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Relation of MDA as Oxidative Stress Marker with Lipid Profile in a Diabetic Patient

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Abstract

Type-2 diabetes mellitus (T2DM) is a disease accompanied by induced oxidative stress (OS) conditions. A reduction in antioxidant activity characterizes the OS conditions. Antioxidants protect cell components from the harmful effects of reactive oxygen species (ROS). The oxidation of the lipid components by ROS has the potential to generate malondialdehyde (MDA). The assessment of MDA (which is a byproduct of lipid peroxidation) may serve as a sign of oxidative damage. This can shed light on the impact of ROS on lipids. This study aims to elucidate the correlation between MDA oxidative stress biomarkers and lipids in individuals diagnosed with type-2 diabetes mellitus. The study comprises two case groups of 30 diabetic patients, 30 obese patients, and 30 healthy patients as the control group. The levels of MDA in the plasma specimens are measured. The serum glucose, serum lipid, and glycated haemoglobin (HbA1c) are evaluated for these groups. The results among patients with and without T2DM are analyzed with regard to age and BMI. The concentration of the MDA is [17.08 ± 1.989 (nmol/ml)] for diabetic patients, [16.08 ± 2.049 (nmol/ml)] for obese patients, and [12.12 ± 1.508 (nmol/ml)] for control patients. A statistically significant difference of $p < 0.0001$ is observed in the elevated levels of MDA among T2DM patients. As compared to healthy control participants, there is no significant difference between T2DM and obese patients. It is concluded that the MDA can be utilized for observing the oxidative stress related to T2DM. The data indicate that utilising MDA could help predict the oxidative environment.

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1. Introduction

Obesity is a multifaceted metabolic condition that is distinguished by an overabundance of adipose tissue. The relationship between obesity and the establishment of metabolic syndrome, type-2 diabetes, cardiovascular disease, and liver problems can be attributed to oxidative stress [1, 2]. Research has shown that there is a correlation between an elevated generation of free radicals with pro-oxidative properties and a decrease or inadequacy of antioxidant defenses within the human body [3]. The presence of antioxidants in blood serves to neutralize reactive oxygen species (ROS) or inhibit the release of ions that trigger lipid peroxidation. Suppression of the body's antioxidants leads to oxidative stress. This is supported by scientific literature [4]. Oxidative stress resulting from oxidative metabolism is responsible for inducing base damage. This form of damage is predominantly indirect and is instigated by the generation of ROS. The chemical species, H_2O_2 (hydrogen peroxide), OH (hydroxyl radical), and O_2 (superoxide radical) have been reported in the literature [5]. Endogenous sources (such as mitochondria, peroxisomes, phagocytic cells, etc.) and exogenous sources (such as environmental pollution, bacteria, and viruses) are both producers of ROS. Endogenous sources are more significant

and Broader than exogenous sources since they occur continuously during the life of every cell's existence in the organism [6].

Diabetes mellitus (DM) is a metabolic disease that is frequently linked to a range of complications, including hyperglycemia, oxidative stress, and inflammation [7]. There are two distinct classifications of diabetes mellitus, namely type-1 and type-2. The most common type is type-2 diabetes mellitus (T2DM), which is characterized by increased concentrations of glucose in the bloodstream. The increasing prevalence of type-2 diabetes is a significant contributor to overall health in both developed and developing nations [8]. Stress is acknowledged as a risk factor that contributes to the onset of type-2 diabetes. During the illness, hyperglycemia triggers an increase in the generation of free radicals, particularly the reactivity of oxygen species, in each tissue. This is caused by glucose autoxidation and the glycosylation of the protein [9]. Malondialdehyde (MDA) is a commonly utilized biomarker for assessing oxidative stress. MDA is one of the secondary products that arise during lipid peroxidation. Its presence in the plasma can be used as an indicator of the overall extent of lipid peroxidation [10]. Malondialdehyde is actually an oxidative result of amino acids, carbohydrates, and DNA as well as an end-product of lipid peroxidation [11]. The elevated concentration of MDA has been observed to correlate with the rise of plasma glucose concentrations and a prolonged time frame for diabetes mellitus and inflammatory states [12,13]. Elevated levels of MDA have the potential to disrupt the structural integrity of the cell membrane, initiate cellular harm, and prompt the secretion of a pro-inflammatory agent [14,15]. MDA can alter or denature multiple functional groups of proteins and DNA, thereby initiating inflammation which is mediated by oxidative stress [16,17]. The study aims to elucidate the correlation between malondialdehyde (MDA) oxidative stress biomarkers and lipids in type-2 diabetes mellitus patients.

