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Serum Cardiac Markers in Patients with Acute Myocardial Infarction: Oxidative Stress, C-Reactive Protein and N-Terminal Probrain Natriuretic Peptide

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Summary **The aim of this study was to investigate the predictive value of an oxidative stress, C-reactive protein (CRP) and N-terminal probrain natriuretic peptide (NT-proBNP) biomarkers in acute myocardial infarction (AMI). The study population contained 100 patients with AMI and 40 healthy subjects. Malondialdehyde (MDA) was measured as thiobarbituric acid reactive substances. Total antioxidant status (TAC) was assayed with colorimetric method. CRP and NT-proBNP was quantitated by immunoassay. MDA, CRP and NT-proBNP levels were found significantly high in patients with AMI as compared to healthy controls (p<0.01). Patients were divided into six groups based on the presence of disease history before AMI. In patients with non-disease before AMI. MDA, CRP and NT-proBNP levels were lowest among the patient groups. MDA levels in patients with hyperlipidemia/ diabetes/renal disease were higher than the other groups. TAC levels in patients with hypertension were lower than as compared to healthy controls (p<0.05). CRP levels in hypertension + hyperlipidemia patients and NT-proBNP levels in cardiovascular + hypertension patients were found high as compared to other patient groups. It is concluded that serum levels of MDA, CRP and NT-proBNP were significantly increased in patients with AMI and these markers were strongly predictive in AMI.**

Key Words**: oxidative stress, C-reactive protein, N-terminal probrain natriuretic peptide, acute myocardial infarction**

Introduction

Acute myocardial infarction (AMI) is one of the major causes of mortality and morbidity in the world. The most common cause of an AMI is atherosclerotic coronary artery disease (CAD) with erosion or rupture of a plaque causing transient, partial or complete arterial occlusion. Heart can not continue to function without adequate blood flow, and if it is severely compromised, death is inevitable. Several risk factors for coronary heart disease have been well documented, including hypertension, hyperlipidemia, diabetes, a positive family story, smoking, obesity and inactivity [*1*]. However, these factors explain only part of attributable cardivascular disease. Evidence suggests that reactive oxygen species (ROS) may play important roles in the pathogenesis in myocardial infarction [*2*]. Following ischemia, ROS are produced during reperfusion phase [*3*, *4*]. ROS are capable of reacting with unsaturated lipids and of initiating the self-perpetuating chain reactions of lipid peroxidation in the

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membranes [*5*, *6*]. Free radicals can also cause oxidation of sulphydryl groups in proteins and strand scission in nucleic acids is also possible [*7*]. Myocardial antioxidants inhibit or delay the oxidative damage to subcellular proteins, carbohydrates, lipids and DNA. There is evidence that antioxidants can protect against free radical protection which is responsible for reperfusion-induced damage and lipid peroxidation, and may thereby inhibit thrombosis, myocardial damage and arrhythmias during AMI [*8*]. Total antioxidant capacity (TAC) is a critical tool for assessing redox status [*9*]. The TAC or related antioxidants may play an important role in protecting the organism from free-radicals-mediated damage [*10*]. The role that such compounds play in AMI development is important, since their presence may decrease the damage resulting from blood ROS during reperfusion.

A growing body of evidence supports the concept that local and systemic inflammation play a role in the initiation and progression of atherosclerosis and its complications [*11–13*]. Inflammatory cells and mediators contribute to destabilizing the protective fibrous cap on atherosclerotic plaques and have been implicated in the pathogenesis of myocardial injury. C-reactive protein (CRP) is an acute-phase reactant marker for underlying systemic inflammation. CRP has been reported to be elevated in patients with MI [*14*]. N-terminal probrain natriuretic peptide (NT-proBNP) as an another new biomarker for myocardial injury, is neurohormone synthesized primarily in atrial or ventricular myocardium and is released from cardiac myocytes in response to ventricular wall stress, ischemia or infarction. NT-proBNP is important prognostic indicator in congestive heart failure and acute coronary syndrome [*15*].

