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Hypercoagulation and Anemia: The predominant parturition-associated coagulatory and hematological abnormality in Ogbomosho southwest, Nigeria

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Abstract

Background: Parturition, or the process of childbirth, is a critical physiological event associated with significant changes in hematology and coagulation. While these changes are often adaptive, they may also predispose mothers to complications such as anemia, thrombosis, or coagulopathy. Understanding these alterations is essential for optimizing maternal care during and after delivery. This study investigates the impact of parturition on hematological and coagulation parameters to identify key changes and their potential clinical implications.

Methodology: A prospective observational study was conducted involving 160 pregnant women attending LAUTECH teaching hospital, Ogbomosho. Between June and December, 2024. Blood samples were collected at two stages: late-third trimester and early postpartum period. Full blood count and coagulatory profiles were assayed using standard procedures and values were statistically compared across the two stages and correlate with maternal outcomes using standard procedures in all.

Results: Significant elevation in WBC ($p = 0.006$), neutrophil ($p= 0.046$) and basophil ($p = 0.009$) were observed postpartum, as well as significant reductions in hemoglobin and hematocrit ($p = 0.044$) and ($p = 0.009$). Also, there were significant increase in incidence of severe, moderate and mild anemia in postpartum. Protein S and PTTK were significantly shortened as well ($p < 0.005$), reflecting temporary changes in coagulation dynamics.

Conclusion: Parturition induces marked changes in hematology and coagulation parameters, reflecting the physiological adaptation to childbirth and associated blood loss. While most changes are transient, close monitoring is essential to identify and manage deviations that may indicate underlying complications. Routine assessment of hematological and coagulation profiles during the peripartum period is recommended to facilitate early detection and management of potential complications.

Keywords: Anemia; Parturition; Postpartum; Hypercoagulation; Complication

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1. Introduction

Parturition, the physiological process of childbirth, induces significant hemodynamic and hematological changes in women. These changes are essential adaptations that prepare the body to meet the increased demands of pregnancy and the eventual challenges of delivery [1]. However, they also predispose women to certain hematological and coagulatory abnormalities, which, if unaddressed, may lead to adverse maternal and neonatal outcomes [2]. Among the most common abnormalities associated with parturition are anemia and hypercoagulation, both of which pose significant clinical challenges in maternal healthcare [3, 4]. Maternal health remains a cornerstone of public health efforts worldwide, particularly in low- and middle-income countries, where complications during pregnancy and childbirth account for a significant proportion of maternal morbidity and mortality [2].

Anemia, characterized by a reduction in hemoglobin concentration or red blood cell count, is a prevalent complication during pregnancy and the postpartum period. Physiological hemodilution, increased iron demand, and blood loss during delivery are key contributors to this condition [5]. Anemia during parturition can lead to fatigue, reduced physical capacity, and, in severe cases, maternal morbidity and mortality [6]. Moreover, it has implications for neonatal health, as maternal anemia is associated with preterm delivery, low birth weight, and impaired cognitive development in offspring [7]. Hypercoagulation, on the other hand, is a natural physiological response to pregnancy aimed at minimizing blood loss during childbirth [8]. Pregnancy is considered a hypercoagulable state due to increased levels of clotting factors, reduced anticoagulant activity, and impaired fibrinolysis [9]. While this adaptation is protective, it also elevates the risk of thromboembolic events, which remain a leading cause of maternal mortality worldwide. The postpartum period is particularly critical, as the risk of venous thromboembolism (VTE) is significantly heightened [10, 11].

Despite the global prevalence of these conditions, there is a paucity of region-specific data addressing the impact of parturition on hematological and coagulatory parameters, particularly in Nigeria. Thus, this study aimed at evaluating comprehensive hematology and coagulatory parameters in women before and after delivery to understand the impact of parturition on these parameters in Ogbomosho. Investigating the dual threat of hypercoagulability and anemia in this context is critical for designing targeted strategies to mitigate these risks. This study filled the knowledge gap by providing data on the prevalence, underlying causes, and outcomes of these conditions in pregnant women. Ultimately, this study contribute to the global effort to reduce maternal mortality and morbidity, in alignment with the Sustainable Development Goals (SDG 3), by improving maternal health in underserved communities like Ogbomosho

2. Material and methods

2.1. Study area

Ogbomosho, a semi-urban community represents a miniature of the broader challenges faced in southwestern Nigeria, with limited access to prenatal care, high rates of poverty, and inadequate public health infrastructure. Ogbomosho is the third largest city in South-west Nigeria with estimated population of 1.2 million spanning an estimated 2,110 km^2 it is bordered to the north by Ilorin, and to the south by Oyo town. Ogbomosho lies Latitude 8°142165 and longitude 4°25 East stretching through a land mass of 36,825km^2.