2. Materials and Methods

2.1. Patient information and biomarker measurement:

30 Type-2 diabetes patients aged between 40 and 60 years were selected. The mean age is 47.9 years. 30 patients in the same age span were characterized by obesity. The mean age was 45.6 years. The healthy group consists of 30 individuals aged between 35 and 55 years. The mean age was 44.2 years. The samples were collected from October 2022 to March 2023. All samples were collected from fasted patients for 12 hours. All the data were obtained through medical records, interviewer-administered questionnaires, physical examinations, and laboratory tests. Information such as age, gender, duration of diabetes, and medical history were collected through the use of a questionnaire. The BMI was calculated by measuring the weight and height of each patient. The lipid profile and MDA were obtained through laboratory tests.

2.2. Exclusion criteria

Type 1 diabetes patients, gestational diabetes patients, pregnancy and patients suffering from any other disease were excluded.

2.3. Sample collection

A venous blood sample of 10 ml each was collected from the patients after a fasting period of 8-12 hours. The blood was allowed to settle for 30 minutes and was centrifuged at 1000 g for 15 minutes. The serum was stored at a temperature of $-20\,°C$ until it was ready for further use. The lipid profiles, which involved total cholesterol, HDL, LDL, and TG, were assessed using a biosystem analyzer. MDA was analyzed using HumaMDA ELISA Kit (MyBioSource, USA).

2.4. Statistical Analysis

GraphPad Prism for Windows, version 22 was used for the statistical analysis. The mean and standard deviation for all data were displayed. The independent ANOVA test was utilized to assess the variances among the three groups. A p-value below 0.05 was used to determine significance.

3. Results and Discussion

Anthropometric and biochemical parameters in T2DM, obese patients, and controls are compared and demonstrated in Table 1. Significantly higher levels of BMI, FBS, HbA1C, total blood cholesterol, and LDL-C were observed in comparison between obese, control, and diabetic patients ($p<0.001$), and significantly lower levels of HDL-C were detected in diabetic patients compared to other groups. While MDA showed no significant difference between diabetic and obese patients Figure 1.

Patients who have type-2 diabetes may have oxidative stress as a result of hyperglycemia. This occurs as a result of elevation in ROS, or free radicals of reactive oxygen species. These are generated via various mechanisms like protein glycation without the use of enzymes and glucose

autoxidation, Pentose phosphate, glycolysis, and polyol. This process is in addition to a reduction in antioxidant action, which is responsible for safeguarding cellular components against ROS damage [18]. Empirical investigations and epidemiological analyses indicate that high levels of reactive oxygen species (ROS) have a significant role in the process of lipid peroxidation. ROS compounds have been observed to induce oxidative injury by reacting with multiple double bonds present in the lipid in the membrane constituents, thereby accepting electrons [19]. During the propagation phase, the oxidation of lipid components by reactive oxygen species (ROS) may result in the production of malondialdehyde (MDA) [20]. The reactivity of ROS compounds poses a challenge for their direct measurement in academic contexts. Consequently, the assessment of MDA levels has the potential to serve as a sign of free radical damage, which can provide an indirect prediction of the impact of oxygen radicals, or ROS [21].

The findings of our investigation indicate that the levels of MDA were elevated against the control group in T2DM patients. T2DM patients and obese patients, on the other hand, did not differ significantly when compared. MDA levels that are elevated are a sign of oxidative stress caused by increased activity of oxygen radicals, or ROS, which causes peroxidation of lipid components in the cellular membrane[22]. Studies have been conducted on the examination of MDA in T2DM patients, particularly in countries with high prevalence rates of diabetes. Chen et al. conducted research in China and discovered that serum MDA levels in T2DM patients (3.69 ± 0.39 µmol /L) were significantly higher than those in the control group (2.87 ± 0.63 µmol /L) ($p<0.01$). Similarly, Khemka et al. conducted research in India and found that significantly high concentrations of serum MDA were seen in non-obese people. individuals with T2DM (3.21 ± 1.84 nmol /L) compared to the control group (2.05 ± 0.99 nmol /L) ($p<0.0001$). In Mexico, Jimenez-Osorio et al. found that the plasma MDA levels of individuals with type-2 diabetes, who did not have their blood sugar under control, were (3.5±1.5).