In this study, we compared lipid peroxidation, total antioxidant capacity, CRP and NT-proBNP levels between different risk groups in patients with acute myocardial infarction. We examined the effects of sex, age, body mass index, smoking habit, physical activity, dietary habit and family history on measured parameters.

Materials and Methods

Chemicals

6-Hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox) and potassium persulphate, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) diammonium salt (ABTS), sodium chloride, potassium chloride, potassium persulphate, trichloroacetic acid and 1,1,3,3-tetraethoxypropane were purchased form Sigma-Aldrich Co. (St. Louis, MO); sodium dihydrogen orthophosphate dihydrate, disodium hydrogen orthophosphate 12-hydrate, 2-thiobarbituric acid were purchased from Merck & Co., Inc (West Point, PA).

Patients

This study was carried out in 140 subjects admitted to the hospital for suspected AMI. Of these, 100 (79 men and 21 women) (mean age 62.17 ± 1.11 years) had evidence of AMI. The other 40 subjects (29 men and 11 women) (57.80 ± 1.11 years) were studied as controls. The diagnosis of AMI was based on a history of prolonged ischemic chest pain, characteristic electrocardiogram (ECG) changes and elevated creatine kinase isoenzyme MB (CK-MB) and troponin T within 12 h after the onset of pain. The patients with AMI were divided into the following six groups according to disease before AMI as hypertension group ($n = 17$), cardiovascular disease group ($n = 9$), cardiovascular disease + hypertension group ($n = 28$), hypertension + hyperlipidemia group ($n = 13$), other disease (hyperlipidemia or diabetes or renal disease group) ($n = 11$) and non-disease group ($n = 22$). Hypertension was defined as a diastolic blood pressure ≧90 mm Hg, systolic blood pressure ≧140 mm Hg, or self-reported use of an antihypertensive drug. Cardiovascular disease was diagnosed angiography, ECG, sintigraphy and effort test, or self-reported use of a β-blocker, angiotensin I converting enzyme (ACE) inhibitor and/or diuretic drug. The patients who had total cholesterol level of>220 mg/dL or triglycerides concentration>200 mg/dL, or receiving lipid lowering drugs were defined as having hyperlipidemia. Diabetes mellitus was diagnosed if the fasting plasma glucose concentration was ≧126 mg/dL or if the patient was treated with insulin or oral hypoglycemic agents. Renal disease was defined as estimated glomerular filtration rate<60 mL/min per 1.73 m^2. Patients with infection, inflammatory diseases, malignancy, congenital malformations of the heart or vessels or history of AMI were excluded. Normal subjects were chosen from the same age group and had free from diabetes mellitus and other chronic disease. No subject (patients or controls) was taking antioxidant or vitamin supplements, probucol, allopurinol, quinidine, disopyramide, or other drugs known as affecting serum lipid peroxidation and and TAC values. Oral consent was obtained from the patients' relatives and normal subjects, prior to study.

Sample collection

Study samples were collected from AMI subjects were drawn soon after admission before starting any medication. Venous blood was collected in the supine position for analysis of malondialdehyde (MDA), TAC, CRP, NT-proBNP, troponin T (TnT), CK-MB and lipid profile. Clotted blood was centrifuged at 4°C, and the serum samples were used for assays on the same day or frozen at −70°C until being analyzed.

