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Alterations in the antioxidant status of patients suffering from diabetes mellitus and associated cardiovascular complications

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ABSTRACT

In view of the high prevalence of type 2 diabetes mellitus, this study aimed at determining the total plasma antioxidant capacity of type 2 diabetic patients with and without macrovascular complications. The erythrocyte catalase level was also evaluated because of the implication of catalase as a risk factor in diabetes. 90 age-, gender- and body mass index-matched subjects were used for this study and divided into healthy subjects (Group I, n=30), diabetic patients (Group II, n=30) and diabetic patients with cardiovascular complications (Group III, n=30). Blood samples collected from 90 eligible subjects were analyzed for glucose, HbA1c, urea, creatinine, total cholesterol, triglyceride, HDL and LDL cholesterol levels. Blood antioxidant activity and erythrocyte catalase levels were assessed. The mean antioxidant status values of Groups II and III were found to be significantly lower than that of Group I ($p < 0.05$). A significant decrease was also observed in the mean catalase level of Groups II and III as compared to Group I ($p < 0.05$) while a significant increase in fasting blood glucose level, glycated hemoglobin, triglycerides and urea was observed in Groups II and III compared to Group I. These data suggest that the *in vivo* antioxidant defense was highly compromised in patients with diabetes and associated cardiovascular complications although they were on medication, thereby suggesting the potential contributory beneficial effects of exogenous antioxidants. Furthermore, a reduction in catalase level may suggest the role of increasing hydrogen peroxide concentration in the disease progression.

KEY WORDS: ***Antioxidant; Erythrocyte catalase; Cardiovascular complications; Type 2 diabetes mellitus***

INTRODUCTION

Cardiovascular diseases (CVDs) are major complications resulting from type 2 diabetes mellitus (type 2 DM) and are the leading cause of early disability and death among people with diabetes. Type 2 DM is now a pandemic clinical disorder with no distinction between developing and developed countries, and continues to contribute to the burden of CVD.[1] Diabetes has been the major cause of mortality in Mauritius with 22.8% deaths in the year 2009 with more than

50% of the diabetics patients dying of ischemic heart diseases.[2]

Patients with type 2 DM have a marked incidence of adverse cardiovascular events primarily coronary, cerebral and peripheral artery disease. Despite significant improvements in the clinical management of both diabetes and CVD over the last few decades, available data suggests that CVD remains the leading cause of morbidity and mortality in people with diabetes.[3] Diabetic complications however correlate with hyperglycemic levels and also with length of exposure to hyperglycemia. The Framingham study has demonstrated since long that diabetes mellitus is associated with a 2- to 5-fold increase in CVD and related deaths.[4] In addition, meta-analyses of relevant trials have also shown consistently that intensive glucose control in type 2 diabetic patients had cardiovascular benefits compared with standard treatment in people with diabetes, without increasing all-cause and cardiovascular mortality.[5-9] In light of the recognition of diabetes as a cardiovascular risk factor, it is expected that diabetes will be an important driver of the future burden of CVD around the world.

Although, the mechanisms underlying these complications have not been well characterized, convincing evidence suggests that prolonged exposure to hyperglycemic environment result in the production of advanced glycated end products (AGEs) as well as oxidative stress and decreased antioxidant defenses in the etiology and development of the vascular complications.[10-11] Hyperglycemic conditions might contribute to increase oxidative stress and the release of reactive oxygen/nitrogen species (ROS/RNS) via several mechanisms including the generation of advanced glycation end products (AGEs), diacylglycerol (DAG) accumulation followed by protein kinase C (PKC) activation in vascular cells,[12] and increased glucose efflux through the aldose reductase pathway.[13] These mechanisms are activated by a single upstream event, the mitochondrial overproduction of reactive oxygen species (ROS).[14]

The mechanisms of diabetic cardiac dysfunction, however, are complex and also involve increased oxidative/nitrosative stress,[15] glycation and/or cleavage of antioxidant enzymes, activation of various downstream transcription factors, proinflammatory and cell death pathways such as nuclear factor (NF)-κB,[16] poly(adenosine diphosphate [ADP]-ribose) polymerase[17] and mitogen-activated protein kinase,[18] inactivation of pro-survival pathways such as Akt,[19] eventually culminating in cell death[20] and changes in the composition of extracellular matrix with enhanced cardiac fibrosis and increased inflammation.[21]

