CHANGES IN ENZYMATIC ANTIOXIDANTS AND RED CELL INDICES WITH MODES OF CHILD DELIVERY AMONGST WOMEN OF REPRODUCTIVE AGE IN OWERRI, IMO STATE, NIGERIA

ABSTRACT

A positive pregnancy outcome is marked by childbirth, and the method of delivery—whether vaginal delivery (VD) or cesarean section (CS)—is essential to maternal health. Antioxidants, which delay or prevent cellular damage by scavenging free radicals, play a vital role in maintaining cellular balance. This cross-sectional study aimed to examine changes in enzymatic antioxidants (SOD, CAT, GPx) and red cell indices (RCI) associated with different delivery methods among women of reproductive age in Owerri, Imo State, Nigeria. The study included 200 pregnant women aged 20 to 39, divided equally into two groups: 100 who underwent VD and 100 who had CS. Venous blood samples (10 ml) were collected at delivery and post-delivery. Of this, 4 ml was placed in an EDTA tube for RCI analysis, while 6 ml was placed in a plain tube for measuring SOD, CAT, and GPx levels. RCI was determined using a Mindray hematology auto-analyzer, and enzymatic antioxidant levels were measured with an enzyme-linked immunosorbent assay (ELISA) microplate reader.The findings revealed significant reductions in the levels of SOD ($p<0.001$), CAT ($p<0.001$), and GPx ($p<0.001$) in women who underwent VD compared to those who had CS. Postpartum red cell indices in VD showed decreases in MCV ($p=0.981$) and MCH ($p<0.001$), while MCHC ($p<0.001$) increased compared to antepartum levels. In CS cases, postpartum MCV ($p<0.001$) was lower, while MCH ($p<0.001$) and MCHC ($p<0.001$) were significantly elevated relative to antepartum levels.Based on these results, it is recommended that the assessment of antioxidant parameters and anemic status be included as part of postpartum care to support better management of maternal health following childbirth.

Keywords:*Cesarean section, vaginal delivery, red cell indices, reactive oxygen species, oxidative stress, superoxide dismutase, catalase, glutathione peroxidase, enzyme-linked immunosorbent assay*

1. Introduction

Advances in maternity care have significantly reduced maternal and infant morbidity and mortality, yet oxidative stress remains a challenge for both vaginal delivery (VD) and cesarean section (CS) [1][2]. The pain and fear associated with VD contribute to a preference for CS among many women [3][4]. Antioxidants play a vital role in countering oxidative stress, which is linked to numerous chronic health conditions [5]. During the perinatal period, oxidative stress

often escalates, marked by increased free radical production and reduced antioxidant capacity, which can impact the health of both mother and baby [6].

Labor and delivery processes amplify oxidative stress, leading to elevated free radical levels that require antioxidant defenses [7]. Red blood cell indices (RCI) offer important information about hemoglobin content and red blood cell size, aiding in diagnosing various types of anemia [8]. As part of a complete blood count (CBC), these indices include mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) [9]. Variations in these indices can indicate distinct types of anemia, each affecting red blood cell characteristics differently [10].

The physical demands of childbirth, particularly labor, contribute to oxidative stress due to heightened metabolic activity and oxygen use during muscle contractions, increasing reactive oxygen species (ROS) levels [11][12]. Research suggests that oxidative stress may vary depending on the mode of delivery, with VD potentially producing more pronounced effects due to the extended exertion of uterine and skeletal muscles [13][14]. However, CS may also contribute to oxidative stress through surgical factors and heightened antioxidant demand.