Serum malondialdehyde levels were determined with the spectrophotometric method [*16*]. 100 µl serum was mixed with 1000 µl 0.67% thiobarbituric acid (TBA) and 500 µl of 20% tricloroacetic acid. The mixture was incubated at 100°C for 20 min. After cooling, the mixture was centrifuged at 12000 g for 5 minutes and the absorbance was measured. Serum TAC levels were determined according to ABTS

radical cation ($ABTS^+$) decolorization assay [*17*]. ABTS radical cation ($ABTS^+$) was produced by reacting 7 mM ABTS solution with 2,45 mM potassium persulfate (final concentration) with a ratio of 1:0.5 and allowing the mixture to stand in the dark at room temperature for 12 – 16 h before use. $ABTS^+$ solution was diluted with PBS, pH 7.4, to an absorbance of 0.700 (±0.020) at 734 nm and 30°C. After addition of 1.0 ml of diluted $ABTS^+$ solution to 10 µl serum or Trolox standarts in PBS the absorbance reading was taken at 30°C exactly 6 minutes after initial mixing. % inihibition values of samples and standarts are calculated and TAC levels are calculated from the calibration graphic.

Determination of hs-CRP level was measured by the nephelometric method on the basis of particle-bound goat antihuman CRP (Beckman Instruments, Inc, Fullerton, CA) and expressed as mg/dL. Serum NT-proBNP levels were measured by automated immuno-assay (Elecsys pro BNP, Roche Diagnostics, Mannheim, Germany). The test principle includes using two polyclonal antibodies directed against N-terminal proBNP; epitope 1:amino acid 1-21 and epitope 2:amino acid 39-50. The results are calibrated against a synthetic NT-proBNP (amino acid 1-76). Both cardiac TnT and CK-MB mass were measured with highly specific monoclonal antibodies in a sensitive chemiluminescence assay, with an Elecsys 2010 instrument (Roche Diagnostics, Mannheim, Germany). Total cholesterol, triglycerides, LDL-cholesterol, VLDL-cholesterol and HDL-cholesterol were analyzed enzymatically.

Data analysis

The data for biochemical analysis were expressed as mean ± SE. Student's t test was applied to determine the significance of biochemical parameters among two groups. One-way analysis of variance (ANOVA) and Duncan test were performed for measures of more than two groups. Pearson correlation coefficients were calculated for relationship between measured parameters. p value of <0.05 was considered as significant. Data were analyzed using the statistical package program SPSS 13.0.

Results

The baseline characteristics of the study population are shown Table 1. As expected, the patients had higher total

Table 1. Demographic characteristics of the study group

	AMI (n = 100)	Controls (n = 40)
Males/females	79/21	29/11
Age (mean ± SE), years	62.17 ± 1.11	57.80 ± 1.11
Body mass index (mean ± SE), kg/m^2	27.05 ± 0.29	24.69 ± 0.25
Risk factors (%)		
Hypertension	17	—
Cardiovascular disease	9	—
Cardiovascular disease + hypertension	28	—
Hypertension + hyperlipidemia	13	—
Other (Hyperlipidemia/diabetes/renal disease)	11	—
Non-disease	22	—
Obesity	15	—
Family history	51	20
Smoking status		
Current smoker	45	12.5
Ex-smoker	40	42.5
Non-smoker	15	45
Physical activity	16	40
Dietary habits		
Olive oil	27	37.5
Olive oil + margarine	73	62.5
Total cholesterol (mean ± SE), mg/dl	175.23 ± 4.83[a]	154.20 ± 4.10
HDL-cholesterol (mean ± SE), mg/dl	41.80 ± 1.15[a]	48.85 ± 1.37
LDL-cholesterol (mean ± SE), mg/dl	107.02 ± 3.90[a]	76.65 ± 3.84
VLDL-cholesterol (mean ± SE), mg/dl	24.72 ± 1.40	28.70 ± 1.00
Triglyceride (mean ± SE), mg/dl	125.77 ± 7.25	134.37 ± 4.18

[a]significant difference from control group (p<0.01).

cholesterol and LDL-cholesterol but lower HDL-cholesterol levels than the healthy controls ($p<0.01$, $p<0.01$, $p<0.01$, respectively). There was no difference in VLDL-cholesterol and triglyceride levels between the patients and the healthy controls.