Given the background that oxidative stress and decreased antioxidant defense lead to a number of pro-atherogenic events such as LDL oxidation, endothelial dysfunction, and vascular smooth muscle proliferation and migration,[10,22,23] this study was conducted to assess the extent of blood biochemical parameters variation with the aim of providing meaningful data on the total plasma antioxidant activity in type 2 DM subjects with or without demonstrated macrovascular complications. The extent of erythrocyte catalase deficiency that has been reported as a risk factor associated with diabetes was also assessed.

MATERIALS AND METHODS

Subjects

The Ministry of Health and Quality of life National Ethics Committee, Republic of Mauritius approved the study protocol referenced MHC/CT/NETH/BSV at its meeting held on the 18th January 2012. Informed written consent was obtained for each subject. The subjects were between 40 and 65 years old. The inclusion and exclusion criteria used in this study have been described in **Table 1**.

Anthropometric measurements were obtained and body mass index (BMI) was calculated by dividing the weight (kg) with height (m^2).

Table 1: Inclusion and exclusion criteria for selection of participants for this study

Inclusion criteria	Exclusion criteria
Non-smokers or former smokers who had stopped smoking for more than 6 months	Cigarette smokers
No alcohol intake	Alcohol consumption
Participants suffering from type II diabetes with and without cardiovascular complications	Participants suffering from type II diabetes with microvascular complications
Participants in the control group were healthy without medication	Participants in the control group who were on medication

90 age- and body weight- matched participants, including both males and females, were recruited for the study. Information was collected from randomly sampled controls from the adult population and from volunteers attending the Out-Patient Department of Victoria Hospital based on the use of a semi-structured questionnaire. The 90 eligible participants who satisfied the inclusion and exclusion criteria for the study were divided into three groups of 30 participants: Group I, II and III. Diabetic subjects were on hypoglycemic drugs while those in Group III were taking lipid-lowering medication in addition to the hypoglycemic medication.

Group I: included 30 healthy individuals who were not on medication and who had no previous diagnosis of diabetes and cardiovascular diseases (Control group).

Group II: included 30 individuals who have been diagnosed with type II diabetes and who did not have any other complications.

Group III: included 30 individuals who have been diagnosed with type II diabetes followed by cardiovascular complications in particular macrovascular complications.

Study protocol

The study was conducted between February 2012 and April 2012 under the supervision of a phlebotomist. Biochemical and antioxidant analyses were carried out at the Department of Health Sciences laboratory of the University of Mauritius, Réduit, Republic of Mauritius and the Department of Biochemistry, Central Health Laboratory, Victoria hospital, Candos, Republic of Mauritius. Subjects were requested to fast for at least 10 hours before blood collection.

Blood collection and preparation for sample analysis

10mL of fasting blood were collected and dispensed into four different tubes comprising heparinised tubes (4mL), fluoride oxalate tube (2–5 mL), EDTA tubes and plain tubes. Fresh blood samples were preserved in ice-bags for analysis. The serum from the plain tube was stored at – 20°C for subsequent estimations.

Analysis of biomarkers

The blood samples were analysed for glucose level, HbA1c, urea, creatinine, total cholesterol, triglyceride, high-density lipoprotein cholesterol (HDL) and low-density lipoprotein cholesterol (LDL). Measurements were made in either clear blood serum or plasma samples after centrifugation. The automated Targa Biotechnica BT2000 System (Biotechnica, Spain) was used for colorimetric analysis of most biomarkers. The reagent kits for fasting blood sugar was the Biosystems glucose oxidase/peroxidase kit (Biosystems, Spain), the Biolabo urea UV kinetic method kit (Biolabo, France), creatinine Randox kit (Randox, UK) was used to determine creatinine, The Biosystem cholesterol kit (Biosystems

Spain) was used to measure the cholesterol level while the human HDL Cholesterol liquicolor kit (Human Diagnostics, Germany) was used for HDL determination and the Human Triglycerides liquicolor mono kit (Human Diagnostics, Germany was used to detect triglycerides. The HbA1c level was measured by an automated Tosoh G7 HbA1c analyzer (Tosoh Biosciences, Japan) based on high performance liquid chromatography.