Key antioxidant enzymes, including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), play protective roles against ROS damage [15]. SOD acts as a first line of defense by converting superoxide radicals into oxygen and hydrogen peroxide, reducing cellular damage [17][18]. SOD activity correlates with inflammation during labor [19], and research shows that term labor can trigger inflammatory responses in fetal membranes, even in the absence of chorioamnionitis [20]. Catalase, found in nearly all organisms exposed to oxygen, decomposes hydrogen peroxide into water and oxygen, working mainly within peroxisomes [21][22]. GPx, synthesized from amino acids like L-cysteine and L-glutamic acid, assists in hydrogen peroxide breakdown and shows higher activity levels in CS neonates compared to those born via VD [23]. Increased oxidative stress is often observed among older first-time mothers, who tend to have lower GPx levels postpartum [23].

Despite existing research, gaps remain in understanding how delivery mode impacts maternal antioxidant and oxidative balance, particularly in healthy pregnancies. This study aims to examine changes in enzymatic antioxidants (SOD, CAT, GPx) and red cell indices (RCI) associated with different delivery modes among women in Owerri, Imo State, Nigeria.

2. Materials and Methods

2.1 Study Location

This study was conducted in Owerri Municipal Area, located within Imo State in the southeastern region of Nigeria. Imo State consists of 27 local government areas, organized into three senatorial zones: Owerri, Orlu, and Okigwe. Geographically, the state is positioned between latitudes 4° 45’N and 7° 25’E, and longitudes 6° 50’E and 7° 25’E, covering an area of

5,100 km² with an estimated population of 4,978,758 as of 2017 (NPC, 2017; Imo Government, 2010). Imo State lies in the heart of Nigeria's southeastern geopolitical zone and shares borders with Abia State to the east, Enugu State to the north, Anambra State to the west, and Rivers State to the south (Vanguard Nigeria, 2015).

2.2 Subject Characterization and Selection

This cross-sectional study included a total of 200 pregnant participants, with 100 delivering through vaginal delivery (VD) and 100 through cesarean section (CS). All participants were at 38 weeks of gestation and were recruited through simple random sampling. The sample size was calculated using Gxpower software (version 3.1.9.2) with a power of 95%.The study population consisted of women at the point of delivery at Federal Medical Center Hospital, Owerri, Imo State, within the reproductive age range of 20–39 years. The study involved full-term pregnant women (37–38 weeks) who were in active labor for VD or were scheduled for CS. All participants met the inclusion and exclusion criteria, resided in Imo State, and provided informed oral consent after the study was explained to them. The research adhered to the guidelines of the Ethical Committee and Head of Delivery Wards of Federal Medical Centre (FMC), Owerri, under the obtained ethical clearance.

2.3 Sample Collection and Analysis

A total of 10 milliliters of blood were collected aseptically from each participant using proper venipuncture technique in the antecubital vein with a sterile syringe and needle, both before and after delivery for each mode of delivery. The procedure involved thorough handwashing, wearing gloves, and maintaining aseptic technique with standard precautions. The process was explained to each subject, and a tourniquet was applied above the antecubital fossa, typically the most accessible site. The collection site was disinfected with diluted alcohol, and the syringe with an attached needle was securely prepared.Collected blood samples were divided into K3EDTA bottles (4 ml for hematological analysis) and plain bottles (6 ml for biochemical analysis). Samples for biochemical analysis were centrifuged at 3000 RPM for 5 minutes, and plasma was separated into plain tubes. Red Cell Indices (RCI) were analyzed using a Mindray hematology autoanalyzer (BC 2800), while biochemical parameters, including Superoxide Dismutase (SOD), Catalase (CAT), and Glutathione Peroxidase (GPx), were measured using an enzyme-linked immunosorbent assay (ELISA) microplate reader (BMG LABTECH).

Blood samples were taken at the point of delivery (labor phase) and after delivery (postpartum phase). The study participants were attending the antenatal clinic at Federal Medical Centre Hospital, Owerri, Imo State, Nigeria. Bio-data and medical histories, including pregnancy duration and age, were obtained from the medical records of the subjects.

