ANTIOXIDANT STATUS AND LIPID PEROXIDATION IN SUBJECTS WITH IMPAIRED GLUCOSE TOLERANCE (IGT)

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ABSTRACT
An imbalance in the antioxidant protective mechanism leading to oxidative stress has been shown in complicated non-insulin dependent diabetes (NIDDM) cases. This work has been conducted to assess the antioxidant activity in IGT which has received much attention as a risk factor for NIDDM. The lipid peroxide malondialdehyde (MDA), a marker of free oxygen radical activity along with blood reduced glutathione and plasma selenium and vitamins C and E were measured in 27 cases with IGT. In addition, 2 age, sex and body mass index-matched groups were studied. They were 20 NIDDM cases with no detectable complications and 20 healthy normal controls with normal oral glucose tolerance. The 4 tested antioxidants were significantly decreased (p<0.001) in MT and NIDDM subjects compared to control. Meanwhile, plasma MDA was significantly increased (p<0.001) in each of IGT and NIDDM groups versus control. Changes were more evident in NIDDM cases but were unrelated to the state of glycemic control (fasting blood sugar and HbA1c) but can be associated partially to the duration of diabetes. In conclusion, the antioxidant status is poor IGT as well as early NIDDM cases. Antioxidant therapy worths trial in future studies as it might possibly delay progression of IGT to frank diabetes.

INTRODUCTION
Impaired glucose tolerance is diagnosed in those with fasting blood glucose lower than that required to be diabetic but in whom, during the oral glucose tolerance test, the 2-hours value lies between the normal and diabetic values. In Egypt, epidemiological studies on IGT computed prevalence rates of 3.84% at urban areas, 5.69% at rural agricultural and 5.33% at desert areas. Individuals with IGT, like diabetics, seem to be at an increased risk for peripheral and coronary vascular disease as well as thrombotic cerebrovascular strokes. Those with IGT are at higher risk than normal subjects to develop diabetes mellitus. Certain factor(s), which could be either completely environmental or with genetic background, has been suggested to make IGT progress to frank diabetes beyond the age of 30 years in Egyptians. The NIDDM can be viewed as being at one end of a spectrum of disorders of glucose metabolism which ranges from the normal state through IGT to overt diabetes. The IGT as a risk factor for NIDDM has received much attention. Diabetes mellitus has been shown to be a state of increased free radical activity. Toxic oxygen-derived products are generated in all aerobic cells and include superoxide radical (O2.-), hydrogen peroxide (H2O2.) and hydroxyl radical (OH.), the latter being the most lethal. A free radical is a chemical species (molecule or atom) with an unpaired electron. It has high reactivity, low chemical specificity, autocatalytic activity and lasts only for a fraction of a second. So, its activity can be assessed indirectly by recording its effects on lipids i.e. lipid peroxides. Baynes postulated a general pathway involving the sequence of events by which oxidative stress leads to tissue damage. According to this process, incomplete scavenging of reactive radicals leads to oxidation of cellular lipids, proteins, nucleic acids and glycoconjugates. The resulting damage at the cellular level is observed as oxidation, fragmentation and cross-linking. The body is protected from these effects by more than 50 antioxidants including enzymes, vitamins, elements, proteins and others. Vitamins C,E, carotene and glutathione provide antioxidant defenses by their ability to exist in reversible oxidized and reduced forms. Selenium as a component of glutathione peroxidase enzyme protects cell membranes and intracellular structures from peroxidative damage. The present work aims to address the lipid peroxidation [as assessed by plasma malondialdehyde (MDA) an end product of lipid peroxidation] and antioxidant status [as reflected by levels of 4 antioxidants namely...
blood reduced glutathione (GSH), plasma selenium and vitamins C and E) in subjects with IGT compared to healthy subjects and patients with non-complicated NIDDM.

SUBJECTS AND METHODS

Subjects:
This work comprised 20 healthy control subjects with normal oral glucose tolerance test (OGTT) as group (I). They were 16 males and 4 females with mean age ± SD of 45.1 ± 4.9 years. Group (II) included 20 cases of NIDDM (15 Males and 5 females) with mean age ± SD of 44.6 ± 7.6 years. They were diagnosed as diabetics according to the WHO criteria after 75 gm OGTT. The duration since detection of NIDDM was less than 2 years. None of them had albuminuria, retinopathy, clinically detectable neuropathy, or an evident coronary or peripheral vascular complications. Group (III) consisted of 27 subjects with impaired glucose tolerance according to WHO criteria after 75gm OGTT. They included 20 males and 7 females with mean ± SD of 41.8 ± 8.4 years.