The mean MDA concentration in control group was found 2.68 ± 0.14 nmol/ml. In the total patient group, the mean was found 4.53 ± 0.22 nmol/ml, which was significantly elevated over the controls ($p<0.01$). When patients were divided into six groups according to disease before AMI, the highest MDA levels were found in hyperlipidemia/diabetes/renal group (5.72 ± 0.68 nmol/ml), the lowest MDA levels in non-disease group (3.71 ± 0.47 nmol/ml). In non-disease group, MDA levels were found low as compared to hyperlipidemia/diabetes/renal group ($p<0.05$), but hig as compared to control group ($p<0.05$). MDA levels in other disease groups were found significantly higher as compared to controls ($p<0.01$) (Table 2).

The mean concentration of TAC in all patients with AMI was 1.27 ± 0.02 µmol/l as compared to 1.33 ± 0.02 µmol/l in controls (Table 2). This difference was not significant, as measured by ANOVA ($p>0.05$). When AMI patients were divided into six group, it was found that patients with hypertension showed significantly lower TAC levels than patients with hyperlipidemia/diabetes/renal disease (1.19 ± 0.04 µmol/l, 1.39 ± 0.08 µmol/l, respectively) ($p<0.05$). The TAC levels in patients with hypertension was also lower than control group ($p<0.01$).

The patients with AMI had significantly higher CRP levels (1.57 ± 0.07 mg/dl) than control group (0.58 ± 0.03 mg/dl) ($p<0.01$). When total patients were divided into six groups according to disease before AMI, all patient groups were higher than control group ($p<0.01$) (Table 2). The CRP levels in patients with non-disease group (1.15 ± 0.13 mg/dl) were lower than the other patient groups (cardiovascular 1.71 ± 0.15 mg/dl; cardivascular + hypertension 1.73 ± 0.11 mg/dl; hypertension + hyperlipidemia 1.98 ± 0.19 mg/dl; hyperlipidemia/diabetes/renal disease 1.81 ± 0.17 mg/dl) ($p<0.05$; $p<0.01$; $p<0.01$; $p<0.01$, respectively) except patients with hypertension (1.33 ± 0.18 mg/dl) ($p>0.05$). Cardiovascular + hypertension and hypertension + hyperlipidemia patients showed significantly high CRP levels when compared hypertension group ($p<0.05$; $p<0.05$, respectively).

NT-proBNP level was also found significantly high in total AMI patients (1432.17 ± 140.64 pg/ml) as compared to controls (93.23 ± 3.25 pg/ml). AMI patients were divided into sub groups according to disease before AMI, the lowest NT-proBNP levels were in patients with non-disease group (818.23 ± 210.91 pg/ml) as compared to other patient groups and there were a significant differences between non-disease

Table 2. Comparison of MDA, TAC, CRP, NT-proBNP, TnT and CK-MB in patient groups and control group