Erythrocyte Catalase (CAT) Activity

The catalase level was measured by the Catalase Assay Kit from Cayman Chemical and as per the manufacturer's instructions. The latter utilizes the peroxidatic function for determination of the enzyme activity. Erythrocytes lysate, which was prepared according to the kits' instructions and the lysates, were diluted 1:5000 prior to analysis. Results were expressed as nmol/min/ml.

Ferric Reducing Antioxidant Power (FRAP) assay

The FRAP assay was adapted from Benzie and Strain.[24] This method measures the reducing ability of the compound being tested. FRAP reagent was freshly prepared by mixing together 10 mM 2,4,6-tripyridyl-s-triazine (TPTZ) and 20mM ferric chloride -6- hydrated in 0.25 M acetate buffer, pH 3.6. The reaction mixture contained 300 µl water, 100 µl plasma (or standard) and 3 ml of FRAP reagent. The absorbance was read at 593 nm after 4 min incubation at ambient temperature. A calibration curve of ferrous sulphate (100-1000 µM) was used to estimate the reducing power and results were expressed in µmol activity per liter of plasma.

Statistical Analysis

Statistical analyses were carried out using the statistical package for social science (SPSS 16.0). Correlation between different variables was determined by using Pearson's correlation coefficients and the corresponding p values for each correlation was calculated, recorded and analyzed. Comparison between mean values was done by two-sample t-test. P values < 0.05 were considered as statistically significant.

RESULTS

The sample population consisted of 45 (50 %) male and 45 (50 %) female Mauritian citizens in the age group of 40 to 65 years old. 30 subjects suffered from diabetes with no reported macrovascular or microvascular complications, 30 subjects were diabetic with peripheral artery diseases and cerebrovascular complications developed after the diagnosis of diabetes while the other 30 subjects of the sample population were healthy subjects. The participants were age- and body weight- matched (**Table 2**). The levels of biomarkers measured for both groups were recorded.

The fasting blood glucose (FBG) levels for the control subjects was was in the range 4.5 and 5.5 mmol/L while that of the diabetic subjects was between 6.1 and 15.5 mmol/L and 6.0 and 12.4 mmol/L in diabetic subjects with cardiovascular diseases. As expected, the mean FBG level in the subjects with diabetes were significantly higher when compared with the control subjects ($p < 0.001$) (**Table 3**).

The mean HbA1c measured in the experimental groups II and III were 8.22 ± 1.95 % and 8.43 ± 1.58 % respectively which were significantly higher than the mean level measured in the healthy subjects (5.81 ± 0.57 %) ($p < 0.001$) (**Table 3**).

The serum urea ranged between 2.2 and 7.4 mmol/L in Group I, 2.8 and 7.4 mmol/L in group II and 3.3 and 9.0 mmol/L in group III while creatinine level were within similar range for groups I (61 and 122 µmol/L) and II (65 and 124 µmol/L) and between 67 and 145 µmol/L in group III. The mean creatinine level of Group I was found to be 84.53 ± 14.79 µmol/L while it was 86.03 ± 14.78 µmol/L in group II and 92.2 ± 16.45 µmol/L in

group III with no significant difference between the groups.

The mean serum uric acid was 290.17 ± 61.27 µmol/L in Group I, 308.27 ± 56.98 µmol/L in group II and 307.48 ± 70.61 µmol/L in group III.

The total cholesterol ranged between 3.5 and 5.2 mmol/L in Group I, 3.9 and 6.6 mmol/L in group II and 3.9 and 9.4 mmol/L in group III. The mean cholesterol level of Group I was found to be 4.63 ± 0.53 mmol/L while it was 4.75 ± 0.76 mmol/L in group II and 4.81 ± 0.89 mmol/L in group III (**Figure 1**).