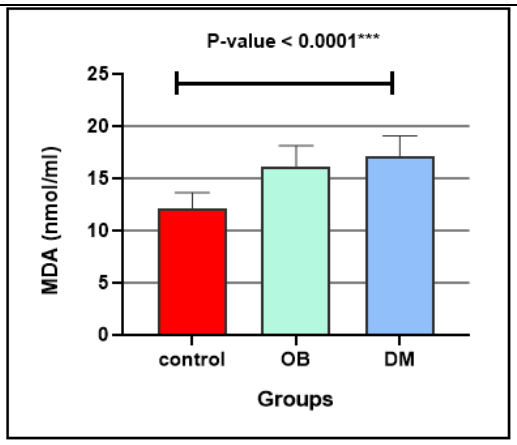

Figure 1. Comparison of malondialdehyde (MDA) concentration between diabetics, obese, with healthy control group.

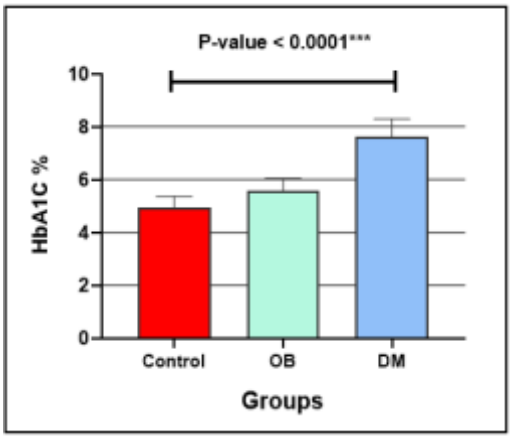

Figure 2. Comparison of concentration (HbA1C) between diabetics, obese, with healthy control group.

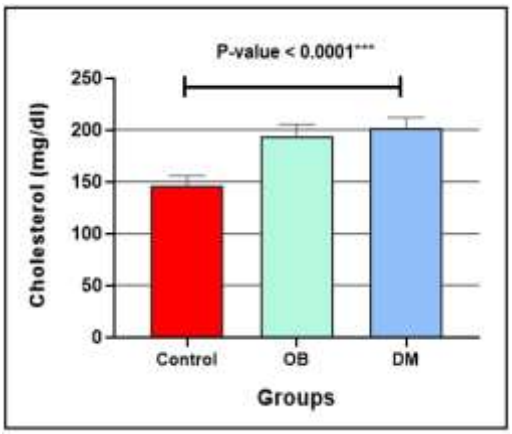

Figure 3. Comparison of concentration (cholesterol) between diabetics, DM; obese,OB; and healthy control group.

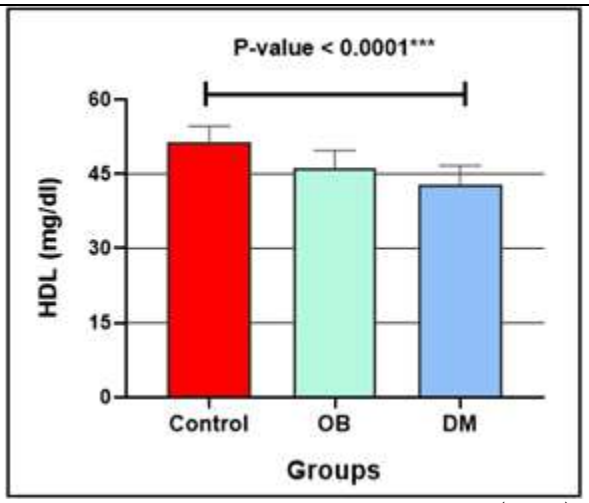

Figure 4. Comparison of concentration (HDL) between diabetics, DM; obese,OB: and healthy control group.

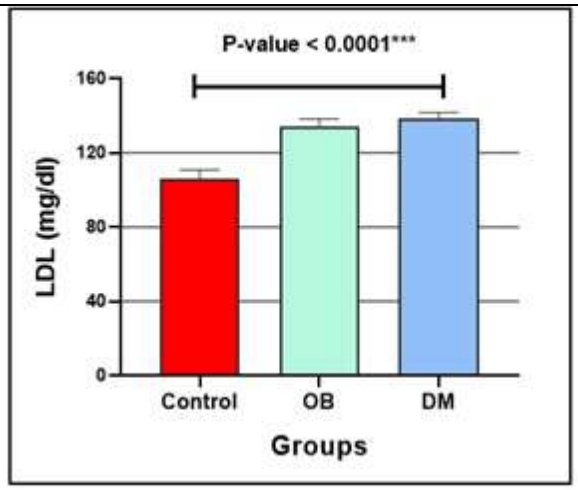

Figure 5. Comparison of concentration (LDL) between diabetics, DM; obese,OB; and healthy control group.

