Effect of Delivery Mode on Maternal Total Antioxidant Status and Glucose Levels in Reproductive-Aged Women in Owerri, Imo State, Nigeria

ABSTRACT

The method of delivery, whether vaginal (VD) or cesarean section (CS), is a key factor in maternal health. Antioxidants play an important role in preventing cellular damage during and after delivery due to their free radical-scavenging properties. Total antioxidant capacity/status (TAC/S) and blood glucose levels (GLu) serve as holistic markers of oxidative balance, assessing the combined antioxidant effects present in plasma and body fluids. Elevated oxidative stress (OS) during delivery, driven by reactive oxygen species (ROS) formation and glucose intolerance, can disrupt cellular balance, highlighting the need to monitor these indicators. This cross-sectional study aimed to investigate changes in TAC/S and GLu associated with different delivery modes among women of reproductive age in Owerri, Imo State, Nigeria. The study involved 200 pregnant women, aged 20 to 39 years, with 100 delivering vaginally and 100 via cesarean section. At the time of delivery and postpartum, 4 ml of venous blood was collected from each participant. Samples were analyzed for TAC/S using enzyme-linked immunosorbent assay (ELISA) and for GLu using a glucometer. Results showed that TAC/S levels ($p<0.001$) were significantly lower in women who delivered vaginally compared to those undergoing CS. Both groups experienced a significant reduction in glucose levels in the postpartum period compared to their levels before delivery. These findings suggest that women who deliver vaginally may experience a greater decrease in antioxidant capacity after childbirth compared to those who have a cesarean section. Reduced glucose levels in both delivery methods indicate changes in metabolic demands postpartum. It is recommended that TAC/S and GLu levels regularly monitored during childbirth to support postpartum health management and reduce oxidative stress complications.

Keywords: vaginal delivery, cesarean section, reactive oxygen species, oxidative stress, childbirth

1.0 Introduction

Advancements in medical technology have greatly improved maternal and infant health outcomes, significantly reducing rates of morbidity and mortality [1]. However, childbirth introduces oxidative stress (OS), with both vaginal delivery (VD) and cesarean section (CS) linked to increased OS levels in mothers [2]. Many women choose CS due to fear or pain associated with vaginal delivery [3][4].

Antioxidants are crucial for protecting cells from damage due to OS, which is a common underlying factor in various chronic diseases [5]. During the postpartum period, known as the perinatal phase, mothers experience heightened OS characterized by increased free radical production and reduced antioxidant availability, leading to potential health imbalances for both mother and infant [6]. Studies have found that OS levels surge during childbirth, producing free radicals that must be managed by antioxidant systems in both mother and child [7]. These effects are magnified during childbirth as physical and metabolic demands rise, particularly through muscular contractions and heightened oxygen use, which increase ROS levels [8][9]. The degree of OS experienced by mothers post-delivery may be influenced by the specific delivery method used [10].

Total antioxidant capacity (TAC) measures the overall antioxidant levels in plasma, providing insight into the body's antioxidant reserves. TAC has diagnostic value across various conditions [11], and is assessed to determine the combined effect of all antioxidants in plasma, yielding a comprehensive measure beyond individual antioxidants. This parameter offers insight into the delicate balance of oxidation and reduction processes in vivo, helping to identify environmental, nutritional, and physiological impacts on human oxidative status. An increase in TAC may indicate an adaptive response to early-stage OS; however, high TAC may not always be beneficial [12].

Pregnancy is inherently oxidative [13], yet in a healthy pregnancy, a balance typically exists between oxidants and antioxidants. Disruptions in this balance contribute to obstetric complications [14][15]. As pregnancy progresses, oxidative processes intensify, particularly in the final stages [16][17], prompting increased antioxidant activity as a compensatory response to rising OS [18]. This dynamic during the peripartum period requires a balance between free radical production and antioxidant system competence, making TAC a relevant metric during childbirth [19].

Glucose, an essential and irreplaceable energy source, is critical for meeting the body's metabolic needs [20]. Blood glucose levels are tightly regulated, as hypoglycemia can lead to brain damage or death within a few hours [21][22]. Shortly after birth, transient low blood glucose levels are common but typically self-correcting in healthy newborns, marking the body’s adaptation to life outside the womb [23]. Despite decades of awareness that low glucose affects neurological health, the specific effects of different delivery methods on glucose levels are not fully understood.