The 3 groups were matched as possible regarding their age and sex distribution and body mass index. All of the subjects included in this work were non-smokers at least 12 months before time of the study and all were inhabitants in Zagazig city during the last 5 years. Those with clinical or laboratory evidence of liver or kidney dysfunction, malignant tumors or coagulation disorders were not included in this study. An informed verbal consent was given by all subjects. None of the cases was receiving drugs known to influence lipid metabolism or antioxidant system (e.g. vitamins) at least 3 months before the study except for sulphonylurea used in cases with NIDDM.

Methods:
[A] All subjects have undergone detailed case history including family history. They were also screened for complications including chest x-ray, ECG, Doppler study for peripheral vascular disease and fundoscopy for retinopathy. All patients had negative urine test for microalbuminuria by Micral-test II (Boehringer Mannheim, Germany) for nephropathy. The OGTT was done after a minimum of 10 hours fasting, 75gm glucose diluted in 250ml of lemon water was drunken within 3 minutes. Blood glucose was assayed at 0, 30, 60, 90 and 120 minutes.

[B] After an overnight fasting, blood was obtained by venipuncture on EDTA (1mg/ml). Whole blood was used to measure blood glucose, glycosylated hemoglobin (HbA1c), and blood reduced glutathione (GSH).

[C] Plasma was separated immediately and stored at -20°C till used within one month for the assays of lipid peroxidation which is measured as thiobarbituric acid reactive species expressed in terms of plasma malondialdehyde (MDA), (II) plasma levels of vitamins C and E estimated colorimetrically and (III) plasma selenium concentrations measured by atomic absorption spectrophotometer.

[D] Statistical analysis: Data from the tested patients represented as mean ± standard deviation (S.D.) were statistically analyzed using the unpaired student (t) test and the correlation co-efficient (r) calculation.

RESULTS

Table (1) demonstrates the clinical and anthropometric characteristics of subjects in the 3 studied groups. The 3 groups were comparable as regards the age and sex distribution as well as body mass index (BMI) of their cases. So, comparison between was valid. There was no gross obesity as can be observed from BMI. The glycated hemoglobin (HbA1c), as also illustrated in Figure (1), was significantly higher in each of NIDDM and IGT groups compared to control (p<0.001).

Meanwhile, it was higher in NIDDM than IGT (p<0.001). Around 70% of diabetic and IGT subjects had positive family history for diabetes mellitus.

Plasma antioxidants (namely blood GSH, plasma selenium and vitamins C and E) were significantly decreased in each of NIDDM and IGT groups accompanied with a significant increase in plasma oxidative stress represented by plasma MDA as can be seen in table (2) and Figures (2) to (6). Changes were significantly more evident in those with frank NIDDM compared to IGT cases. Table (3) shows a non-significant positive correlation of plasma MDA to the degree of glyceremic control (blood HbA1c) in each of NIDDM and IGT cases. Significant inverse correlations were detected between the increase in oxidative stress and the decrease in each of the studied antioxidants in diabetics. These correlations were only evident in IGT between plasma MDA and each of blood GSH (p<0.01) and plasma vitamin C (p<0.05) but not with other tested antioxidants.

Among NIDDM changes, in oxidant-antioxidant status occurred regardless the state of glyceremic control (as evident by fasting blood sugar and HbA1c) as demonstrated in table (4). Yet, the duration of the disease seems to affect plasma MDA and vitamin C levels in these cases (table 4).

DISCUSSION

Both NIDDM and IGT groups in our study showed statistically significant rise in HbA1c compared to the normal control group. Thus, with the present criteria for IGT diagnosis, subjects with diabetic pathological changes might also be labeled as having IGT. So, hypoglycemic therapy might be delayed or denied at these early stages. This is concordant with 2 previous studies that IGT cases had higher than normal levels of glycated hemoglobin. Kadawski and colleagues observed that the initial degree of hyperglycemia is an important index predictive of subsequent worsening to diabetes. Marshall and associates found that subjects with IGT have an increased risk of
An imbalance in the antioxidant protective mechanism(s) leading to oxidative stress in the cells is being identified as a common factor in diabetes as well as several other disorders. Some authors report that increased levels of lipid peroxides, consequence of free radical activity, reach statistical significance only in diabetics with vascular complications. Others did not provide the prevalence of clinically detectable diabetic complications in their studies. One study failed to detected any significant increase in lipid peroxidation in NIDDM cases. Interestingly, approximately one third of IGT cases revert apparently spontaneously to normal glucose tolerance.