2.2. Study design

A hospital-based longitudinal study approach was adopted to determine the impact child birth process on hematological and coagulatory parameters among pregnant women at LAUTECH teaching hospital, Ogbomosho. The parameters were evaluated serially among the participants at their late 3rd trimesters and at early postpartum period.

2.3. Inclusion and exclusion criteria

Eligible criteria for participation include; booked pregnant women in their 3rd trimester, who were between the ages of 18 to 45 years, without any pregnancy-related complication and who delivered a singleton via vaginal spontaneously. Those excluded from this study includes; women with multiple gestation, those taking anticoagulants and antiplatelet agent, those below 18 or above 45 years of age, those unwilling to provide informed consent for study participation, those with history of bleeding and clotting disorders, those with cardiovascular, cerebrovascular, liver, kidney, diabetes mellitus and autoimmune diseases were also excluded.

2.4. Operational definition

Anemia was categorized using WHO definition; mild anemia (100 – 109 g/L), moderate anemia (70 – 99 g/L) and severe anemia (< 70 g/L)

Hypercoagulation was determined by shortened aPTT, normal or shortened PT, elevated D-dimer, decreased Protein S.

2.5. Socio-demographic and clinical data collection

A semi-structured and pretested questionnaire was used to collect socio-demographic and clinical data from the enrollees. The socio-demographic data that were included were age, occupation, residence, and level of education. Behavioral data such as the habit of regular physical exercise and cigarette smoking were collected using questionnaire with a face-to-face interview by trained nurses working in the chronic illness clinic of the

2.6. Blood samples collection

At appropriate time during their late third trimester, about 6 milliliters of venous blood samples was collected, 3mL was dispensed into a tri-potassium Ethylene Diamine Tetra acetic Acid (EDTA) and 2.7mL of blood was collected to a tube containing 0.3mL of 3.2% sodium citrate. The EDTA anti-coagulated blood was used for full blood count (FBC), protein S and D-dimer tests, while the sodium citrate anti-coagulated blood was used for prothrombin time (PT), activated partial thromboplastin time (PTTK), and mixing tests. At appropriate time during early postpartum period, the sample collection and laboratory investigations procedure was repeated.

2.7. Ethical clearance

Ethical approval was obtained from the ethical review committee of Oyo State Ministry of Health with reference number OSHREC/PRS/569T/626. The research was carried out in line with the ethics governing the use of human samples and in accordance with Helsinki declaration. Ethical practices such as participant consent, confidentiality and safety laboratory practice were observed in the course of the study.

2.8. Statistical analysis

The statistical analysis was carried out using the IBM SPSS version 26 for window software (SPSS Inc. Chicago, IL USA). Descriptive analysis, and pair t' test was used for the comparisons of data. Quantitative variables were presented as mean ± standard deviation and qualitative variables as percentages. P-values of < 0.05 were considered significant.

3. Results

3.1. Demographics and clinical characteristics of the participant

Table 1 displayed the clinical data of participants, the age of participants was categorized using American College of Obstetricians and Gynecologists (ACOG) recommendation. Accordingly, five categories of maternal age were observed in this study; those in the age bracket (25 - 44) years constituted the largest population, 53.8%, this was follow by (35 - 39) years, 21.9%, the highest age observed in this study was 44 years, thus no participant was categorized as (≥ 45) years. 98.1% of the participants were married, the remaining were single. In respect to their parity, 23.8%, 45%and 31.2% were primigravid, secundigravida and multiparous respectively. Both the previous and current history of postpartum hemorrhage were gather and evaluated as shown on the table.

3.2. Comparison of hematological parameters between late-third trimesters and early postpartum period

Table 2 show the outcome of comparative analysis of hematology parameters of the participants at their late third trimesters (LTT) and early postpartum period (EPP). As it was shown on the table, while the values of WBC count, neutrophil and basophil were significantly elevated, the values of RBC count, hemoglobin and hematocrit level were significantly reduced in EPP in relation to the LTT. There were no significant differences in the values of the remaining hematological parameters between the two periods.

3.3. Comparative data on the different level of anemia between late trimester and early postpartum period

Figure 1 represent the distribution pattern of the three categories of anemic level among the participants before and after delivery. As it appeared in the figure, the incidence of severe anemia was 0% at LTT, but rose to 3.8% post-delivery. 15% of the participants had mild anemia prior to delivery. The worse scenario was the occurrence of moderate anemia which was prior to delivery 9.4% and later rose to 31.9% after delivery.