The mean HDL cholesterol level of Group I was found to be 1.01 ± 0.17 mmol/L while it was 0.96 ± 0.13 mmol/L in group II and 1.04 ± 0.17 mmol/L in group III (**Figure 1**).

The mean LDL cholesterol level of Group I was found to be 3.35 ± 0.46 mmol/L while it was slightly higher in group II and III (3.45 ± 0.65 mmol/L and 3.59 ± 1.16 mmol/L respectively) (**Figure 1**).

The triglycerides levels were variable in the different groups ranged between 0.9 and 2.2 mmol/L in Group I, 0.8 and 3.3 mmol/L in group II and 1.0 and 4.4 mmol/L in group III. (**Figure 1**)

Table 2: Demographic characteristics of groups under study

Characteristics	Group I	Group II	Group III
Sample size	30	30	30
Gender (Male/Female)	15/15	15/15	15/15
Age (years)	52.7 ± 7.1	52.8 ± 7.5	54.5 ± 6.6
BMI (kg/m^2)	23.35 ± 1.04	23.53 ± 0.95	23.24 ± 1.14

Table 3: Biochemical markers in the sample population distributed in 3 groups

	Group I		Group II		Group III	
Parameters	**Range measured *in vivo***	**Mean ±SD**	**Range measured *in vivo***	**Mean ±SD**	**Range measured *in vivo***	**Mean ±SD**
FBG (mmol/L)	4.5 – 5.5	5.09 ± 0.27	6.1 –15.1	8.14 ± 2.10**	6.0 – 12.4	8.64 ± 1.66**
HbA1c (%)	4.5 – 6.7	5.81 ± 0.57	6.3 – 14.7	8.22 ± 1.95**	7.0 – 12.5	8.43 ± 1.58**
Urea (mmol/L)	2.2 – 7.4	4.26 ± 1.32	2.8 – 7.4	4.73 ± 1.27*	3.3 – 9.0	5.27 ± 1.64*
Creatinine (µmol/L)	61 – 122	84.53 ± 14.79	65 – 124	86.03 ± 14.78	67 – 145	92.2 ± 16.45
Uric acid (µmol/L)	144 – 410	290.17 ± 61.27	202 – 420	308.27 ± 56.98	200 – 538	307.48 ± 70.61
Cholesterol (mmol/L)	3.5 – 5.2	4.63 ± 0.53	3.9 – 6.6	4.75 ± 0.76	3.9 – 9.4	4.81 ± 0.89
Triglycerides (mmol/L)	0.9 – 2.2	1.36 ± 0.38	0.8 – 3.3	1.69 ± 0.59**	1.0 – 4.4	2.03 ± 0.86**
HDL (mmol/L)	0.7 – 1.5	1.01 ± 0.17	0.7 – 1.2	0.96 ± 0.13	0.7 – 1.3	1.04 ± 0.17
LDL (mmol/L)	2.2 – 4.0	3.35 ± 0.46	2.7 – 5.0	3.45 ± 0.65	2.4 – 7.8	3.59 ± 1.16