Although TAC and glucose are critical aspects of maternal health, studies exploring their relationship with delivery methods remain limited. Research on TAC and glucose levels in relation to delivery type under healthy conditions is scarce [24]. This study therefore aims to investigate how delivery mode affects maternal TAC and glucose levels, in addition to maternal weight and age, among reproductive-aged women in Owerri, Imo State, Nigeria.

2.0 Materials and Methods

2.1 Study Location

This study was carried out in Owerri Municipal Area of Imo state, South Eastern Nigeria. Imo state with 27 local government areas divided into three senatorial zones (Owerri, Orlu and Okigwe Zones) is located at Latitude 4^{O} 45’N and 7^{O} 25’E and Longitude 6^{O} 50’E and 7^{O} 25’E with an estimated population of 4, 978,758 [25] in an area of 5,100km^{2}. The state is one of the states in the South -Eastern geopolitical zone. In the heart of the East, the state is bordered by Abia State, Enugu State, Anambra State and River State to the South [26]. With a growing population and limited healthcare infrastructure, the region faces a high burden of maternal and neonatal health issues. Notably, the prevalence of cesarean sections is on the rise in urban centers like Owerri, driven by factors such as increased maternal age, urbanization, and access to tertiary healthcare facilities. Additionally, environmental and genetic factors, such as dietary patterns, high ambient temperatures, and genetic predispositions to oxidative stress, may contribute to maternal and fetal outcomes in this population [26].

2.2 Subject Characterization and Selection

The study employed a cross-sectional design and included 200 pregnant women, evenly divided into those undergoing vaginal delivery (100 women) and cesarean sections (100 women). Participants were selected through simple random sampling to ensure representativeness of the population. All participants were at 38 weeks of gestation and were selected through simple random sampling. The sample size was calculated using G*Power software (version 3.1.9.2), achieving a study power of 95%. The study population comprised women at the point of delivery at the Federal Medical Center Hospital in Owerri, Imo State, within the reproductive age range of 20 to 39 years.

To control for potential confounding factors, strict inclusion and exclusion criteria were applied. These included excluding participants with pre-existing maternal health conditions such as hypertension, gestational diabetes, or anemia, as well as those with adverse pregnancy outcomes like stillbirth or improper fetal positioning. Additionally, the medical history and dietary habits of the participants were reviewed to exclude those with glucose intolerance or significant dietary deviations that could influence oxidative stress. Standardized timing of blood sample collection was maintained postpartum to minimize variability, with samples collected exactly 6 hours after delivery across all participants.

This study was conducted under the guidelines of the Ethical Committee and Head of Delivery Wards at the Federal Medical Centre (FMC), Owerri, with ethical clearance obtained before commencement.

2.3 Inclusion and Exclusion Criteria

This study included pregnant participants between 37 and 38 weeks of gestation who were either in active labor for vaginal delivery or scheduled for cesarean section. Eligible participants were women aged 20 to 39 years who provided informed consent for participation. The study excluded pregnant women who were not at full term (below 37 weeks), those who did not provide informed consent, or those younger than 20 or older than 39 years. Additional exclusion factors included medical complications such as hypertension, gestational diabetes, iron-deficiency anemia, severe nausea, improper fetal positioning, maternal sepsis, placenta previa, or macrosomia, based on hospital records. Women whose labor was induced with infusions and those who experienced stillbirth were also excluded.

2.4 Sample Collection and Analysis

Four milliliters (4 mL) of blood samples were collected through aseptic venipuncture before delivery during active labor and 6 hours postpartum. This timing was chosen to capture changes in oxidative stress and glucose levels during the immediate postpartum recovery phase. This blood collection was done by thoroughly washing of hands, wearing hand gloves, using aseptic technique and observing standard precautions throughout the procedure, explaining the procedure to the subject, applying tourniquet above the antecubital fossa sites which is most often the easiest to assess, disinfecting the area/collection site with diluted alcohol, having syringe with needle securely attached. The blood samples were put into plain bottles, for biochemical analysis. Samples were centrifuged for 5 minutes at 3000 RPM for biochemical analysis. The samples were separated into plain tubes. The results were read using enzyme-linked immunosorbent assay (ELISA) microplate reader (BMG LABTECH). Glucose levels were measured using a glucometer.