3.4. Prevalence of reduced PTTK between pre and post delivery

Figure 2 represent the prevalence of reduced PTTK among the participants before and after delivery. As shown on the figure, the percentage of patients with reduced PTTK values rose from 23.8% at LTT to 51.3% postpartum.

3.5. Evaluation dependent of clinical data on the incidence of anemia

Table 3 displayed the outcome of association between the incidences of anemia in relation to different clinical characteristics. Parity, duration of labor and previous history of CS show significant association with the occurrence of anemia. On the other hand, the data shows that there the frequency of anemia is not depend on the age of patients, blood group, previous history of postpartum haemorrhage and BMI.

Table 1 Clinical data of the participants

Characteristics		Frequency	Percentages
Age range (years)	13 – 19	16	10.0
	20 – 24	13	8.1
	25 – 34	86	53.8
	35 – 39	35	21.9
	40 – 44	10	6.2
	≥ 45	0	--
Marital status	Married	157	98.1
	Single	03	1.9
BMI (km^2)	Normal	150	93.8
	Overweight	10	6.2
Parity	Primiparity	38	23.8
	Secundiparity	72	45.0
	Multiparity	50	31.2
Previous history of PPH	No	98	61.3
	Yes	24	15.0
Current history of PPH	No	121	75.6
	Yes	39	24.4
Previous history of caesarean section	No	85	53.1
	Yes	37	23.1
Duration of labor	Normal	138	86.2
	Prolonged	22	13.8
Induction with oxytocin	Yes	46	28.8
	No	114	71.3

The values are frequency and percentage of occurrences of those data among the participants, BMI = Body mass index, PPH = Postpartum hemorrhage,

Table 2 Comparison of hematological parameters between late-third trimesters and early postpartum period

Parameters	LTT	EPP	P-value
White blood cells count (x 10^9/L)	6.22 ± 0.37	11.38 ± 4.54	0.006*
Lymphocytes (%)	39.75 ± 14.05	24.82 ± 13.25	0.264
Neutrophil (%)	54.01 ± 4.85	70.84 ± 6.11	0.046*
Monocytes (%)	3.40 ± 1.21	4.47 ± 1.67	0.423

Eosinophil (%)	0.89 ± 0.16	1.01 ± 0.92	0.086
Basophil (%)	0.32 ± 0.19	1.60 ± 0.21	0.009*
Red blood cells count (x 10^{12}/L)	4.98 ± 0.41	3.74 ± 0.66	0.010*
Hemoglobin (g/dL)	12.93 ± 1.07	10.15 ± 1.94	0.044*
Hematocrit (%)	37.98 ± 3.44	30.79 ± 3.04	0.009*
MCV (fL)	87.2 ± 5.64	85.3 ± 8.39	0.276
MCH (Pg)	24.29 ± 2.23	27.74 ± 4.96	0.190
MHCH (g/dL)	28.17 ± 1.06	33.47 ± 1.97	0.314
Platelets count (x 10^9/L)	226.13 ± 55.5	205.11 ± 89.8	0.869
NLR	1.68 ± 0.84	2.97 ± 0.82	0.057
PLR	6.44 ± 0.19	10.20 ± 4.05	0.123
Fibrinogen (g/L)	2.64 ± 1.33	2.94 ± 0.46	0.747
D-Dimer (g/dL)	491.09 ± 373.1	667.68 ± 196.9	0.094
Protein S (fL)	6.84 ± 0.73	3.43 ± 1.56	0.002*
PT (sec)	14.35 ± 2.72	10.64 ± 3.13	0.086
PTTK (sec)	29.03 ± 3.05	16.83 ± 7.58	0.004*

The values are mean ± standard deviation, Student t-test was used to compare the means and p = 0.005, MCH = mean corpuscular hemoglobin, MCHC = mean corpuscular hemoglobin concentration, MCV = mean corpuscular volume, NLR = neutrophil to lymphocytes ratio, PLR = platelet to lymphocytes ratio.