**$p < 0.01$ compared to healthy control; *$p < 0.05$ compared to healthy control

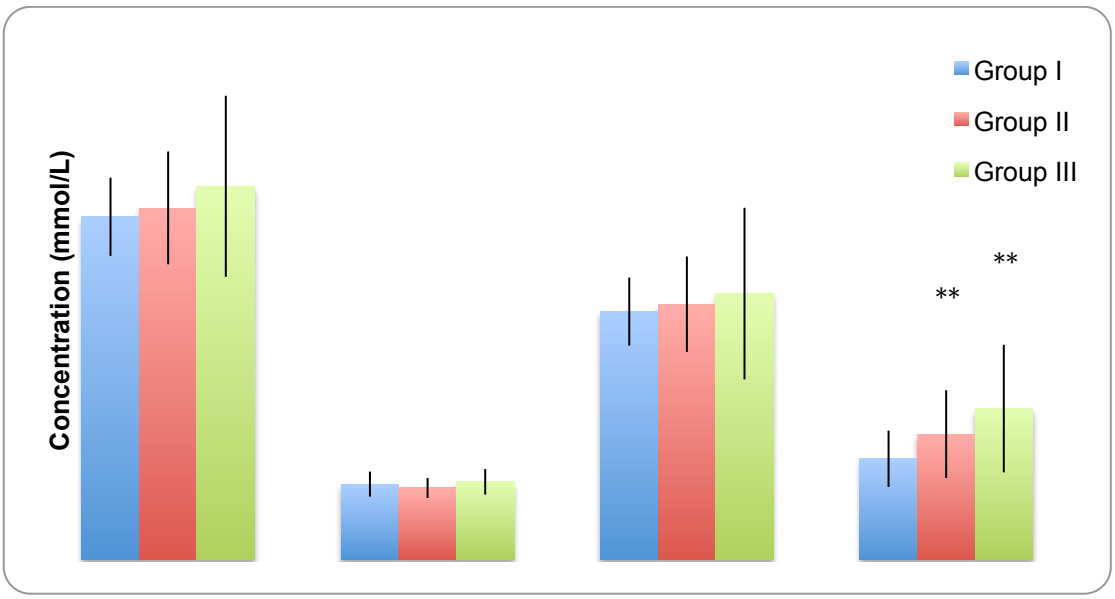

Figure 1: Comparison of mean cholesterol, HDL cholesterol, LDL cholesterol and triglycerides of Group I, II and III; **p < 0.01 compared to healthy control

Antioxidant Capacity of the erythrocyte lysate and the plasma

The level of CAT activity in the erythrocyte lysates ranged between 11240.13 and 21641.45 nmol/min/ml in Group I, 5200.66 and 14595.39 nmol/min/ml in Group II and 4865.13 and 14930.92 nmol/min/ml in Group III (**Table 4**).

The mean CAT activity of group II and III (10446 and 10244.73 µmol activity per liter of plasma respectively) were significantly lower ($p < 0.001$) than healthy controls Group 1 (15512.50 µmol activity per liter of plasma).

The total antioxidant level as measured by FRAP was more potent in Group I than in Group II and Group III (**Table 4**). The mean FRAP value of group II and III being significantly lower ($p < 0.01$) than healthy controls (**Table 4**).

Table 4: Comparison of antioxidant parameters of the different groups under study

	Group I		Group II		Group III	
Parameters	***Range of antioxidant capacity***	***Mean ± SD***	***Range of antioxidant capacity***	***Mean ± SD***	***Range of antioxidant capacity***	***Mean ± SD***
CAT (nmol/min/ml)	11240.13–21641.45	15512.5± 2801.59	5200.66–14595.39	10446.0± 2928.3**	4865.13–14930.92	10244.7± 2429.89**
TAC (µmol/L)	861.90–1125.24	1005.57± 76.70	687.14–963.33	851.36± 93.64**	623.33–935.24	796± 89.52**

**p < 0.01 compared to healthy control; *p < 0.05 compared to healthy control

DISCUSSION

Chronic hyperglycemia induces a number of alterations in the vascular tissue that leads to cardiovascular complications in diabetic patients and in turn cardiovascular disease account for disabilities and high mortality rates in patients with diabetes. Whilst diabetes is a major risk factor for cardiovascular morbidity and mortality, the development of diabetic linked complications have been closely associated with imbalance of pro- and antioxidative cell impairment and change of redox potential. The possible molecular mechanisms include stimulation of expression of adhesion

molecules (intercellular adhesion molecule-1, vascular cell adhesion molecule-1, E-selectin) as well as interleukin-6 through oxidative stress generation via both protein kinase C-dependent activation of NADPH oxidase and mitochondrial electron transport chain to the formation of peroxynitrite which result in increased activity of the redox-sensitive transcription factor nuclear factor-κB, which could lead to vascular inflammation and altered gene expression of cytokines and growth factors.[15,25]

This study determined the level of endogenous antioxidants, effective markers of oxidative stress level, in the diabetic experimental groups and the healthy control. Age-matched and BMI-matched subjects were randomly selected for this study in order to eliminate variation mainly because studies have reported the association of overweight and obesity (increase in BMI) with enhanced levels of different indices of oxidants and also increase of oxidative stress with aging.[26] Diabetic subjects with CVD complications suffered mainly from cerebrovascular disease and peripheral vascular disease with no microangiopathy diagnosed at the time of the study.