The biomarkers selected for this study, TAC and glucose levels, were chosen for their relevance in understanding oxidative stress and metabolic changes during childbirth. Other oxidative stress markers, such as malondialdehyde (MDA) or superoxide dismutase (SOD), were not included due to logistical constraints and the primary focus of this study on easily measurable, clinically relevant biomarkers. Nevertheless, future research may benefit from incorporating these complementary markers for a more comprehensive analysis of oxidative stress dynamics.

2.5 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.

3.0 Results

3.1 Demographic Characteristics of the Study Subjects.

The study involved 200 pregnant subjects; women who had reached 38 weeks (mean gestational weeks) of pregnancy and are in labor at the point of delivery. One Hundred (100) of the pregnant women delivered by vaginal mode of delivery (VD) while 100 delivered through Cesarean Section (CS). The mean age of subjects was 27 ± 5 years for vaginal mode of delivery and 29 ± 5 years for Cesarean Section mode of delivery. Also, the mean weight of the subjects that had a vaginal mode of delivery was 84.14 ± 10.77kg and cesarean section mode of delivery, 84.32 ± 11.63kg.

Table 1: The Mean Demographic Data of Study Subjects.

Mode of Child Delivery	Gestational Weeks	Age (years)	Weight (kg)
Vaginal Delivery Subjects (N = 100)	38	27 ± 5	83.14 ± 10.77
Cesarean Section Delivery Subjects (N = 100)	38	29 ± 5	84.32 ± 11.63

3.2 Comparison of Maternal Mean Values of TAS in the Labor (Antepartum) Period and after Delivery (Postpartum) Period of Vaginal and Cesarean Mode of Child Delivery.

The mean values of 55.81 ± 1.84 U/ml for TAC/S in the antepartum period for vaginal delivery showed significant difference on the decrease in the postpartum values (after delivery) period with 50.87 ± 0.72 U/ml (p<0.001). While the mean values in antepartum (labor) periods of 55.82 ± 1.67 U/ml for TAC/S showed significant difference on the increase with values of 61.48 ± 0.85 U/ml in the CS postpartum periods (p<0.001). The results of TAC/S in postpartum periods of VD, 50.87 ± 0.72 U/ml for TAC/S showed a higher significant difference of 61.48 ± 0.85 U/ml in the postpartum period of CS mode of delivery (p<0.001).

Table 2: Comparison of Mean Maternal Levels for TAC/S in the Labor (Antepartum) Period and after Delivery (Postpartum) Period of Vaginal and Cesarean Section Modes of Child Delivery

	TAC/S (U/ml) Vaginal Delivery	**TAC/S (U/ml) Cesarean Section**
Antepartum Period (N = 100)	55.81 ± 1.84	55.81 ± 1.67
Postpartum Period (N = 100)	50.87 ± 0.72	61.48 ± 0.85
p-value	0.001	0.001
F-value	3.992	7.561

TAC/S= Total Antioxidant Capacity/Status; VD= Vaginal Delivery; CS=Cesarean Section

3.3 Comparison of Mean ± SD Maternal Glucose Levels of Subjects for Antepartum and Postpartum Periods in Vaginal and Cesarean Section Modes of Child Delivery

The mean value of 89.97 ± 13.78 mg/dl for glucose in the antepartum (labor) period showed significant difference on the decrease in the postpartum (after delivery) period with value, 78.65 ± 13.65 mg/dl (p<0.001) for Vaginal mode of Child Delivery. Also, the mean values in antepartum (labor) periods of 86.28 ± 15.04mg/dl for glucose showed significant difference on the decrease with values of 76.05 ± 15.16mg/dl for glucose in the Cesarean Section postpartum periods (p=0.003).