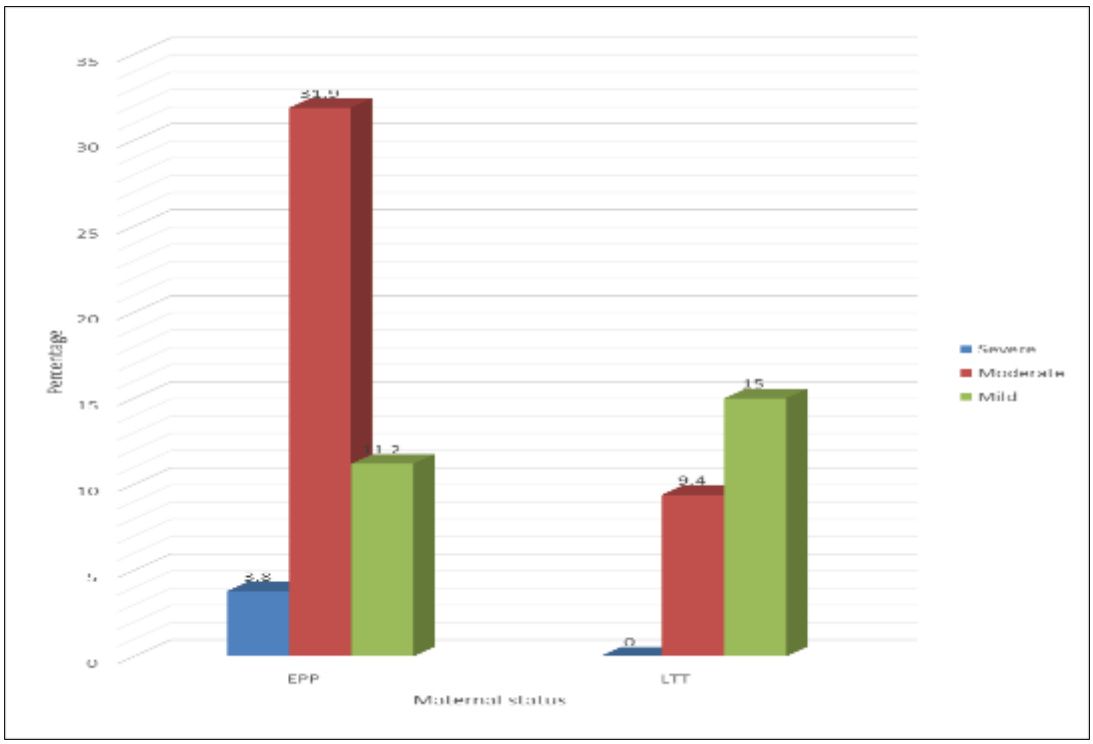

Figure 1 The distribution of categories of anemia among the participants

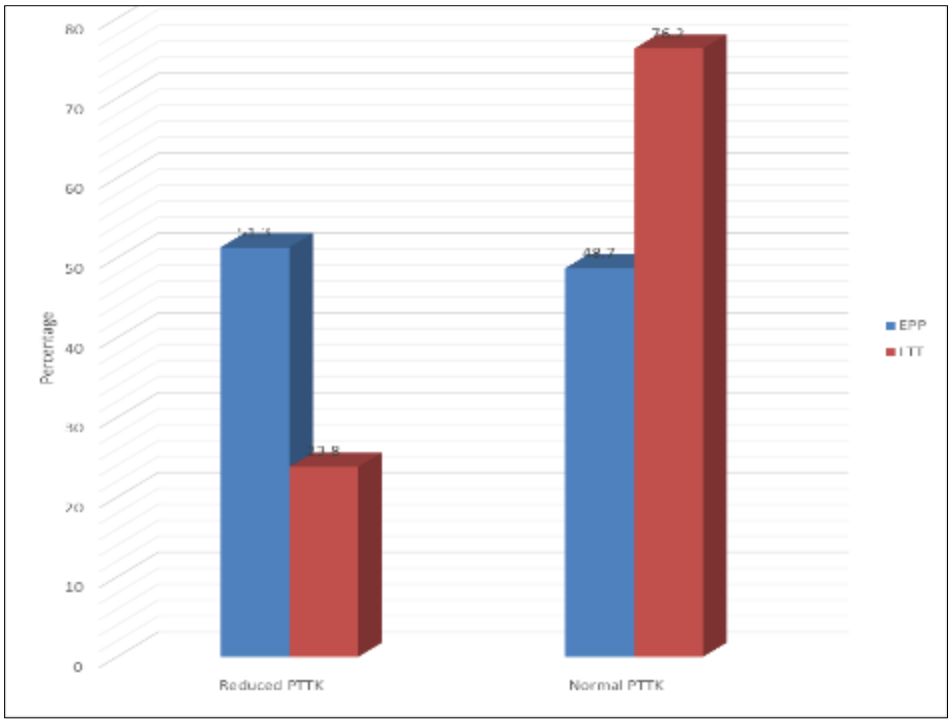

Figure 2 Pattern of PTTK before and after parturition among the participants

Table 3 Evaluation of impact of clinical data on the incidence of anemia

Clinical data		**Non-anemic.**	**Anemic**	**χ-value**	**p-value**
Age (years)	15 – 19	13 (8.1)	3 (1.9)	6.20	0.185
	20 – 24	7 (4.4)	6 (3.8)		
	25 - 34	44 (27.5)	42 (26.3)		
	35 – 39	17 (10.6)	18 (11.3)		
	40 - 44	4 (2.5)	6 (3.8)		
BMI (km^2)	Normal	79 (49.4)	70 (43.8)	0.01	0.922
	Overweight	06 (3.8)	05 (3.1)		
Previous PPH	No	34 (21.3)	64 (40)	3.09	0.008*
	Yes	13 (8.1)	11 (6.9)		
Parity	Primiparity	17 (10.6)	21 (13.1)	14.66	0.001*
	Secundiparity	50 (31.3)	22 (13.8)		
	Multiparity	18 (11.3)	32 (20)		
Duration of labor	Normal	81 (50.6)	57 (35.6)	12.5	0.001*
	Prolonged	04 (2.5)	18 (11.3)		
Induction with oxytocin	No	28 (17.5)	13 (8.1)	1.44	0.230
	Yes	52 (32.5)	62 (38.8)		
Previous CS	No	25 (15.6)	60 (37.5)	9.83	0.002*
	Yes	22 (13.8)	15 (9.4)		

The values are finding (%). Chi-square test was used to determine the independent of anemia on those clinical variables at p = 0.05 (95% confidence level) with degree of freedom 1- 4. BMI = Body mass index, PPH = Post-partum haemorrhage, CS = Caesarean section

4. Discussion

The major event in pregnancy between late third trimester and early postpartum period is childbirth, and it has been established to accompany by several changes physiologically. It was thus anticipated that any changes observed in the participants in between the two durations was as a result of parturition. Coupled with the facts that the participants were monitored for the occurrence of cofounders during the period of study. A total of 160 pregnant women in their third trimesters were serially enrolled and monitored till after postpartum following a stringent exclusion criteria. A standard questionnaire and interview method were used to gather relevant information from the participants after an informed consent has been sought. Questionnaire has the advantages of easy administration and gathering of enormous information [12]. The socio-demographic and clinical data of the studied participants were gathered, to include; age, parity, BMI, history of previous CS, mode of delivery among others.

