysfunction. These insights stress the importance of close hematological monitoring in neonates born to preeclamptic mothers to ensure timely diagnosis and intervention. Early identification and management of hematological abnormalities can mitigate potential complications and improve neonatal outcome.[10]

Conclusion-

Present study showed that maternal preeclampsia significantly alters neonatal hematological profiles, most likely due to chronic intrauterine hypoxia, placental insufficiency, and systemic inflammation. Our findings emphasized the pathophysiological link between maternal hypertensive disorders and fetal hematological adaptation, clinically, highlighting the importance of routine hematological screening in neonates born to preeclamptic mothers. Early identification of abnormalities such as thrombocytopenia, anemia, or polycythemia enables timely interventions like monitoring, transfusion support, or infection surveillance of the neonates that can prevent complications reducing neonatal morbidity and and improving overall outcomes. Our study advocates for enhanced perinatal care strategies to mitigate the risks associated with preeclampsia and optimize neonatal health.

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References-

1. Brown, M. A., Magee, L. A., Kenny, L. C., et al. (2018). Hypertensive disorders of pregnancy: ISSHP classification, diagnosis, and management recommendations. *Hypertension*, 72(1), 24–43.
2. Mol, B. W., Roberts, C. T., Thangaratinam, S., Magee, L. A., de Groot, C. J., & Hofmeyr, G. J. (2016). Pre-eclampsia. *The Lancet*, 387(10022), 999–1011.
3. Rana, S., Lemoine, E., Granger, J. P., & Karumanchi, S. A. (2019). Preeclampsia: Pathophysiology, challenges, and perspectives. *Circulation Research*, 124(7),1094–1112.
4. Roberts, J. M., & Hubel, C. A. (2009). The two-stage model of preeclampsia: variations on the theme. *Placenta*, 30, S32–S37.
5. Korkmaz, A., Yiğit, Ş., Firat, M., & Oran, O. (2000). Neonatal hematological parameters in preeclampsia. *Journal of Maternal-Fetal & Neonatal Medicine*, 9(1), 1–5.
6. Parshad, O., Richards, C., & Mathur, M. (2018). Neonatal hematological parameters and outcomes in preeclamptic pregnancies. *West Indian Medical Journal*, 67(1), 23–28.
7. Al-Tamimi, M., Tamim, H., & Almawi, W. Y. (2014). Impact of preeclampsia on neonatal outcome. *Journal of Pregnancy*, 2014, Article ID 204319. https://doi.org/10.1155/2014/204319
8. American College of Obstetricians and Gynecologists (ACOG). (2020). Gestational hypertension and preeclampsia: ACOG Practice Bulletin, Number 222. *Obstetrics & Gynecology*, 135(6), e237–e260.
9. Christensen, R. D., & Henry, E. (2013). Reference intervals for blood concentrations of newborns. *NeoReviews*, 14(9), e434–e446. https://doi.org/10.1542/neo.14-9-e434
10. KalavaKuru Mouna, et al. "Changes in Haematological Parameters in Newborns Born to Preeclamptic Mothers - A Case Control Study in a Rural Hospital." *Journal of Clinical and Diagnostic Research.* 2017 Jul; 11(7): EC26–EC29. doi: 10.7860/JCDR/2017/29137.10303.
11. Mulatie M, et al. "Hematological profiles of neonates born to preeclamptic and normotensive mothers in Ethiopia." *BMC Pediatrics.* 2024; 24:17. https://doi.org/10.1186/s12887-023-04491-3.
12. GhasemMiriAliabad, Fatemeh Dahmardeh. "Hematological Parameters in Newborns of Mothers with and without Preeclampsia." *Medical Surgical Nursing Journal*. 2022 February; 11(1):e128840. https://doi.org/10.5812/msnj-128840.
13. Noreen A, Abro F, Dawood S, Hussain M, Alam SS, Arshad U. Neonatal Hematological Abnormalities Associated with Maternal Pre-eclampsia at Birth. Pak J Med Dent. 2024;13(1): 31-36. Doi: 10.36283/PJMD13-1/0071
14. Mohammad A. A. Bayoum et al., Effect of Maternal Preeclampsia on Hematological Profile of Newborns in Qatar, BioMed Research International Volume 2020, Article ID 7953289, 6 pages https://doi.org/10.1155/2020/7953289

15. Mahmoud M Elgari et al., Correlations between changes in hematological indices of mothers with preeclampsia and umbilical cord blood of newborns, Clin Exp Hypertens. 2019;41(1):58-61. doi: 10.1080/10641963.2018.1441861. Epub 2018 Feb 23.
16. Helen C. Okoye et al., Effects of maternal hypertension on the neonatal haemogram in southern Nigeria: A case-control study, Malawi Medical Journal 28 (4): December 2016
17. Zewudu Mulatie et al., Hematological profiles of newborns of mothers with hypertensive disorders of pregnancy delivered at the University of Gondar comprehensive specialized hospital: a comparative cross-sectional study, BMC Pediatr. 2024 Jan 5;24(1):17.doi: 10.1186/s12887-023-04491-3.