CARDIOVASCULAR RISK FACTORS IN ELDERLY NORMOLIPIDEMIC ACUTE MYOCARDIAL INFARCT PATIENTS - A CASE CONTROLLED STUDY FROM INDIA

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Abstract. The goal of the present study was to address the various risk factors associated in normolipidemic acute myocardial infarction (AMI) patients admitted to the intensive coronary care unit (ICCU). The study compared serum lipid profiles, lipid peroxidation markers, antioxidants and inflammatory markers in acute myocardial infarction (AMI) patients and age/sex-matched controls. A lipid profile, lipid peroxidation, enzyme antioxidants, endogenous antioxidants, ischemia modified-albumin (IscMA), ceruloplasmin, C-reactive protein (CRP), fibrinogen, lipoprotein (a) and paraoxonase-1 activities were analyzed in 330 subjects, 165 acute myocardial infarction (AMI) patients and 165 age/sex-matched controls. We observed significantly higher (p<0.0001) total cholesterol and triglyceride levels and lower high-density lipoprotein cholesterol (HDL-C) levels in the AMI patients. The lipoprotein (a), ceruloplasmin, CRP and fibrinogen levels were higher and the bilirubin, ascorbic acid, uric acid, albumin, superoxide dismutase, catalase, glutathione peroxidase and paraoxonase-1 activities were lower in AMI patients than controls. The malondialdehyde (MDA) and conjugated diene (CD) levels were significantly higher (p<0.0001) in AMI patients.

INTRODUCTION

With the explosive rise in the incidence of coronary artery disease (CAD) it is projected to be the leading cause of morbidity and mortality among Indians by the year 2015 (Reddy, 1993). The World Health Organization (WHO) predicts that deaths due to circulatory system diseases are projected to double between 1985 and 2015 (Bulatao and Stephens, 1990; Reddy and Yusuf, 1998). Indians living abroad have a 40% higher risk of ischemic heart disease (IHD) mortality than Europeans (Balarajan, 1996).

CAD is associated with multiple factors including hereditary, hyperlipidemia, obesity, hypertension, environmental factors and life style variables, such as stress, smoking, and alcohol consumption (Chopra and Wasir 1998). Lipids have been investigated extensively in recent years; they are deranged in a large proportion of coronary artery disease patients. Asians show a mixed picture of dyslipidemia (Vasisht *et al*, 1990). Dyslipidemic patients are more prone to myocardial infarction due to increased free radical generation and ischemia (Gomez *et al*,1996; Malhotra *et al*, 2003; Rajasekhar *et al*, 2004; Mishra *et al*, 2005; Rani *et al*, 2005;

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Ghosh *et al*, 2006; Patil *et al*, 2007). Low high density lipoprotein cholesterol (HDL-C) levels are common in MI patients (Malhotra *et al*, 2003; Rajasekhar *et al*, 2004; Mishra *et al*, 2005; Rani *et al*, 2005; Ghosh *et al*, 2006; Patil *et al*, 2007). The HDL-C level is the most important independent protective factor against arteriosclerosis which underlies coronary heart disease (CHD). HDL-C associated paraoxonase-1 enzyme (PON1) is protective against lipid peroxidation (Singh *et al*, 2007).

Numerous cohort studies and clinical trials have confirmed the association between a low HDL-C and increased risk of CAD. Low density lipoprotein-cholesterol (LDL-C) is considered as the most important risk factor for CAD. Its oxidized form promotes foam cell formation which initiates the process of atherosclerosis by accumulating in sub-endothelium cells leading to fatty streaks and complex fibro-fatty or atheromatous plaque formation (Berliner *et al*, 1995). The oxidation of LDL-C is limited by the antioxidant enzyme system, including superoxide dismutase, catalase, glutathione peroxidase, antioxidant vitamins C, A, E and other carotenoids. The endogenous antioxidant system includes albumin, uric acid, and total bilirubin. Imbalance of this system, either due to excess free radical formation or insufficient removal by antioxidants, leads to oxidative stress (Frei *et al*, 1998; Shrinivas *et al*, 2000; Maritim *et al*, 2003).