The American College of Obstetricians and Gynecologists (ACOG) recommendation for categorization of maternal age was adopted in this study. It is widely accepted and used in obstetric practice research and policy-making [13]. Accordingly, six age categories exist, however, only five maternal age were observed in this study; the adolescent, Adolescents (13-19 years) made up 10% of the participants, highlighting the need to consider the unique physiological changes in younger mothers. Young adults (20-24 years), representing 8.1%, suggest a smaller cohort in the early reproductive years, possibly influenced by socio-economic factors like education or employment. The adult (25-34 years) who were in their prime reproductive years constituted 53.%, reflecting the typical age group for childbirth and emphasizing the relevance of this study to maternal health outcomes. Advanced maternal-aged women (35–39 years) comprised 21.9%, suggesting inclusion of individuals with varied reproductive histories, potentially affecting hematological and coagulatory profiles. Advanced maternal aged women prevalence was 6.2%, represent a minority but may provide valuable data on long-term impacts of parturition. This distribution is similar to what was earlier reported by [14]. This age distribution ensures a comprehensive understanding of the variations in hematological and coagulatory parameters across different reproductive stages, underscoring the importance of age-specific analyses in maternal health research.

Anemia was evaluated in this study using hemoglobin (HBG) level, hematocrit (HCT), and red blood cell (RBC) count, these parameters directly reflect oxygen-carrying capacity and red cell concentration in the blood [15]. Hemoglobin is the primary oxygen transport molecule, while hematocrit measures the proportion of blood volume occupied by red cells, and RBC count quantifies the number of erythrocytes per unit volume of blood [16]. These indices are standard markers for diagnosing and monitoring anemia, as recommended by clinical guidelines [17]. On the other hand, hypercoagulation was evaluated using PTTK, PT, D-dimer, and Protein S levels. PTTK and PT assess the functionality of the intrinsic and extrinsic coagulation pathways, respectively, while D-dimer serves as a marker of fibrin degradation, indicating ongoing thrombus formation and breakdown [18]. Protein S, a natural anticoagulant, is evaluated to detect deficiencies that predispose to thrombosis. These tests are widely utilized in diagnosing coagulation disorders and hypercoagulable states, providing critical insights into the hemostatic system [19].