In the present work, the mean plasma level of MDA, as a marker of lipid peroxidation, was significantly increased in each of the NIDDM (14.3%) and IGT (14.5%) groups compared to normal. This finding in NIDDM cases is consistent with previous reports. The sources of free oxygen radicals in diabetics may be autoxidation of glucose and glycosylated proteins, intermediate products of cyclooxygenase catalysis and intracellular production from mitochondria. In vitro studies have shown that the incubation of lipids with glycosylated proteins resulted in elevation of lipid peroxidation. Activated neutrophils and macrophages in addition to vascular endothelial cells may also contribute to the increased free oxygen radicals generation in NIDDM. It has also been suggested that hyperglycemia per se may, even acutely, itself induce an oxidative stress. Furthermore, the increased blood glucose leads to increased sorbitol oxidation creating a state of pseudohypoxia with an increase in NADH/NAD ratio that results in increased generation of free oxygen radicals probably via increased prostaglandin synthesis. Alternatively, inactivation or inhibition of antioxidant enzymes by glycosylation in poorly controlled diabetics may give rise to increased lipid peroxidation. Moreover, it should be noted that high glucose in the circulation may interfere with the assay used for the assessment of lipid peroxidation products. Thus, the higher MDA observed in NIDDM is not solely the result of peroxidative damage.

In literature, the only published study on the oxidant-antioxidant status in cases of impaired glucose tolerance is a recent report by Vijayalingum and his colleagues. They reported 10% increase in lipid peroxidation in plasma of their cases compared to normal. This is consonant with the (14.5%) elevation in plasma MDA noticed in our IGT cases. Free oxygen radicals may have many deleterious effects on lipids, proteins and DNA leading to cell injury, enzyme inactivation and mutations. They are cytotoxic to B-cells of islets of the pancreas. It has been postulated that increased oxygen radicals mediate glucose-induced gene expression for extracellular matrix constituents i.e. type IV collagen, fibronectin and laminin. Furthermore, oxidative stress has been associated with insulin resistance.

The elevated plasma MDA in diabetic group was inversely correlated to the 4 tested antioxidants. The strongest correlation was to blood GSH (p<0.001) and the least (p < 0.05) was with plasma vitamin E and selenium. In those with IGT, the increase in plasma MDA was associated with the decrements in plasma vitamin C and selenium. In those with IGT, the increase in plasma MDA was associated with the decrements in plasma vitamin C and selenium. Thus, in diabetes the decrease in the antioxidant activity might denote a trial to limit the rise in lipid peroxidation on the expense of the plasma levels of antioxidants. Moreover, insignificant positive correlations were observed between the plasma MDA and the blood level of HbA1c (which is a good index of long term control of glycemic state) in each of the diabetic and IGT groups. This finding appears to support the assumption that factors other than hyperglycemia, whether genetic or metabolic, seem to contribute to the elevated lipid peroxidation incriminated in the progression of glucose intolerance and the occurrence of complications in these cases.

Vitamins E and C, carotene and glutathione provide antioxidant defenses by their ability to exist in reversible oxidized and reduced forms. In our series of cases, the pattern of change in the plasma antioxidant scavenger levels is interesting. In NIDDM, the maximum reduction was seen in vitamin C (29.6%) followed by GSH (20.1%) then vitamin E (19.2%) and selenium (17%). In IGT, the reductions were less evident. The significant decrease in antioxidants might be due to poor intake and/or excessive consumption in the fight against increased free oxygen radicals generation. Ashina et al. detected a decrease in the function of antioxidant scavengers in endothelial cells exposed to high glucose medium. These free radical scavengers were found to protect B-cells from destruction in experimental diabetes. In our NIDDM group, plasma vitamin C concentrations were decreased significantly compared to normal control (p< 0.01). Reduced levels and altered metabolic turnover of ascorbic acid have been reported in several tissues in experimentally induced diabetes and in NIDDM patients. This might be explained by the assumption that high glucose levels (which are more with uncontrolled diabetes) inhibit the uptake of dehydroascorbic acid by erythrocytes and leukocytes preventing its reduction to ascorbate which occurs inside these cells, and leading eventually to low plasma vitamin C levels. Moreover, diabetics might catabolize vitamin C more rapidly and/or conserve it less well than do non-diabetics. Sinclair et al. reported reduced ascorbic acid concentration and increased oxidative stress (as evidenced by the ratio of dehydroascorbic acid / ascorbic acid).
acids) in NIDDM compared to the normal control. It is worth mentioning that dehydroascorbate is reduced to vitamin C by the selenium-dependent glutathione peroxidase. Thus, the reduced plasma selenium noticed in our NIDDM group might contribute to the low vitamin C level in these cases. Stolba et al. found that vitamin C lowered the non-enzymatic glutation of serum proteins and collagens in vitro and in vivo. They suggested the use of vitamin C as an adjuvant therapy to prevent or delay complications in diabetes.

