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Original Research Article

# The Impact of Vitamin C on Glycemic Control and Oxidative Stress in Patients Recently Diagnosed with Type-2 Diabetes Mellitus

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**Abstract**

**Introduction:** Diabetes mellitus (DM) is a metabolic condition characterized by insufficient insulin production or diminished insulin effectiveness, leading to disruptions in carbohydrate, fat, and protein metabolism.

**Aim:** This study aims to evaluate the positive impact of vitamin C on glycemic control and oxidative stress.

**Materials & Methods:** A total of 120 patients with DM were enrolled, and 5 ml of venous blood was drawn from each participant for the assessment of baseline glycemic levels (HbA1c, FBS, and PPBS) and oxidative stress markers (MDA and TAC). The participants were divided into two groups: Group A received Metformin 1000mg + Voglibose 0.2mg/day for 3 months, while Group B received Metformin 1000mg + Voglibose 0.2mg/day + vitamin C 1000mg/day for the same duration. Following the initiation of the study, blood glucose and oxidative stress parameters were measured and compared to baseline values.

**Results:** Both groups showed significant decreases in mean HbA1c, FBS, and PPBS after 3 months of treatment ($p<0.05$). However, only Group B showed a significant increase in TAC levels and a decrease in MDA levels, unlike Group A.

**Conclusion:** While both groups achieved good glycemic control, only the patients receiving vitamin C alongside antidiabetic medications demonstrated improved oxidative stress management. These findings suggest that the addition of vitamin C to antidiabetic therapy may help mitigate oxidative stress and its related complications.

**Keywords:** Diabetes mellitus, blood glucose, MDA (Malondialdehyde), TAC (Total Antioxidant Capacity).

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## Introduction

Diabetes mellitus (DM) is a complex disease characterized by insufficient insulin production, diminished insulin effectiveness, or a combination of both, which disrupts the metabolism of carbohydrates, fats, and proteins. The primary symptoms of diabetes mellitus include polyuria, polyphagia, and polydipsia, along with additional signs such as blurred vision, weight loss, and severe fatigue. [1,2,3]

This condition represents a significant public health challenge worldwide. In the 21st century, India ranks second only to China in the number of diabetes patients. [4] Current statistics indicate that over 72.96 million individuals in India are affected by diabetes. The prevalence is notably higher in urban areas (10.9%-14.2%) compared to rural regions (3.0%-7.8%). Oxidative stress arises from an imbalance between the generation and elimination of free radicals, including reactive oxygen species (ROS) and reactive nitrogen species (RNS). These free radicals can transfer their unpaired electrons, leading to cellular damage through the oxidation of cellular components. A sustained increase in ROS and RNS can result in endothelial dysfunction, changes in the quantity and functionality of β-cells, insulin resistance, and ultimately, microvascular and macrovascular complications. [5] Free radicals transfer their free electron and damage the cells by oxidation of their components.

It is crucial to regulate the levels of free radicals at minimal thresholds, a process facilitated by various antioxidant systems within the body, [6] which encompass both in vivo antioxidant enzymes and

dietary sources of antioxidants. Enzymatic antioxidants include superoxide dismutase (SOD), which converts superoxide into hydrogen peroxide; 8 this hydrogen peroxide is subsequently transformed into water in the cytosol and peroxisome by Glutathione Peroxidase (GPx) and Catalase, respectively, thus safeguarding cells from the harmful effects of free radicals. Non-enzymatic antioxidants comprise vitamins A, C, E, B1, B2, B6, and B12, trace elements such as copper, zinc, and selenium, as well as cofactors like folic acid uric acid, and albumin. Vitamin E (Tocopherol) and vitamin C (Ascorbic acid) serve as dietary antioxidants that can inhibit the chain-breaking reaction of lipid peroxidation across all cell membranes.

In this study, two parameters were utilized to assess oxidative stress in newly diagnosed patients with type-2 diabetes mellitus: Malondialdehyde and Total Antioxidant Capacity. The former is employed to evaluate lipid peroxidation, which tends to rise during oxidative stress, [8] while the latter assesses the levels of endogenous antioxidants.

## Materials and Methods

This study is a prospective, open-label, non-randomized controlled clinical trial conducted in the Department of Pharmacology in collaboration with the Department of General Medicine at Rama Medical College, Mandana, Kanpur, U.P., from June 2020 to May 2021. Prior to the commencement of the study, permission and informed consent were obtained from the institutional ethical committee and the study participants, respectively. The following criteria were established for participant recruitment.