4.1. White blood cells between LTT and EPP

Comparison of the total WBC count and the percentage of neutrophil between pre and post-parturition revealed a significant elevation in both parameters during post-partum duration ($p = 0.006$) and ($p = 0.048$) respectively (Table 2). This finding aligned with that from [9, 20]. The elevation observed could be attributed to the process of childbirth, it is associated with severe physiological stress, and sometimes accompany with trauma to the uterus and surrounding tissues [3]. Stress of such kind often triggers cortisol release [21]. The cumulative effect of those physiological activities stimulates leukocytosis and subsequent acute inflammatory response that manifest by increase in WBCs and neutrophils. The finding and level of leukocytosis established the existence of significant inflammation during postpartum period. The primary function of WBCs is to defend the body against foreign substances through leukocytosis and antibody production [22]. Neutrophils are the most abundant leukocytes and play a key role in innate immunity [23]. Their levels increase in response to the heightened inflammatory state during and immediately after delivery [24]. Another key role of neutrophil is to facilitate wound healing and preventing infections at the site of placental detachment and other potential entry points for pathogens [22].

Also, variations were observed in basophil and eosinophil counts during this time, with basophil levels showing a significant increase ($p =0.009$), while changes in eosinophil counts are not statistically significant ($p =0.086$). Basophils, though constituting a small fraction of circulating leukocytes, play a crucial role in immune responses, particularly in allergic reactions and parasitic infections [25]. The significant elevation of basophil counts postpartum may be attributed to the immune system's reactivation following the immunosuppressive state of pregnancy. This rebound effect could lead to an increased production or release of basophils as the body readjusts its immune surveillance

mechanisms [26]. These differential patterns in basophil and eosinophil counts highlight the complex and distinct regulatory mechanisms governing various leukocyte populations during the postpartum period.

4.2. Red blood cells profile between LTT and EPP

As evident from Table 2, the significant decrease in RBC count ($p = 0.010$), Hb ($p = 0.044$), and HCT ($p = 0.009$) was noticed postpartum. The outcome was consistent with physiological and pathological changes associated with childbirth. During pregnancy, plasma volume expands significantly, leading to hemodilution, which can mask the severity of anemia [6]. However, the physiological hypervolemia resolves during postpartum, and the actual blood loss during delivery becomes more apparent [3]. Studies indicate that the average blood loss during vaginal delivery is approximately 300 to 500 mL, while cesarean sections can result in losses exceeding 1,000 mL, further depleting RBC count, hemoglobin, and PCV levels [27]. Additionally, labor itself may cause stress-induced hemolysis, further reducing RBC levels [3]. More so, nutritional deficiencies, particularly of iron and folate, which are common in pregnancy and postpartum due to increased demands, can exacerbate anemia [28]. The decrease in hemoglobin and PCV postpartum may also reflect inadequate replenishment of maternal iron stores, especially in women who had insufficient antenatal care or iron supplementation [29]. Furthermore, hormonal and inflammatory changes after delivery can suppress erythropoiesis, delaying recovery of hematological parameters [3]. One of the effective strategies to address this include routine postpartum iron supplementation and nutritional counseling to ensure adequate recovery [30]. This finding underscores the need for postpartum monitoring and care to prevent and manage postpartum anemia, which is associated with fatigue, delayed wound healing, and reduced maternal-infant bonding [31]

By extension, the changes may also have implications on RBC indices (MCH, MCHC and MCV). As shown on the Table, no significant differences were observed in the mean values of MCV, MCH and MCHC between the two periods, the p-values were; ($p = 0.209$), ($p = 0.321$) and ($p = 0.794$) respectively. These results align with previous studies by [3]. Both MCH and MHCH level are likely unchanged or slightly increased in early postpartum because the absolute decrease in Hb is generally proportional to the decrease in RBC count and HCT respectively [4]. Thus, any significant deviation in MCHC could indicate a concurrent pathological condition (e.g., iron deficiency or hemolysis). MCV is also expected to remain stable postpartum unless there is an underlying condition such as iron and vit-B12/foliate deficiency that decrease and elevate MCV and manifested as microcytosis and macrocytosis respectively [9]. In general, RBC index are expected to remain stable unless there are specific underlying nutritional deficiencies or pathological processes.