The data indicated a significant difference ($p < 0.05$) in the mean values of FBG and HbA_{1C} in the diabetic patients and the diabetic patients with CVD complications compared to the healthy individuals. A strong positive correlation was obtained between FBG and HbA_{1C} level in the experimental groups. In fact, the HbA_{1C} level has previously been reported as proportional to the average blood glucose concentration as measured over a period of four weeks to three months.[27] The mean HbA_{1C} levels in Group II (8.22 ± 1.95 %) and Group III (8.43 ± 1.58 %) suggested poor glycemic control as compared to the mean HbA_{1C} of 5.81 ± 0.57 % in the healthy sample population. Literature data suggest a significant increase in the risk of CVD death and all CVD events in type 2 diabetic subjects with HbA1c levels higher than7.0% compared with diabetic subjects with lower HbA1c.[28]

An investigation of the blood biochemical parameters urea and creatinine showed an increase in the mean levels of urea and creatinine in diabetic patients with diabetic complications. These findings revealed that an increase in the blood sugar level was associated with a significant increase in the urea level. The latter is an established marker of glomerular filtration rate, though plasma creatinine is a more sensitive index of kidney function and the data suggest possible renal impairment in Group III thereby warranting further investigation. Goud et al have found that increased serum urea and serum creatinine in diabetic rats indicated progressive renal damage.[29]

Uric acid reported as the most abundant aqueous antioxidant in humans and which contributes about two-thirds of all free radical scavenging capacity in plasma was higher in the diabetic subjects with and without complications but no statistical difference was noted. Literature data shows inconsistencies whether increased concentrations of uric acid in diseases associated with oxidative stress, such as diabetes, atherosclerotic coronary heart disease (CHD), stroke, and peripheral arterial occlusive disease, are a protective response or a primary cause.[30] In this study, a negative significant correlation ($R = -0.419$, $p < 0.05$) was obtained between uric acid and FBG in the diabetic subjects while no such correlation was observed in the diabetic group with CVD. Conflicting data regarding the association of uric acid and the diabetic condition has been reported. For instance, a number of studies have reported that there was a positive association between high serum uric acid levels and diabetes,[31-33] while Oda et al and Nan et al reported that serum uric acid was inversely associated with diabetes mellitus.[34,35] A possible mechanism for the observed results of an inverse association between increasing serum uric acid and diabetes mellitus

might be related to the inhibition of uric acid reabsorption in the proximal tubule by high glucose levels in diabetic individuals.[36]

Hyperlipidemia, characterized by elevated levels of total cholesterol and/or triglycerides and high concentrations of LDL cholesterol has been observed in subjects of group II and III. Similarly, factors influencing hyperlipidemia have been associated with oxidative stress and inflammation.[37] The increased risk of CVD development might in part be due to dyslipidemia. Increased susceptibility of LDL cholesterol to oxidation in DM patients and oxidized-LDL has been implicated in processes of atherogenesis.[38]

CAT is considered as a primary antioxidant enzyme since it is involved in the direct elimination of reactive oxygen species. It is responsible for the removal of hydrogen peroxide hence reducing the toxic effects of the latter and of other free radicals derived from secondary reactions.[39] Erythrocyte CAT activity is usually measured to assess the level of oxidative stress in the blood and besides catalasemia (catalase deficiency) in the blood has been reported as an etiological cause of diabetes as well as being involved in the progression of the disease. Severe catalase deficiency in erythrocytes induced the aggregation of erythrocytes by the generation of relatively high concentration of hydrogen peroxide which can result in impaired bloodstream in the progression of the disease.[40] A significant decrease in mean CAT activity was observed in Group II (10446.05 ± 2928.34 nmol/min/ml) and in Group III (10244.73 ± 2429.89 nmol/min/ml) when compared to that of Group I (15512.50 ± 2801.59 nmol/min/ml, $p < 0.05$). The decrease in CAT activity could result from inactivation by glycation of the enzyme. Sindhu et al[41] reported a significant decrease in CAT activity in diabetic group as compared to normal controls potentially resulting in a number of deleterious effects due to the accumulation of superoxide radicals and hydrogen peroxide.[39]