### Inclusion Criteria:

- Newly diagnosed patients with type-2 diabetes mellitus.
- Patients with HbA1c levels ranging from 7.6% to 9.0%.
- Individuals aged between 30 and 60 years, regardless of sex.

### Exclusion Criteria:

- Patients with type-1 diabetes mellitus.
- Individuals with hypersensitivity to vitamin C or any of the study medications.
- Those unwilling to participate or lacking the mental capacity to take the medications.
- Smokers or individuals with alcohol dependency.
- Pregnant or lactating women.
- Patients undergoing steroid therapy, with a history of chronic infections such as TB or leprosy, or those who have experienced recent trauma or surgery.
- Individuals currently taking other antioxidants, such as vitamins E or A.
- Patients with psychiatric disorders, liver, kidney, or cardiac issues.

A total of 120 newly diagnosed type-2 diabetes mellitus patients attending the outpatient department of General Medicine were recruited for this study after obtaining their consent. Family health history and socio-demographic information were gathered from each participant. A venous blood sample of 5 ml was collected from each participant and sent to the central clinical laboratory for the estimation of glycemic HbA1c using the ion exchange resin method, [9] fasting blood sugar (FBS) and postprandial blood sugar (PPBS) using the GOD POD enzymatic method, [10] and malondialdehyde (MDA) using the thiobarbituric acid reactive substances (TBARS) assay, along with total antioxidant capacity (TAC) assessed by the ferric reducing ability of plasma (FRAP) method. The participants were divided into two groups: Group A (n=60) and Group B (n=60). Patients in Group A received Metformin 1000 mg plus Voglibose 0.2 mg per day, while Group B received Metformin 1000 mg plus Voglibose 0.2 mg and vitamin C 1000 mg per day for a duration of 3 months. The study included six visits, which were scheduled throughout the trial.

**Statistical Analysis:** The gathered data were input into MS Excel and analyzed using SPSS software version 23.0. The analysis was conducted using the 'Unpaired' method, and results were expressed as mean± SD. P value <0.05, indicating statistical significance.

## Results

In this study, a total of 120 participants diagnosed with type-2 diabetes mellitus (DM) were recruited. They were divided into two groups, Group A and Group B. Patients in Group A received metformin 1000mg combined with voglibose 0.2mg per day, while those in Group B were treated with metformin 1000mg, voglibose 0.2mg, and vitamin C 1000mg daily for a duration of 3 months.

Out of the 120 participants, 66 were male and 54 were female. The largest group of diabetic patients (n=76) fell within the age range of 41–50 years, followed by 32 individuals aged 51–60 years, and 12 individuals aged 31–40 years. The average body mass index (BMI) was 24.0 ± 0.5.

When comparison was made between the groups, no significant variation was noticed at the beginning of the study. Group A had the following measurements: HbA1c: 8.18± 0.28; FBS: 170.3± 10.54; PPBS: 261.1±13.5; MDA: 4.84 ± 0.59; and TAC: 0.81± 0.14. In contrast, Group B's measurements were: HbA1c: 8.29 ± 0.42; FBS:

174.6 ± 10.54; PPBS: 266.6 ±10.8; MDA: 5.12 ± 0.38; and TAC: 0.79 ± 0.12.

After three months of treatment with metformin 1000mg and voglibose 0.2mg per day, Group A exhibited a significant decrease in mean HbA1c (7.40 ± 0.27), FBS (142.3 ± 9.32), and PPBS (226.4 ±8.47) compared to baseline values (P<0.05).

As shown in Table 1, after three months of treatment with metformin 1000mg, voglibose 0.2mg, and vitamin C 1000mg per day, Group B also demonstrated a significant reduction in mean HbA1c (7.33 ± 0.41), FBS (142.3 ± 8.42), and PPBS (228.4 ±7.18) compared to baseline values (P<0.05). Table 2 following the three-month treatment period, no significant changes were observed in MDA (5.00± 0.59) and TAC (0.78± 0.13) levels in Group A when compared to baseline values. However, in Group B, a significant decrease in MDA (4.66 ± 0.40) and an increase in TAC (0.87 ± 0.16) levels were noted when compared to baseline values (p<0.05).