4.3. Coagulatory factors between LTT and EPP

Furthermore, the comparison of coagulatory profiles between the LTT and EPP as shown in Table 2, revealed dynamic changes consistent with the physiological adaptations of pregnancy and the postpartum state. Fibrinogen levels demonstrated a slight increase from LTT to EPP, though the change was not statistically significant ($p = 0.747$), aligning with previous studies that reported elevated fibrinogen levels throughout pregnancy and early postpartum as part of the hypercoagulable state aimed at minimizing hemorrhage during delivery [7]. Similarly, D-dimer levels were higher in postpartum, indicative of heightened fibrinolytic activity, but the difference did not reach statistical significance ($p = 0.094$), consistent with findings by [32], who observed significant postpartum increases in D-dimer levels. Protein S levels, a marker of anticoagulant activity, were significantly reduced in the postpartum period ($p = 0.002$), reflecting the reversal of the pregnancy-induced decline, a phenomenon also reported by [33]. Although PT showed a slight decrease postpartum, the change was not statistically significant ($p = 0.086$), aligning with similar observations by [34]. The significant reduction in aPTT in the early postpartum period ($p = 0.004$) further supports a hypercoagulable state, which is well-documented in studies such as that by [35].

These studies collectively emphasize the complex alterations in coagulation profiles during and after pregnancy. The reduction in PTTK and fluctuations in PT postpartum reflect the body's adaptation to prevent excessive bleeding following childbirth. However, these changes also predispose women to thromboembolic events, necessitating vigilant monitoring and, when appropriate, prophylactic interventions to mitigate potential risks.

4.4. Hematological inflammatory markers between LTT and EPP

As further evident from Table 2, there were no significant differences in the values of NLR and PLR between pre and post-delivery. The finding is in line with that of [22]. The fact that the two parameters (NLR and PLR) relatively remain stable across third trimesters and into the postpartum period, reflecting the body’s ability to maintain an inflammatory balance despite physiological stress. Pregnancy induces a unique challenge for the maternal immune system, which must tolerate the presence of a semi-allogenic foetus and still maintain a strong immune response against invading pathogens [36]. In a similar study, [37] attributed the lack of significant variation in the inflammatory biomarkers to the gradual resolution of the pro-inflammatory state of pregnancy without abrupt immunological shifts postpartum. It can

also be inferred from the outcome of this study that the incidences obstetric complication is low among the participants. Because, while study by [23] revealed a significant elevations in NLR and PLR in complicated pregnancies, these markers showed no significant changes in normal pregnancies during the early postpartum period.

4.5. The distribution of categories of anemia in study group

Having identified the predominant of anemia postpartum, effort was made to categorize the anemic state according to WHO standard. Figure 1 depicted the distribution of different categories of anemia among the participants. Going by the WHO categorization for anemia; pregnant women with hemoglobin level in the range of 100 - 109 g/L is considered mild anemia, 70 – 99 g/L is moderate anemia, and those with less than 70 g/L are categorized as severe anemia [15]. The occurrence of severe anemia rose from 0% to 3% from late-third trimester to postpartum, while moderate anemia rose from 9.4% to 31.9%. This further proof that parturition increases or predispose to anemia. In all, the significant rise in the prevalence and severity of anemia from late third trimester (24.4%) to postpartum (46.9%) aligns with findings from previous studies that highlight anemia as a common postpartum complication. Research consistently attributes this increase to substantial blood loss during delivery, with an average blood loss of 500 mL during vaginal delivery and up to 1,000 mL during cesarean section, leading to a depletion of iron stores. A study by [27] reported that postpartum anemia affects 50% of women in low- and middle-income countries and up to 20% in high-income settings, emphasizing the role of delivery-related blood loss and suboptimal iron replenishment. Furthermore, the emergence of severe anemia postpartum in this study (3.8%) is consistent with findings from [6], who highlighted that inadequate iron supplementation during late pregnancy and postpartum exacerbates the progression of anemia. The observed shift from mild anemia in the third trimester to moderate and severe anemia postpartum underscores the critical importance of postpartum iron supplementation, as corroborated by [3], who demonstrated that routine iron supplementation postpartum significantly reduces the prevalence of moderate-to-severe anemia. This data underscores the need for targeted interventions, including routine screening, dietary counseling, and postpartum iron supplementation, to address the dual burden of anemia in pregnancy and the postpartum period, ensuring better maternal and neonatal outcomes.