In well controlled NIDDM, studies recorded a non-significant decrease in plasma vitamin C concentrations. This reduction reached statistical significance only in poorly controlled NIDDM in the study of Esmaeel and his colleagues. On the contrary, our NIDDM group showed no significant correlation between the plasma vitamin C levels and parameters reflecting carbohydrate metabolism (fasting blood sugar and HbA1c). This is consonant with findings in other studies. Furthermore, a recently significant inverse correlation (p < 0.05) could be demonstrated between the plasma vitamin C and the duration of diabetes in our patients. This finding goes with that reported by Sundaram and associates. Thus, the duration of diabetes seems to be an important predictor of the plasma vitamin C level, and the duration of diabetes in our patients. This finding goes with that reported by Sundaram and associates.

Studies on the role of vitamin E as an antioxidant therapy in diabetes are controversial. In streptozotocin-induced experimental diabetes, a significant decrease in plasma vitamin E was recorded. In NIDDM cases, we could detect a significant decrease in plasma vitamin E levels. Griesmacher et al. reported a slight insignificant decrease in its plasma level in NIDDM. Another study recorded no change in plasma vitamin E in both NIDDM and normal control in response to hyperglycemia-induced oxidative stress. However, our finding goes with that of previous studies in non-complicated NIDDM cases. The reduced plasma vitamin E can be ascribed to its increased consumption during free oxygen radical counteraction. Moreover, vitamin C has been reported to have a sparing effect on vitamin E by regenerating its active form. Moreover, vitamin E in daily doses of 600 to 1200 mg stimulates pancreatic insulin producing function and normalizes lipid peroxidation in NIDDM cases regardless the kind of diabetic therapy administered. An effective protective role of vitamin E (15mg/kg/day) on residual beta cell function has been recorded in patients with recent onset IDDM undergoing intensive insulin therapy.

Neither the duration of diabetes nor parameters of carbohydrate metabolism were correlated to plasma vitamin E level. This is inconsistent with the report of Esmaeel et al. which recorded a negative correlation with HbA1c. Yet, others failed to detect any correlation between the glycemic control or the duration of diabetes and plasma vitamin E which is concordant with our work. Selenium is an essential trace element in humans. It is a constituent of the enzyme glutathione peroxidase that helps to defend against oxidant stress. Thus, catalyzes the breakdown of hydrogen peroxide, phospholipid hydroperoxides and other free hydroperoxides. Selenium tissue levels are dependent on its intake and selenium deficiency produces decreased tissue glutathione peroxidase activity.

In our NIDDM cases, plasma selenium concentrations were lower than normal control. Similar observation was recorded in streptozotocin-induced experimental diabetes and in NIDDM cases with no detectable complications. In literature, an increased activity of erythrocyte selenium dependent glutathione peroxidase was detected in cases with NIDDM as well as those with IGT. Our study detected a non-significant negative correlation of plasma selenium to the glycemic control in NIDDM. This is at variance to the negative correlation noticed in another study. This discrepancy might be ascribed to the difference in the prevalence of poorly controlled diabetics in-between the 2 studies. However, glutathione peroxidase requires glutathione in its reduced form as a cofactor to enable it to inactivate peroxide and function as an effective antioxidant.