After three months of treatment, a comparison between the groups revealed no significant differences in glycemic control. However, patients in group B, who received vitamin C in conjunction with antidiabetic medications, showed a reduction in oxidative stress levels. Table 3.

**Table 1: Glycemic and oxidative stress levels in group A**

| Variables | Baseline (Mean± SD) | 3months (Mean± SD) | Mean difference | P value |
|---|---|---|---|---|
| HbA1c (%) | 8.18± 0.28 | 7.40 ± 0.27 | 0.77 ± 0.0003 | 0.001** |
| FBS(mg/dl) | 170.3± 10.54 | 142.3 ± 9.32 | 28.08 ± 1.21 | 0.001** |
| PPBS(mg/dl) | 261.1±13.5 | 226.4 ±8.47 | 34.69 ± 5.02 | 0.001** |
| MDA(mmol/l) | 4.84 ± 0.59 | 5.00± 0.59 | -0.15 ±0.005 | 0.064 |
| TAC(mmol/l) | 0.81± 0.14 | 0.78± 0.13 | 0.03 ±0.003 | 0.266 |

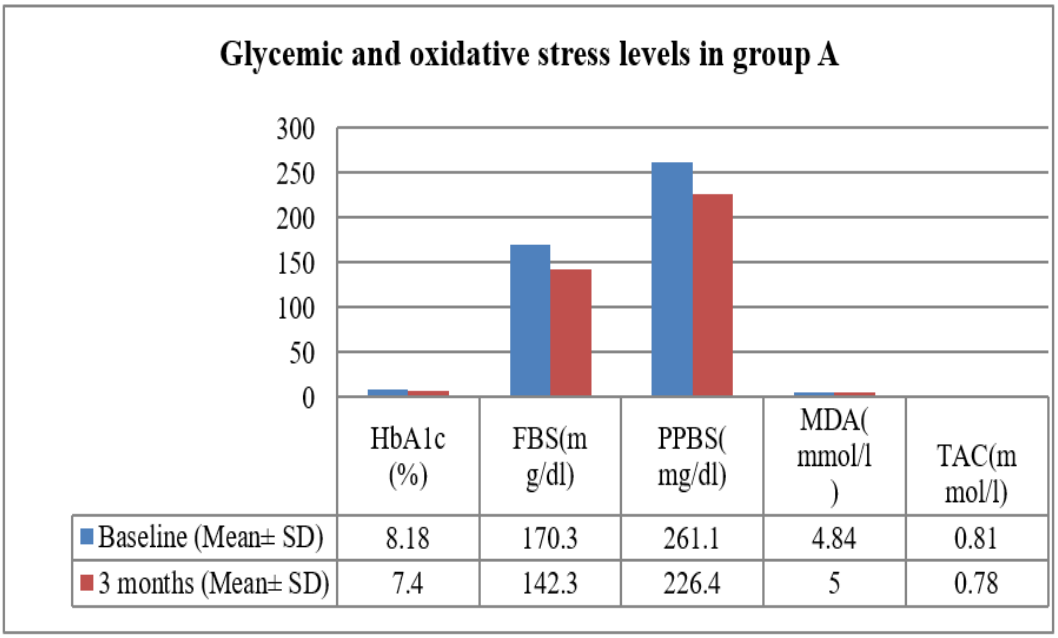


**Figure 1: Bar diagram showing glycemic and oxidative stress levels changes after treatment in group A**

**Table 2: Glycemic and oxidative stress levels in group B**

| Variables | Baseline (Mean± SD) | 3 months (Mean± SD) | Mean difference | P value |
|---|---|---|---|---|
| HbA1c (%) | 8.29 ± 0.42 | 7.33 ± 0.41 | 0.96± 0.01 | 0.001** |
| FBS(mg/dl) | 174.6 ± 10.54 | 141.1 ± 8.42 | 33.5 ± 2.01 | 0.001** |
| PPBS(mg/dl) | 266.6 ±10.8 | 228.4 ±7.18 | 38.12 ± 3.61 | 0.001** |
| MDA(mmol/l) | 5.12 ± 0.38 | 4.66 ± 0.40 | 0.46 ±0.02 | 0.001** |
| TAC(mmol/l) | 0.79 ± 0.12 | 0.87 ± 0.16 | 0.08 ±0.03 | 0.05** |