2.4 Statistical Analysis

Analysis of data from this study was done using Statistical Package for Social Sciences (SPSS) version 23. All values were expressed as mean ± standard deviation and presented in tables. Comparison of means of parameters was done using independent t-test (one tail) and ANOVA, with $p \leq 0.05$ being considered statistically significant.

3 Results

3.1Comparison of Maternal Mean Values of the Parameters for Enzymatic Antioxidants (SOD, CAT, &GPx) in the Labor (Antepartum) Period and after Delivery (Postpartum) Period of Vaginal Mode of Child Delivery.

The mean values for these subjects for enzymatic antioxidants in labor periods were 62.18 ± 0.80 U/L for SOD, 94.65 ± 1.78 KU/L for CAT, 84.33 ± 0.75 ng/ml for GPx relatively to after delivery values showed significant decrease of 58.19 ± 3.14 U/L for SOD, 93.34 ± 1.5 KU/L for CAT, 78.61 ± 1.50 ng/ml for GPx respectively ($p < 0.001$).

Table 1:Comparison of Mean Maternal Levels for Enzymatic Antioxidants (SOD, CAT &GPx) in the Labor (Antepartum) Period and after Delivery (Postpartum) Period of Vaginal Mode of Child Delivery.

	Enzymatic Antioxidants		
	SOD (U/L)	**CAT (KU/L)**	**GPx (ng/ml)**
Antepartum Period(N = 100)	62.18 ±0.80	94.65 ±1.78	84.33 ±0.75
Postpartum Period(N = 100)	58.19 ±3.14	93.34 ± 1.50	78.61 ± 1.50
p-value	0.001	0.001	0.001

***SOD= Superoxide Dismutase; GPx= Glutathione Peroxidase; CAT= Catalase.**

3.2 Comparison of Mean Maternal Values for Enzymatic Antioxidants (SOD, CAT &GPx) in the Labor (Antepartum) Period and after Delivery (Postpartum) Period of Cesarean Section Mode of Child Delivery.

The mean maternal values for enzymatic antioxidants of the result showed a significant increase difference in the antepartum values of 60.21 ± 0.97 U/L for SOD, 97.35 ± 0.57 KU/L for CAT and 81.26 ± 1.09 ng/ml for GPx to the postpartum (after CS delivery) values of 65.29 ± 2.27 U/L for SOD, 99.46 ± 0.44 KU/L for CAT and 96.07 ± 3.66 ng/ml for GPx respectively for enzymatic antioxidants ($p<0.001$).

Table 2: Comparison of Mean Maternal Levels for Enzymatic Antioxidants (SOD, CAT &GPx) in the Antepartum and Postpartum Periods of Cesarean Section Mode of Child Delivery.

	Enzymatic Antioxidants		
	SOD (U/L)	**CAT (KU/L)**	**GPx (ng/ml)**

Antepartum Period (N = 100)	60.21 ± 0.97	97.35 ± 0.57	81.26 ± 1.09
Postpartum Period(N = 100)	65.29 ± 2.27	99.46 ± 0.44	96.07 ± 3.66
p-value	0.001	0.001	0.001

***SOD= Superoxide Dismutase; GPx= Glutathione Peroxidase; CAT= Catalase.**

3.3: Comparison of Mean ± SD of Enzymatic Antioxidants (SOD, CAT &GPx) in Postpartum Periods of VD and CS Modes of Child Delivery

The enzymatic antioxidant levels for vaginal delivery were 58.19 ± 3.14 U/L for SOD, 93.34 ± 1.50 KU/L for CAT, and 78.61 ± 1.50 ng/ml for GPx. The result showed relatively significant higher levels for Cesarean Section enzymatic antioxidants of 65.29 ± 2.27 U/L for SOD, 99.46 ± 0.44 KU/L for CAT and 96.07 ± 3.66 ng/ml for GPx ($p<0.001$).