In our study, blood reduced glutathione (GSH) levels were reduced by 20.2% in NIDDM group, and by 12.4% in cases with IGT. In NIDDM, previous reports recorded a decrease in blood GSH-levels by 11% and by 15.6%. One study found a reduction of 15.1% in blood GSH in IGT. Insignificant negative correlation was found in our NIDDM cases between the blood GSH and each of the duration of diabetes and parameters reflecting the glycemic state (fasting glucose and HbA1c). This is in agreement with the findings of a recent report. Review of the metabolism of glutathione revealed that there is more than one pool of GSH and that fluctuations of GSH measured are much more complex than a simple cause and effect relationship. Liver is the major source of extracellular GSH and a sinusoidal carrier-mediated transport of GSH from liver was essential for GSH homeostasis. Glutathione is the first line of defense against preoxidant stress. It exists in the oxidized (GSSG) and reduced (GSH) forms which are interconvertable. Starvation leads to hepatic GSH depletion but no parallel reductions were seen in heart, lung, intestine or in erythrocytes in experimental rats. Reduction in the proportion of reduced glutathione by oxidized glutathione led to the characteristic functional imbalances in the glucose-stimulated insulin response in pancreatic islets. Data provided by these authors and other studies suggest that alterations in the redox state of thiols in the islet cells, resulting from antioxidant deficiency or reactive oxygen species induced by diabetogenic agents, may lead to reduction in insulin secretion in NIDDM as well as IGT cases. In the present work, the elevated plasma lipid peroxidation (as reflected by plasma MDA) in
subjects with IGT was accompanied by diminished antioxidant levels (GSH, selenium and vitamins C and E) which is increased with the increase in glucose intolerance in that abnormalities were greater in those with frank NIDDM than in those with IGT. This is in accordance with the study of Vijayalingam and associates. From the observations of this study we can conclude that the antioxidant deficiency and the excessive peroxidative damage appear very early in NIDDM cases well before the development of clinically evident secondary complications. These oxidant-antioxidant alternations appear to be independent from the degree of glycemic control. The duration of diabetes seems to correlate positively to the lipid peroxidation and negatively to plasma vitamin C in these patients. Interestingly, this alteration in the oxidant-antioxidant status is already present in subjects with IGT and may contribute to tissue damage resulting in the progression to manifest NIDDM. Future studies are needed to further elucidate the situation of the antioxidant status in subjects susceptible to NIDDM. Therapeutic measures, to control lipid peroxidation and increase antioxidants, will be interesting to evaluate in subjects with IGT. Controlled follow up trials are awaited to see if it can delay the development of NIDDM in these cases. Moreover, further prospective studies are needed to clarify the prognostic relevance of lipid peroxides as well.

REFERENCES

27- Kaji, H.; Juraska, M. and Ito, K.: Increased lipid peroxide value and glutathione peroxidase activity in blood plasma of


47- Szalezcky, E.; Braun, L.; Sar-

**TABLE (1) AGE AND SEX DISTRIBUTION, BODY MASS INDEX (BMI) AND LEVELS OF GLYCOXYLATED HEMOGLOBIN (HBA1C) AND FASTING BLOOD SUGAR IN THE 3 STUDIED GROUPS.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group I Normal control (n = 20)</th>
<th>Group II NIDDM (n = 20)</th>
<th>Group III IGT (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>45.1 ± 4.9</td>
<td>44.6 ± 7.6</td>
<td>41.8 ± 8.4</td>
</tr>
<tr>
<td>Males / Females</td>
<td>16/4</td>
<td>15/5</td>
<td>20/7</td>
</tr>
<tr>
<td>Family history of D.M.</td>
<td>4 (20%)</td>
<td>15 (75%)</td>
<td>18 (66.7%)</td>
</tr>
<tr>
<td>BMI (kg/m2BSA)</td>
<td>27.4 ± 5.3</td>
<td>29.1 ± 3.4</td>
<td>28.3 ± 7.9</td>
</tr>
<tr>
<td>HBA1c (%)</td>
<td>4.7 ± 0.4</td>
<td>*11.4 ± 1.3</td>
<td>*6.4 ± 1.1</td>
</tr>
<tr>
<td>Fasting blood sugar (mg/dL)</td>
<td>88.4 ± 9.2</td>
<td>*173.1 ± 46.8</td>
<td>*99.7 ± 8.5</td>
</tr>
</tbody>
</table>

*p < 0.001 versus control group.
* p < 0.001 versus IGT group.