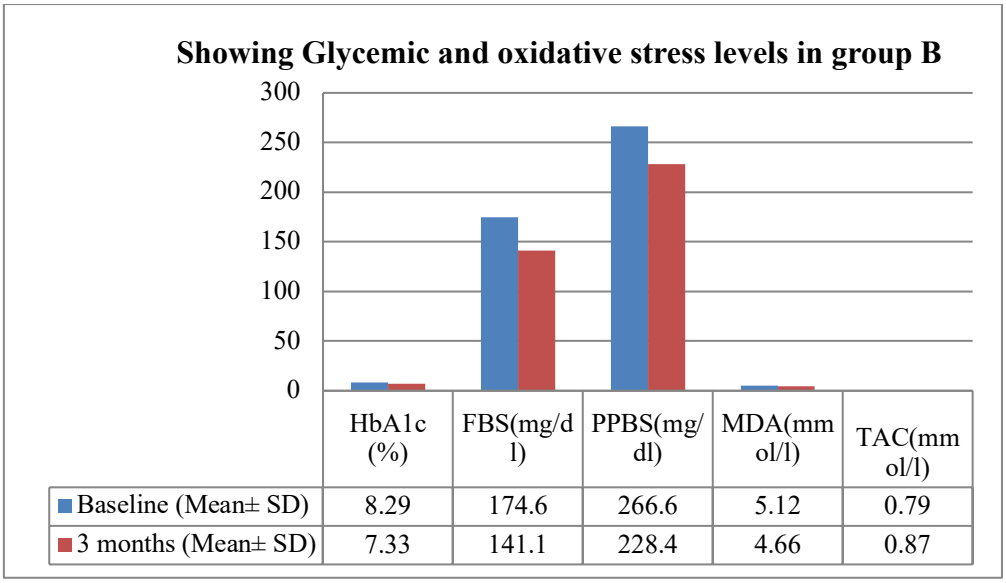


**Figure 2: Bardiagram showing glycemic and oxidative stress levels changes after treatment in group B**

**Table 3: Glycemic and oxidative stress levels in group A and group B at 3rd month**

| Variables | Group-A | Group-B | Mean difference | P value |
|---|---|---|---|---|
| HbA1c (%) | 7.40 ± 0.27 | 7.33 ± 0.41 | 0.07±0.14 | 0.09 |
| FBS(mg/dl) | 142.3 ± 9.32 | 141.1 ± 8.42 | 1.2±0.9 | 0.08 |
| PPBS(mg/dl) | 226.4 ±8.47 | 228.4 ±7.18 | 2±1.29 | 0.062 |
| MDA(mmol/l) | 5.00± 0.59 | 4.66 ± 0.40 | 0.4±0.19 | 0.001** |
| TAC(mmol/l) | 0.78± 0.13 | 0.87 ± 0.16 | 0.09±0.03 | 0.05** |