Table 3: Comparison of Mean ± SD of Enzymatic Antioxidants in Postpartum Periods of VD and CS Modes of Child Delivery

	Enzymatic Antioxidants		
	SOD (U/L)	**CAT (KU/L)**	**GPx (ng/ml)**
Vaginal Postpartum Period(N = 100)	58.19 ± 3.14	93.34 ± 1.50	78.61 ± 1.50
Cesarean Postpartum Period(N = 100)	65.29 ± 2.27	99.46 ± 0.44	96.07 ± 3.16
p-value	0.001	0.001	0.001

***SOD= Superoxide Dismutase; GPx= Glutathione Peroxidase; CAT= Catalase.**

3.4: Comparison of Mean ± SD of Red Cell Indices of Subjects Based on Vaginal Mode of Delivery.

The mean value of 92.81 ± 5.70 fl in the antepartum (during labor) period showed non-significant difference on the decrease in the postpartum (after delivery) period with values,92.79 ± 6.08 fl ($p=0.981$) for MCV. The result value of 31.51 ± 2.05 pg in the antepartum (during

labor) period showed significant difference on the decrease in the postpartum (after delivery) period with values, 29.71 ± 1.89 pg ($p<0.001$) for MCH. The mean value in the antepartum (labor) period of 31.86 ± 1.59 g/dl for MCHC showed significant difference on the increase in the postpartum (after delivery) period, with values of 33.20 ± 2.50 g/dl ($p<0.001$).

Table 4:Comparison of Mean ± SD of Red Cell Indices of Subjects Based on Vaginal Mode of Delivery.

	Red Cell Indices		
	MCV (fl)	**MCH (pg)**	**MCHC (g/dl)**
Antepartum(labor) Period(N = 100)	92.81 ± 5.70	31.51 ± 2.05	31.86 ± 1.59
Postpartum (After) Period (N = 100)	92.79 ± 6.08	29.71 ± 1.89	33.20 ± 2.50
p-value	0.981	0.001	0.001

***MCV= Mean Cell Volume; MCH= Mean Cell Hemoglobin; MCHC= Mean Cell Hemoglobin Concentration.**

3.5: Comparison of Mean ± SD of Red Cell Indices of Subjects Based on Cesarean Section Mode of Delivery.

The mean value of 90.20 ± 4.53 fl in the antepartum (during labor) period showed significant difference on the decrease in the postpartum (after delivery) period with values, 84.59 ± 4.72 fl ($p<0.001$) for MCV. The result value of 29.31 ± 2.39 pg in the antepartum (during labor) period showed significant difference on the increase in the postpartum (after delivery) period with values, 31.81 ± 1.94 pg ($p=0.010$) for MCH. The mean value in the antepartum (labor) period of 32.59 ± 2.38 g/dl for MCHC showed significant difference on the increase in the postpartum (after delivery) period, with values of 33.90 ± 2.14 g/dl ($p=0.012$).

Table 5:Comparison of Mean ± SD of Red Cell Indices of Subjects Based on Cesarean Section Mode of Child Delivery.

	Red Cell Indices		
	MCV (fl)	**MCH (pg)**	**MCHC (g/dl)**
Antepartum (labor) Period(N = 100)	90.20 ± 4.53	29.31 ± 2.05	32.59 ± 2.38
Postpartum (After) Period(N = 100)	84.59 ± 4.72	31.81 ± 1.94	33.90 ± 2.14
p-value	0.001	0.010	0.012

***MCV= Mean Cell Volume; MCH= Mean Cell Hemoglobin; MCHC= Mean Cell Hemoglobin Concentration.**

4 Discussion

The study revealed that mothers undergoing cesarean section deliveries were typically older than those who had vaginal deliveries. This finding indicates that advanced maternal age and delayed pregnancies contribute to a higher prevalence of CS, consistent with previous research suggesting that social, educational, and demographic factors often lead women to postpone pregnancy until later in their reproductive years, increasing the likelihood of CS due to pre-existing health conditions and associated risk factors [27][28]. Higher body weight and body mass index (BMI) are also linked to CS deliveries, as increased weight affects physiological changes during pregnancy and is associated with longer active labor phases. This can lead to emergency CS following spontaneous labor due to slower cervical dilation [29][30].