**TABLE (2) MEAN ±SD OF PLASMA LIPID PEROXIDATION (IN TERMS OF MDA) AND LEVELS OF ANTIOXIDANT SCAVENGER VITAMINS C & E, REDUCED GLUTATHIONE (GSH) AND SELENIUM IN EACH OF THE 3 STUDIED GROUPS.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group I Normal control (n = 20)</th>
<th>Group II NIDDM (n = 20)</th>
<th>Group III IGT (n = 27)</th>
<th>Statistical significance (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma MDA (µmol/L)</td>
<td>3.65 ± 0.18</td>
<td>5.21 ± 0.36</td>
<td>4.18 ± 0.72</td>
<td>&lt;0.001 &lt;0.001 &lt;0.01</td>
</tr>
<tr>
<td>Plasma vitamin C (mg/dL)</td>
<td>1.08 ± 0.15</td>
<td>0.76 ± 0.09</td>
<td>0.89 ± 0.21</td>
<td>&lt;0.001 &lt;0.001 &lt;0.05</td>
</tr>
<tr>
<td>Plasma vitamin E (µg/ml)</td>
<td>10.93 ± 0.71</td>
<td>8.82 ± 1.13</td>
<td>9.71 ± 1.22</td>
<td>&lt;0.001 &lt;0.001 &lt;0.05</td>
</tr>
<tr>
<td>Plasma selenium (µg/dL)</td>
<td>49.2 ± 3.76</td>
<td>40.8 ± 2.33</td>
<td>44.7 ± 2.87</td>
<td>&lt;0.001 &lt;0.01 &lt;0.01</td>
</tr>
<tr>
<td>Blood GSH (µmol/L)</td>
<td>54.1 ± 5.82</td>
<td>43.2 ± 3.73</td>
<td>47.4 ± 3.91</td>
<td>&lt;0.001 &lt;0.001 &lt;0.01</td>
</tr>
</tbody>
</table>
Fig. (1): Mean blood glycosylated hemoglobin in the 3 groups.

Fig. (2): Mean plasma malondialdehyde in the 3 studied groups.

Fig. (3): Mean plasma vitamin C (mg/dl) in the 3 studied groups.

Fig. (4): Mean plasma vitamin E in the 3 studied groups.

Fig. (5): Mean plasma selenium in the 3 studied groups.

Fig. (6): Mean blood reduced glutathione in the 3 studied groups.
### TABLE (3) THE CORRELATIONS BETWEEN LIPID PEROXIDATION (IN TERMS OF PLASMA MDA) AND EACH OF THE GLYCEMIC CONTROL STATUS (AS REFLECTED BY THE HbA1c), THE BLOOD REDUCED GLUTATHIONE (GSH) AND PLASMA SELENIUM AND VITAMINS C AND E IN BOTH NIDDM (N = 20) AND IGT (N = 27) GROUPS.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group</th>
<th>NIDDM (n = 20)</th>
<th>IGT (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
<td>r</td>
</tr>
<tr>
<td>and HbA1c</td>
<td>+0.206</td>
<td>&gt; 0.05</td>
<td>+0.187</td>
</tr>
<tr>
<td>and blood GSH</td>
<td>-0.725</td>
<td>&lt; 0.001</td>
<td>-0.497</td>
</tr>
<tr>
<td>and pl. selenium</td>
<td>-0.448</td>
<td>&lt; 0.05</td>
<td>-0.241</td>
</tr>
<tr>
<td>and pl. vitamin C</td>
<td>-0.574</td>
<td>&lt; 0.01</td>
<td>-0.427</td>
</tr>
<tr>
<td>and pl. vitamin E</td>
<td>0.459</td>
<td>&lt; 0.05</td>
<td>-0.243</td>
</tr>
</tbody>
</table>

### TABLE (4) THE CORRELATIONS OF THE STATE OF GLYCEMIC CONTROL (AS REFLECTED BY FASTING BLOOD SUGAR AND HbA1C), AND THE DURATION OF DIABETES VERSUS EACH OF THE PLASMA MDA, BLOOD GSH, PLASMA SELENIUM AND VITAMINS C AND E IN CASES OF NIDDM (N =20).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Fasting blood sugar</th>
<th>Blood HbA1C</th>
<th>Duration of NIDDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma MDA</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>** p &lt; 0.01</td>
</tr>
<tr>
<td>Blood GSH</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>Plasma selenium</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>Plasma vitamin C</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>*p &lt; 0.05</td>
</tr>
<tr>
<td>Plasma vitamin E</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
</tr>
</tbody>
</table>

* Significant negative correlation (r = -0.613).
** Significant positive correlation (r = +0.481).