	MDA (nmol/ml)	TAC (µmol/l)	CRP (mg/dl)	NT-proBNP (pg/ml)	TnT (ng/ml)	CK-MB (U/l)
Hypertension group (n = 17)	4.67 ± 0.40[a]	1.19 ± 0.04[a]	1.33 ± 0.18[a]	847.98 ± 140.90[a]	1.32 ± 0.37[a]	126.06 ± 34.71[a]
Cardiovascular group (n = 9)	4.08 ± 0.54[a]	1.22 ± 0.07	1.71 ± 0.15[a]	2216.16 ± 668.48[a,i]	1.47 ± 0.44[a]	155.00 ± 45.23[a]
Cardiovascular + hypertension group (n = 28)	4.90 ± 0.49[a]	1.27 ± 0.04	1.73 ± 0.11[a,i]	1957.86 ± 255.19[a,h]	1.28 ± 0.29[a]	115.43 ± 17.80[a]
Hypertension + hyperlipidemia group (n = 13)	4.28 ± 0.64[a]	1.29 ± 0.07	1.98 ± 0.19[a,i]	1681.87 ± 569.82[a]	1.21 ± 0.33[a]	109.23 ± 20.42[a]
Hyperlipidemia / diabetes / renal group (n = 11)	5.72 ± 0.68[a]	1.39 ± 0.08[i]	1.81 ± 0.17[a]	1288.29 ± 292.61[a]	0.95 ± 0.35[a]	183.55 ± 48.39[a]
Non-disease group (n = 22)	3.71 ± 0.47[b,g]	1.27 ± 0.04	1.15 ± 0.13[a,c,d,e,f]	818.23 ± 210.91[a,c,d]	0.88 ± 0.30[a]	84.59 ± 14.23[a,g]
Total patients (n = 100)	4.53 ± 0.22[a]	1.27 ± 0.02	1.57 ± 0.07[a]	1432.17 ± 140.64[a]	1.17 ± 0.14[a]	120.70 ± 11.08[a]
Controls (n = 40)	2.68 ± 0.14	1.33 ± 0.02	0.58 ± 0.03	93.23 ± 3.25	0.01 ± 0.00	12.55 ± 0.82

[a]significant difference from control group ($p<0.01$), [b]significant difference from control group ($p<0.05$), [c]significant difference from cardiovascular group ($p<0.05$), [d]significant difference from cardiovascular + hypertension group ($p<0.01$), [e]significant difference from hypertension + hyperlipidemia group ($p<0.01$), [f]significant difference from hyperlipidemia + diabetes + renal group ($p<0.01$), [g]significant difference from hyperlipidemia + diabetes + renal group ($p<0.05$), [h]significant difference from hypertension group ($p<0.01$), [i]significant difference from hypertension group ($p<0.05$).

group and cardiovascular group (2216.16 ± 668.48 pg/ml) and cardiovascular + hypertension group (1957.86 ± 255.19 pg/ml) ($p<0.05$; $p<0.01$, respectively). A significant differences were found between patients with hypertension (847.98 ± 140.90 pg/ml) and cardiovascular group (2216.16 ± 668.48 pg/ml) ($p<0.05$), hypertension group and cardiovascular + hypertension group (1957.86 ± 255.19 pg/ml) ($p<0.01$) (Table 2).

Serum TnT and CK-MB levels were also significantly high in total AMI patients (1.17 ± 0.14 ng/ml; 120.70 ± 11.08 U/l) as compared to controls (0.01 ± 0.00 ng/ml; 12.55 ± 0.82 U/l) ($p<0.01$; $p<0.01$, respectively). When patients were divided into six groups according to disease before AMI, the highest CK-MB levels were found in hyperlipidemia/diabetes/renal group (183.55 ± 48.39 U/l), the lowest CK-MB levels in non-disease group (84.59 ± 14.23 U/l) and a significant difference was found between these groups ($p<0.05$) (Table 2).

Serum TnT values in patients with AMI showed positive correlations with NT-proBNP ($r = 0.28$, $p<0.01$), CK-MB ($r = 0.31$, $p<0.01$) and MDA ($r = 0.23$, $p<0.01$) (Table 3). There were inverse correlations between HDL-cholesterol and CRP ($r = -0.22$, $p<0.05$), HDL-cholesterol and NT-proBNP ($r = 0.21$, $p<0.05$), total cholesterol and NT-proBNP ($r = 0.22$, $p<0.05$) in total patients. Another inverse correlation was also found in control group between HDL-cholesterol and TAC ($r = -0.54$, $p<0.01$) (Table 3). No significant differences could be identified with regard to sex, age, body mass index, obesity, family history, smoking habit, physical activity, dietary habit and family history in patients with AMI.