The total antioxidant capacity as measured by FRAP reflected the collative contribution to reducing properties of the individual antioxidants or electron donating components.[42] In the present study, significant decrease in the FRAP levels was observed in Group II (mean FRAP value of 851.36 ± 93.64 µmol/L) and in Group III (mean FRAP value of 796 ± 89.52 µmol/L) when compared to Group I (1005.57 ± 76.70 µmol/L, $p < 0.05$). Kuppusamy et al reported a significantly lower FRAP level in type 2 diabetic patients of Malay and Indian ethnicity.[43] Similarly, Colak et al documented a decrease in type 2 diabetic patients with cardiovascular complications.[44] Lower total antioxidant capacity in diabetic patients can be ascribed to higher oxidative stress status due to the impairment of the endogenous antioxidant system. The negative correlation between FBG, HbA_{1C} and total antioxidants would emphasize the role of hyperglycemia in induction of oxidative stress and indirect reduction of antioxidative agents in diabetes.[45]

It is noteworthy that all the diabetic subjects were on hypoglycemic drugs. 73.3% of the subjects in group II and III were on Metformin, while 15% were taking a combination of Metformin and Daonil and 11.7% were on Metformin and Gliclazide. All the diabetic patients with cardiovascular complications were on lipid lowering drugs in addition to hypoglycemic drugs. Recent studies have established that Metformin, an oral hypoglycemic drug widely used in case of diabetes, possesses antioxidant effects.[46] Statins, used as lipid lowering drugs, have been found to up-regulate the activity of antioxidant enzymes such as catalase.[47] Nevertheless, despite the reported antioxidant effect of the hypoglycemic and the lipid lowering drugs, this study showed that the endogenous antioxidant capacity of diabetic patients with and without cardiovascular complications

were highly compromised. This could be ascribed to hyperglycemia induced oxidative stress, which sets the stage for further disease progression. Determination of markers of antioxidative defense not only contributes to a better understanding of the effect of oxidative stress on the development of diabetes and diabetic complications, but also opens new perspectives for the treatment of diabetic complications, particularly in the prevention of atherosclerosis and diabetic cardiovascular complications through exogenous antioxidant supplementation.

As the pathogenesis of both diabetes and cardiovascular disease involves oxidative stress, the use of antioxidants can be envisaged. However, the use of traditional antioxidants such as vitamin E or C in large clinical trials has failed to demonstrate any beneficial effect on cardiovascular disease or all-cause mortality, even when only diabetic patients were analyzed. Nevertheless, the application of a standard antioxidant treatment for 15 days consisting of a thiol containing antioxidant (N-acetylcysteine 600 g/d), a bound antioxidant (vitamin E 300 g/d), and an aqueous phase antioxidant (vitamin C 250 mg/d) showed changes in oxidation-reduction balance, NO bioavailability, and nonthrombogenic endothelial factors.[48] Similarly, after 12 weeks of supplementation, Pycnogenol resulted in improved diabetes control, lowered CVD risk factors, and reduced antihypertensive medicine use versus controls and more recently dietary antioxidant capacity is inversely associated with diabetes biomarkers.[49,50]

CONCLUSION

The diabetic subjects were all taking hypoglycaemic drugs for the management of the clinical condition during the conduct of the study. Nevertheless a poor glycaemic control was observed, in addition, to a compromised total antioxidant status. Furthermore, the decrease in catalase levels, observed in the diabetic subjects indicate a possible increase in hydrogen peroxide concentration, both having been reported as risk factors for type II diabetes and related diabetic complications. Hence, the findings suggest that patients may be at an increased risk of diabetic complications especially those in Group II while the patients in Group III may observe a worsening of the diabetic complications. Consequently, appropriate consideration or review of the treatment provided in Mauritius for the management of diabetes is therefore warranted, a scenario, which can apply globally.

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