4.6. Pattern of incidence of shortened of PTTK at LTT and EPP

Of all the criteria of establishing hypercoagulation (shortened PTTK, shortened PT, elevated D-dimer, and decreased Protein S), shortened PTTK was the predominant finding. Thus, the level of incidence of hypercoagulation was rated by shortened PTTK. As it was evident in the Figure 2, the percentage of pregnant women with shortened PTTK was 28.3% at LTT, but after delivery during their EPP, on repeating the test, it was found that the percentage has risen to 51.3%. The observation is in line with earlier finding by [33]. This finding point to the fact that parturition increase the tendency of hypercoagulation. The finding collectively emphasize the complex alterations in coagulation profiles during and after pregnancy. The reduction in aPTT and fluctuations in PT postpartum reflect the body's adaptation to prevent excessive bleeding following childbirth [4].

4.7. Evaluation of the impact of clinical features on anemia

Table 3 displayed the outcome of association between the incidences of anemia in relation to their clinical characteristics. The characteristics such as parity, duration of labor and previous history of CS show significant association with the occurrence of anemia. On the other hand, the data shows that the frequency of anemia is not depend on the age of patients, previous history of postpartum haemorrhage (PPH) and BMI. The results underscore the multifactorial nature of anemia among participants, highlighting the importance of parity, labor duration, and surgical history as key contributors.

Prolonged labor may delay timely medical intervention, increasing the risk of complications such as postpartum hemorrhage, which is a direct contributor to anemia [13]. The lack of association between age and anemia could indicate that other factors, such as nutritional status, parity, or access to healthcare, play a more pivotal role than chronological age. For the PPH, the finding could suggest that effective medical management of PPH in prior pregnancies or differences in participants' recovery and nutritional replenishment may mitigate its long-term impact on anemia risk [34]. The lack of relationship between BMI and anemia challenges common assumptions that underweight individuals are more likely to experience anemia due to nutritional deficiencies. However, this finding might reflect variability in dietary quality, supplementation, or other compensatory factors among participants with different BMI categories.

5. Conclusion

A significant alteration observed in white blood cells profile in EPP designate a selective leukocyte mobilization and consistent with the immune/hematological adaptations in postpartum period. These changes reflect the body's preparation for tissue repair and recovery following delivery.

The study observed a notable increase in the incidence of anemia from the LTT to the EPP, it thus, underscores the physiological challenges associated with increased blood loss during delivery and the subsequent hemodynamic adjustments postpartum. The finding therefore justify the need for adequate monitoring and management of maternal anemia to prevent adverse outcomes during this critical period.

The coagulatory profile revealed significant alterations between LTT and EPP, reflective of the physiological shifts in hemostatic balance. The significant reduction in PTTK and increased Protein S levels in EPP indicate a hypercoagulable state postpartum, likely as a protective mechanism against hemorrhage. The lack of significant differences in fibrinogen and D-dimer levels further underscores the complex interplay of coagulation and fibrinolysis during pregnancy and postpartum. These findings emphasize the importance of understanding coagulation dynamics to mitigate the risks of thrombotic and bleeding complications.

The lack of significant differences in NLR and PLR during the LTT and EPP aligns with the body's mechanisms for maintaining inflammatory and coagulatory homeostasis. These findings reemphasize the importance of considering baseline physiological changes during pregnancy when interpreting these markers. Though, suggesting an absence of significant systemic inflammation during these periods. Future research might focus on exploring these parameters in pathological pregnancies or assessing their role in predicting postpartum recovery.

In general, this study established the dynamic changes in hematological and coagulatory parameters from the late third trimester to the early postpartum period, reflecting the body's physiological adaptations to pregnancy and recovery after delivery. These findings highpoint the importance of vigilant maternal care and targeted interventions during these stages to ensure optimal outcomes for maternal health. Future studies should aim to explore the clinical implications of these changes and their impact on maternal and neonatal outcomes.

Compliance with ethical standards

Author's contribution

- Kikelomo O.O.: Conceptualization, final editing and validation
- Moninuola V.A.: Carried out hematological and coagulation analysis
- Ibrahim .E. S: Carried out statistical analysis and initial manuscript writing.
- Ahmed O.Y.: Responsible for patient recruitment and data generation
- Saheed.O.A: Writing of original manuscript and provision of reagents
- Olayinka B.A: Provision of reagents, Proofreading of the manuscript
- Motolani.S.b.: Proofreading and final editing and validation

Disclosure of conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be understood as a potential conflict of interest.

Statement of ethical approval

Ethical approval was obtained from the ethical review committee of Oyo State Ministry of Health with reference number OSHREC/PRS/569T/626. The research was carried out in line with the ethics governing the use of human samples and in accordance with Helsinki declaration. Ethical practices such as participant's consent, confidentiality and safety laboratory practice were strictly adhered to in the course of the study.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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