Discussion

Several experimental reports demonstrate that ischemia followed by reperfusion elicit a cascade of proinflammatory reactions that are known to lead to the production of ROS [*18*], activation of the complement system [*19*], leukocyte mediated injury of myocardial cells [*20*], and production of cytokines [*21*]. There is a growing evidence that increased free radical production and impaired antioxidant protection are relevant to plaque activation. In addition to traditional risk factors, oxidative stress has been regarded as one of the most important contributors to the progression of atherosclerosis [*22*]. Increased lipid peroxidation is thought to be a consequence of oxidative stress which occurs when the dynamic balance between prooxidant and antioxidant mechanism is impaired [*23*]. In ischemia, the ATP is drastically reduced and is converted to hypoxanthine and then to uric acid by xanthine oxidase upon reperfusion. During this process, enormous amounts of superoxide radicals formed which can simulate Haber-Weiss reaction for further generation of ROS, initiating lipid peroxidation [*24*]. It has been suggested that increased lipid peroxides levels in blood of patients with AMI [*25*, *26*]. We observed that increased concentrations of MDA in the circulation of total AMI patients indicating increased lipid peroxidation. Our results are in accordance with previous reports [*25–27*]. In our study, we observed MDA levels both total patients and each patient group classified presence of disease before AMI, as compared to control group. MDA levels in non-disease group were lower than the other patient groups, and a significant difference was only found between non-disease group and hyperlipidemia/diabetes/renal group. In our opinion, lipid peroxidation might be increased due to the presence of systemic diseases including hyperlipidemia or diabetes mellitus or renal disease in addition to myocardial infarction.

Several antioxidant protective mechanisms exist against free radical damage and constitute a primary defensive system including vitamins such as vitamins C, E and β-carotene and enzymatic defences [*28–30*]. It is known that plasma antioxidant capacity decreases and oxidative/antioxidative balance shifts to the oxidative side in patients with CAD [*31*, *32*]. Kharb and Singh [*33*] showed that plasma vitamin E was significantly lower in AMI patients as compared to healthy controls. Yao *et al.* [*34*] have reported that decrease of the TAC value following AMI. Their data indicated that the TAC value decreased continously, and finally, it became stable. Similary, Senthil *et al.* found low concentrations of vitamin C, vitamin E and β-carotene in the circulation of patients with AMI may be due to increased utilization to scavenge lipid peroxides. In contrast, Chamblee *et al.* showed that TAC levels in AMI patients was not

Table 3. Pearson correlation coefficients between measured parameters in total patient and control groups

		CRP	NT-proBNP	CK-MB	MDA	TAC
Total patients	TnT	—	0.28**	0.31**	0.23**	—
	HDL-cholesterol	−0.22*	−0.21*	—	—	—
	Total-cholesterol	—	−0.22*	—	—	—
Controls	HDL-cholesterol	—	—	—	—	−0.54**

*Correlation is significant for $p<0.05$

**Correlation is significant for $p<0.01$

different from the control population. In this study, TAC levels were lower in total patients with AMI than in control group, but this difference was not statistically significant. However, in hypertensive-myocardial infarcts, TAC level was less than that found in healthy controls and hyperlipidemia/diabetes/renal group. It is not known why there is a decrease in TAC levels in hypertension.

Inflammation plays a role in the development of atherosclerosis and coronary heart disease [*35*]. Elevated markers of inflammation, in particular CRP, are associated with an increased risk of future cardiovascular events in healthy subjects, in patients with stable or unstable coronary artery disease and acute myocardial infarction [*36*, *37*]. Although the prognostic value of CRP in patients with myocardial infarction has not been tested in large studies, several data indicate that CRP is an important marker of risk also in this clinical setting [*38*, *39*]. CRP has been reported to be elevated during AMI [*14*, *40*]. In this study, we observed increased CRP levels in AMI patients as compared to healthy controls. Moreover, CRP concentrations in each patient group were found higher than the control group. We have observed highest concentrations of CRP in patients with hypertension + hyperlipidemia among the patient groups. Elevated CRP levels were also observed in hyperlipidemia/diabetes/renal group and cardiovascular + hypertension group, respectively. We found an elevation of CRP levels in cardiovascular + hypertension group and hypertension + hyperlipidemia group as compared to hypertension group. Hypertension plus cardiovascular disease or hyperlipidemia seems to be responsible for the elevation of CRP levels. Hypertension, diabetes mellitus, older age, extension of necrosis area, previous AMI, and anterior site of AMI are considered among the most important features leading to heart failure during AMI [*41*, *42*]. CRP concentration in non-disease group was the lowest in the patient groups and a significant differences were observed between the other groups except patients with hypertension.