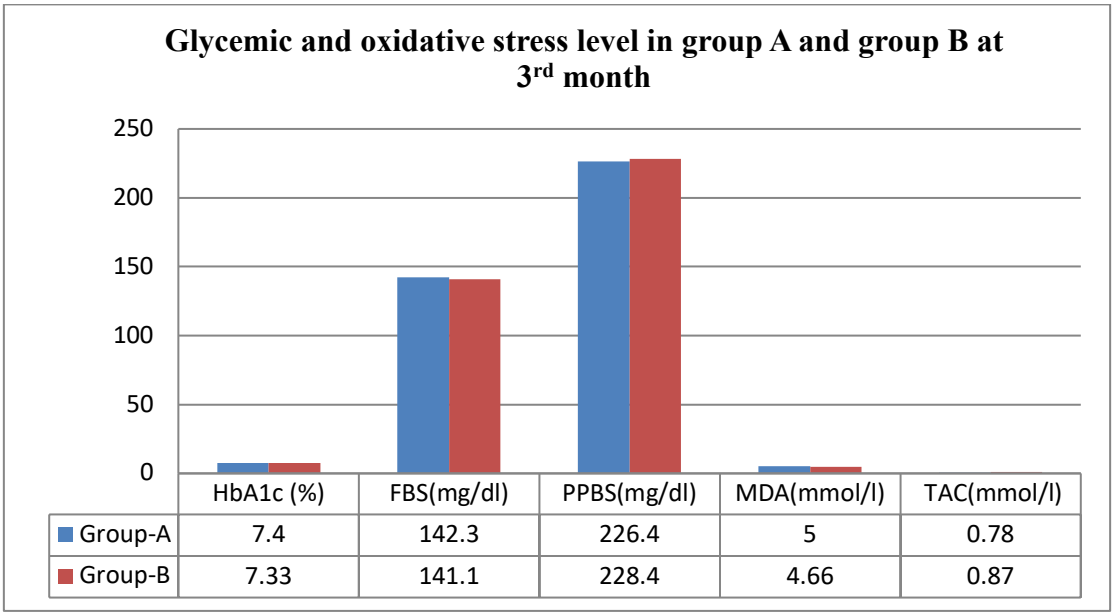


**Figure 3: Bar diagram showing glycemic and oxidative stress levels changes after treatment in group A and group B**

## Discussion

This study sought to investigate the beneficial effects of vitamin C on glycemic control and oxidative stress.

Although there are several classes of antidiabetic medications available, their main purpose is to regulate blood glucose levels. Oxidative stress is acknowledged as a factor that contributes to complications in diabetes, which include both microvascular and macrovascular issues. The use of antioxidants may help reduce or prevent complications linked to oxidative stress. Consequently, in this research, diabetic patients were administered vitamin C (an antioxidant) in conjunction with their antidiabetic treatment to

evaluate its positive effects on glycemic control and oxidative stress levels. A total of 120 diabetic patients were enrolled in the study. Among these participants, 55% (n=66) were male and 45.8% (n=54) were female, which aligns with findings from previous research.11 The majority of the diabetic patients (n=76) fell within the age range of 41–50 years, followed by 32 patients aged 51–60 years, and 12 patients in the 31–40 year age group. This age distribution pattern is consistent with earlier studies. [12,13] An average BMI of diabetic patients in the present study was 24.0 ± 0.5, which is in line with the results of a previous study. [13] Furthermore, all participants from both groups exhibited nearly identical mean values for HbA1c, FBS, PPBS, and TAC at the start of the study, which is consistent with findings from previous research. [14]

After three months of treatment, group A (metformin 1000 mg + voglibose 0.2 mg) and group B (metformin 1000 mg + voglibose 0.2 mg + vitamin C 1000 mg) exhibited a significant reduction in blood glucose parameters, including HbA1c, FBS, and PPBS, with statistical significance. Image-1 Furthermore, patients in group B who received vitamin C alongside their antidiabetic medications demonstrated a notable increase in mean TAC levels and a significant decrease in MAD values, whereas such outcomes were not observed in group A. Upon comparing the two groups after three months of treatment, no significant differences were found in glycemic parameters ($p>0.05$). Table-3 & Figure -3

A prior study indicated that after three months of treatment with metformin and vitamin C, there was a notable decrease in mean HbA1c, FBS, and PPBS levels. It was also noted that vitamin C is well tolerated, exhibits no side effects, and enhances the levels of plasma ascorbic acid. [15]

Another study highlighted that the addition of vitamin C to antidiabetic medications resulted in significant changes in FBS, PPBS, and HbA1c, as well as in lipid profile parameters including TG, TC, LDL, and HDL. [16] Furthermore, a similar investigation found that the reduction in mean FBS and HbA1c was comparable in patients treated with metformin alone and those receiving both metformin and voglibose; however, there was a significant difference in PPBS levels among patients taking both medications. [17]

Vitamin C acts as a natural antioxidant, aiding in the elimination of free radicals, which has been linked to a decrease in oxidative stress among patients with type 2 diabetes mellitus. Being water-soluble, Vitamin C poses no risk of hypervitaminosis or related toxicity. Numerous studies have indicated that the combination of Vitamin C supplementation with antidiabetic medications has contributed to a reduction in oxidative stress [18] and has also enhanced glycemic control. [19] Furthermore, Vitamin C helps prevent end-organ damage in hyperglycaemic conditions by scavenging free radicals, inhibiting sorbitol accumulation, reducing capillary fragility, and preventing protein glycosylation. [20,21]

## Conclusion

A notable regulation of glycemic levels was observed in patients from both groups; however, the reduction of oxidative stress, indicated by an increase in TAC and a decrease in MDA, was only evident in patients who were administered Vitamin C in conjunction with antidiabetic medications. Based on these findings, we can infer that incorporating vitamin C with antidiabetic drugs may helps to reduce oxidative stress and its related complications.

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