Table 3: Comparison of Mean ± SD Maternal Glucose Levels of Subjects for Antepartum and Postpartum Periods in Vaginal and Cesarean Section Modes of Child Delivery

	Glucose Levels	
	VD	**CS**
	Glu (mg/dl)	**Glu (mg/dl)**
Antepartum Period (N=100)	89.97 ± 13.78	86.28 ± 15.04
Postpartum Period (N = 100)	78.65 ± 13.65	76.05 ± 15.16
p-value	0.001	0.003

Glu=Glucose; VD= Vaginal Delivery; CS=Cesarean Section.

4.0 DISCUSSION

This study found that mothers undergoing cesarean section (CS) were significantly older than those opting for vaginal delivery (VD), consistent with the findings of Bayrampour and Heaman (2011), which suggest that advanced maternal age and delayed childbirth are major contributors to increased CS rates due to pre-pregnancy health conditions and associated risks. Social, educational, and demographic factors often lead women to postpone childbirth, influencing these trends [24]. Additionally, elevated body weight and increased BMI were more common among women undergoing CS, echoing studies highlighting the physiological changes in pregnancy that predispose individuals to prolonged labor and emergency interventions [28][29]. Prolonged active labor and delayed cervical dilation in individuals with higher BMI levels increase the likelihood of surgical delivery, reinforcing the relationship between maternal age, BMI, and delivery mode.

The study also revealed that TAC/S was significantly higher in CS deliveries than in VD, suggesting a difference in antioxidant responses based on the mode of delivery. TAC/S reflects the overall antioxidant defense, encompassing both enzymatic and non-enzymatic antioxidants, and serves as an essential measure of oxidative stress. The higher TAC/S observed in CS deliveries aligns with previous studies suggesting that surgical intervention may mitigate the oxidative stress associated with labor by reducing the physical exertion required during childbirth [30][15]. However, surgical stress itself might stimulate distinct antioxidant responses, potentially explaining the observed elevation in TAC/S in CS deliveries. This difference raises questions about whether the reduction in TAC/S after VD could result from the intense physical and metabolic demands of labor, such as increased oxygen consumption and heightened energy expenditure. Alternatively, surgical procedures in CS might prompt a controlled oxidative response that enhances antioxidant mobilization [31][32].

Both delivery modes exhibited a marked reduction in postpartum glucose levels compared to antepartum levels, reflecting the substantial metabolic demands of childbirth. This reduction aligns with expected metabolic changes, including increased insulin sensitivity, depletion of glycogen stores, and heightened energy requirements postpartum. These findings are consistent with Bragg *et al*. [34], who documented significant metabolic adaptations following delivery, and Dude *et al.* [35], who emphasized the importance of individualized glucose management during this period. However, the observed decline in glucose warrants further investigation to determine whether these changes are uniform across populations or influenced by regional factors such as diet and genetic predisposition. Understanding these dynamics is crucial for tailoring postpartum nutritional and glycemic interventions.

The clinical implications of these findings are significant for guiding postpartum care in Owerri and similar settings. The elevated TAC/S in CS deliveries suggests that surgical delivery may better preserve antioxidant reserves, which could inform recovery protocols for mothers who undergo VD and face heightened oxidative stress. Strategies to replenish antioxidant defenses, such as dietary supplementation or pharmacological interventions, may benefit VD mothers.

Additionally, the observed glucose reductions highlight the need for postpartum nutritional plans that address energy deficits and ensure adequate glucose availability for recovery and lactation.

5.0 CONCLUSION

This study aimed to evaluate the impact of delivery method on maternal total antioxidant capacity/status (TAC/S) and glucose levels in Owerri, Imo State. Findings indicated that TAC/S levels were significantly lower in the postpartum period than in the antepartum period among women who delivered vaginally. Conversely, TAC/S levels were significantly higher postpartum compared to antepartum in women who underwent cesarean sections, with CS subjects showing notably higher TAC/S levels than those who had vaginal deliveries. Regarding glucose levels, both delivery methods displayed a significant decrease in glucose in the postpartum period compared to the elevated antepartum levels. Additionally, maternal age was generally higher among women who delivered via cesarean section, suggesting a trend of delayed childbirth in this group. The analysis also indicated that maternal body weight might influence the choice of delivery method, as higher maternal weight was associated with cesarean delivery. Overall, these results highlight the effects of delivery mode on antioxidant and glucose parameters in postpartum maternal health.

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.

CONSENT

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

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1.

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