Natriuretic hormones are a family of vasoactive peptides that act as balanced arterial and venous vasodilators and they promote, as their name suggests, natriuresis and diuresis. The ability to measure the circulating concentration of these hormones has lead to an interest in using these levels to enhance diagnostic and prognostic assessment among patients with cardiovascular disease. Previous studies have convincingly demonstrated that circulating levels of NT–proBNP are increased in patients with AMI and predict mortality [*43*, *44*]. Sabatine *et al.* [*45*]. demonstrate that an important link between the severity of an acute ischemic insult and the circulating levels of BNP. In this study, we observed increased NT-proBNP levels in patients with AMI as compared to healthy population. NT-proBNP levels in cardiovascular patient group were found highest among the patient groups. Second group of sequence was cardivascular + hypertension group according to increased levels of NT-proBNP. A significant differences were found between hypertension group and cardiovascular group, hypertension group and cardiovascular + hypertension group. Similar differences were observed between non-disease group and cardiovascular group, non-disease group and cardiovascular + hypertension group.

Troponins I and T are proteins of the troponin regulatory complex involved in cardiac contractility. Both have very high myocardial tissue specificity, are not detectable in the blood of healthy persons and offer an improved sensitivity and specificity for AMI versus a combination of ECG and traditional biochemical markers. The cardiac-specific troponins are highly sensitive and specific markers of myocardial damage [*46*] and therefore cardiac troponins are the preferred markers for the diagnosis of myocardial infarction [*47*]. In this study, increased TnT levels were found in patients with AMI as compared to healthy controls, as expected. The highest TnT levels were observed in cardiovascular group and the lowest TnT levels in non-disease group among the patient groups.

CK and more particularly its isoenzyme CK-MB still have a formal place in defining myocardial infarction. However the current definition is not a particularly useful one because studies have shown that, as currently defined, patients with myocardial infarction and unstable angina have similar outcomes [*48*, *49*]. In this study, as expected, CK-MB levels in patients with AMI were higher than healthy population. We found an significant elevation of CK-MB in group of hyperlipidemia/diabetes/renal disease. When the patient groups were compared according to CK-MB levels, a significant difference was found between hyperlipidemia/diabetes/renal group and non-disease group.

Lipoproteins with higher concentrations of vitamin E are more able to resist damage from oxidative stress [*50*]. Thus, exposure and susceptibility of lipids to oxidation appear to be important factors in the initiation and growth of atherosclerotic plaques. In this study, we found that elevated LDL and decreased HDL levels in patients with AMI as compared to healthy controls.

In conclusion, our study shows a significant increase in MDA, CRP and NT-proBNP in the circulation of patients with AMI. A significant decrease of TAC levels observe only in AMI patients with hypertension. Therefore these biomarkers may be useful diagnosis of patients with AMI. A larger study with a sample size capable to detect differences in clinical outcome is now warranted.

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Abbreviations

CRP, C-reactive protein; NT-proBNP, N-terminal probrain natriuretic peptide; AMI, acute myocardial infarction; MDA, malondialdehyde; TBARS, thiobarbituric acid reactive substances; TAC, total antioxidant status; TnT, Troponin T; CK-MB, creatine kinase isoenzyme MB; CAD, coronary artery disease; ROS, reactive oxygen species.

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