Significantly higher levels of enzymatic antioxidants such as SOD, CAT, and GPx, were observed in postpartum women who delivered by CS compared to those who delivered by VD. This aligns with the idea that CS may be less physically demanding than VD, where active labor requires greater maternal exertion, resulting in increased levels of stress hormones such as cortisol and catecholamines. These levels are comparatively lower in CS, thus reducing oxidative stress [31]. Consequently, mothers who deliver vaginally are more prone to oxidative damage than those delivering by CS [32].

The elevated activities of SOD, CAT, and GPx in CS deliveries suggest a stronger defense mechanism against reactive oxygen species (ROS), as these enzymes are essential in minimizing ROS production, preventing apoptosis or necrosis, and protecting the body from oxidative stress [33]. At the cellular level, ROS can be toxic, contributing to aging and various disorders by disrupting metabolic processes and impairing organ function [34][35]. During VD, neonatal adaptation to extrauterine life involves intense muscular contractions as the baby moves through the birth canal, which significantly increases energy demand and oxygen consumption. This elevated oxygen use leads to ROS formation, inducing oxidative stress and potentially exposing the mother to free radical damage [36][37].

The study also observed that postpartum mean corpuscular hemoglobin (MCH) values significantly decreased from antepartum levels in VD, indicating reduced hemoglobin (Hb) levels postpartum. This reduction aligns with the role of MCH in assessing the average hemoglobin content per red blood cell. In contrast, postpartum mean corpuscular volume (MCV) values showed a non-significant decrease, while mean corpuscular hemoglobin concentration (MCHC) values significantly increased, suggesting stable hemoglobin content relative to cell size with no indication of microcytic, hypochromic anemia [38].

For CS deliveries, postpartum MCV levels showed a significant decrease from antepartum values, which may reflect substantial intra-operative blood loss, reducing red blood cell size [39]. Postpartum MCH values significantly increased in CS deliveries, consistent with findings on blood transfusions and recovery measures in CS patients [40]. Additionally, higher postpartum MCHC values in CS deliveries suggest a potential risk of maternal microcytic anemia, as they reflect an elevated concentration of hemoglobin within red blood cells due to these compensatory interventions.

5 Conclusion

This study revealed a significant reduction in antioxidant parameter levels during the postpartum period compared to the antepartum state in subjects who delivered vaginally. In contrast, the antioxidant parameter levels were significantly elevated in the postpartum period relative to the antepartum state in subjects who underwent cesarean section. Additionally, the results indicated that antioxidant levels were significantly higher in subjects who had CS compared to those who delivered vaginally.

The analysis of red cell indices for vaginal deliveries showed a significant decrease in MCH, a non-significant reduction in MCV, and a significant increase in MCHC in the postpartum period compared to the antepartum state. For CS subjects, postpartum periods exhibited significant increases in MCH and MCHC, along with significant decreases in MCV when compared to the antepartum state. Furthermore, postpartum glucose levels were significantly lower in both vaginal and CS deliveries compared to their respective antepartum glucose levels.

The maternal demographic data indicated that the ages of mothers were higher for those undergoing CS, suggesting that advanced maternal age could be associated with the decision for CS over vaginal delivery. Additionally, maternal body weight appeared to be a potential factor influencing the mode of delivery. These findings collectively demonstrate the impact of delivery mode on various physiological parameters.

COMPLIANCE WITH ETHICAL STANDARDS

STATEMENT OF ETHICAL APPROVAL

Ethical approval was obtained from Health Research Ethics Committee, Federal Medical Centre, Owerri Imo State, with the approval number FMC/OW/HREC/192.

STATEMENT OF INFORMED CONSENT

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

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