Table 1. Comparison among study parameters in diabetic, obese patients, and control group.

Variables	Control (n = 30)	Obese patients (n =30)	T2DM patients (n = 30)	P-Value
Age (years)	44.20 ± 6.805	45.63 ± 9.796	47.90 ± 9.953	<0.0001
Weight (kg)	63.95 ± 9.752	102.5 ± 7.310[b]	68.43 ± 8.208[d]	
BMI (kg/m2)	24.36 ± 2.579	34.94 ± 4.014[b]	24.59 ± 2.06[d]	
FBS (mg/dl)	102.7 ± 11.86	122.2 ± 10.61[b]	150.5 ± 11.52[b,d]	
HbA1C (%)	4.960 ± 0.4039	5.567 ± 0.4859[b]	7.627 ± 0.6716[b,d]	
Cholesterol (mg/dl)	145.8 ± 9.835	194.4±10.57[b]	201.4±10.53[b]	
TG (mg/dl)	106.5 ± 15.80	133.8±12.33[b]	160.3 ± 14.70[b,d]	
HDL-C (mg/dl	51.47 ± 3.213	46.27 ± 3.513[a]	42.83 ± 3.842[b]	
LDL-C (mg/dl)	106.1 ± 4.671	134.3 ± 3.852[b]	137.9 ± 3.610[b,c]	
VLDL (mg/dl)	21.31 ± 3.160	26.75 ± 2.467[b]	32.07 ± 2.940[b,d]	
MDA (nmol/ml)	12.12 ± 1.508	16.08 ± 2.049[b]	17.08 ± 1.989[b]	

Abbreviations: BMI, body mass index; FBS, fasting blood sugar; HDL-C, high-density lipoprotein-cholesterol; LDL-C,low-density lipoprotein- cholesterol; MDA, malondialdehyde; TG, triglycerides; T2DM, type 2 diabetes mellitus. [a]p < .05 vs. controls, [b]p < .001 vs. controls, [c]p < .05 vs. obese, [d]p < .001 vs. obese

nmol /L) greater than the levels of those who did (3.07±1.5 nmol /L), (p<0.05) [23,24]. This explains that the accumulation of MDA can be further aggravated by a reduction in the efficacy of antioxidant protection methods. It was, reported that there is an enormous rise in the MDA levels among people with T2DM, and these oxidants are known to be associated with complications related to T2DM [25]. A notable correlation has been established between hyperglycemia and glucose autoxidation, as well as the production of unbound electrons, generation of toxic ROS, and development of oxidative stress, thereby highlighting the contributory role of hyperglycemia in these processes [26]. Our findings indicate a significant association between dyslipidemia and increased lipid peroxidation, leading to the production of reactive oxygen species (ROS) and subsequent vascular complications [27]. The reaction between ROS and PUFAs present in barrier lipid components results in the production of different aldehyde species, for instance, MDA. Malondialdehyde is a biomolecule resulting from the degradation of membrane

lipids, which serves as an indicator of lipid peroxidation in those who have T2DM [28]. In the diabetes mellitus group, serum MDA levels have a positive correlation with fasting blood sugar, cholesterol, and LDL. Conversely, Serum MDA levels have a negative correlation with HDL levels in the same group. In the obese group, serum MDA levels have a positive correlation with fasting blood sugar (FBS), and BMI. A noteworthy finding was observed in the overweight cohort, wherein a substantial direct association was established between BMI and a converse association with HDL. This is In agreement with the viewpoint posited by Farhan et al. that a correlation exists between MDA levels and fasting glucose, which characterizes the advancement of the ailment and the emergence of persistent complications in DM [28]. Klisic et al. and Tangvarasittichai et al. reported comparable findings, indicating a strong and statistically significant association between serum lipids and MDA [29,30].

4. Conclusions

A notable rise in MDA concentration marker of oxidative stress in diabetic patients as compared with healthy and obese patients. The disturbance of lipid profile in diabetic patients is worse than that in obese patients. It is clear that obesity worsens the disturbance as it raises HbA1C significantly, and this is an early indicator of high blood sugar.

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