Other risk factors for CAD have been identified apart from dyslipidemia, namely ceruloplasmin, CRP, lipoprotein (a) and plasma fibrinogen. Since we have encountered myocardial infarction patients with normal serum lipid concentrations, we conducted a prospective case-control study to evaluate the concentration of antioxidant enzymes, degree of lipid peroxidation and other risk factors associated with acute myocardial infarction.

MATERIALS AND METHODS

The prospective case-control study consisted of 165 patients (123 men and 42 women) with acute myocardial infarction (AMI) admitted to the intensive cardiac care unit (ICCU) of Sharda Hospital, India. The diagnosis of AMI was established according to diagnostic criteria: chest pain lasting for ≤3 hours, electrocardiographic (ECG) changes (ST elevation ≥ 2 mm in at least two leads) and elevation in serum creatine phosphokinase (CPK) and aspartate aminotransferase (AST). The control group consisted of 165 age/sex-matched healthy volunteers (123 men and 42 women). The design of this study was pre-approved by the institutional ethical committee board and informed consent was obtained from the patients and controls. Inclusion criteria were patients with a diagnosis of AMI with a normal lipid profile. Patients with diabetes mellitus, renal insufficiency, current and past smokers, those with hepatic disease or taking lipid lowering drugs or antioxidant vitamin supplements were excluded from the study. Normolipidemic status was judged by the following criteria: LDL-C ≤160 mg/dl, HDL ≥35 mg/dl, a total cholesterol (TC) <200 mg/dl, and a triglyceride (TG) level <150 mg/dl (NCEP, ATP-III, 2001). Ten milliliters of blood was collected after overnight fasting for a lipid profile. For ischemia-modified albumin (IscMA) analysis, 2 ml of blood was collected from the patients immediately after admission to the intensive care unit.

TC, TG and HDL-C were analyzed enzymatically using a kit obtained from Randox Laboratories, Crumlin, UK. LDL-C was determined from the values of the TC and HDL-C using the following formula:

$$\text{LDL-C} = \frac{\text{TC} - \text{TG} - \text{HDL-C}}{5}$$

Serum albumin was measured by the Bromocresol green binding method (Perry

and Doumas, 1979). Serum uric acid was determined by the method of Brown (1945) based on the development of a blue color (due to tungsten blue) when phosphotungstic acid is reduced by uric acid in alkaline medium. Serum total bilirubin was determined using the method of Jendrassik and Grof (1938). Glutathione peroxidase (GPx) activity was determined using the method of Paglia and Valentine (1967). Superoxide dismutase (SOD) enzyme activity was determined using a SOD assay kit, using a rate of inhibition of 2-(4-indophenyl)-(4-nitrophenol)-5-phenyltetrazolium chloride (INT) reduction method modified by Sun *et al* (1988). Catalase activity was measured spectrophotometrically as described by Beutler (1984). MDA levels were estimated by thiobarbituric acid (TBA) reaction (Bernheim *et al*, 1948). Conjugated diene (CD) levels were determined using the method of Recknagel and Glende (1984) with slight modification. Ceruloplasmin assay was done by the *p*-phenylene diamine method (Ravin, 1961). Ischemia-modified albumin (IscMA) concentration was determined by the addition of a known amount of cobalt (II) to a serum sample and measurement of the unbound cobalt (II) by the intensity of the colored complex formed after reacting with dithiothreitol (DTT) by colorimeter (Libby, 2003). Lipoprotein (a) levels were determined by the latex-enhanced turbidimetric method. Serum paraoxonase was estimated using a Zeptometrix Assay Kit obtained from Zeptometrix Corp, New York, based on the cleavage of phenyl acetate resulting in phenol formation. The rate of formation of phenol was measured by monitoring the increase in absorbance at 270 nm at 25ºC.

Estimation of ascorbic acid was carried out by the Roe and Kuether method (1943). CRP was determined using a high sensitivity enzyme immunoassay kit manufactured by Life Diagnostics. The principle of the assay was based on a solid phase enzyme-linked immunosorbent assay (Kumar and Sivakanesan, 2008). The plasma fibrinogen was determined using a kit obtained from TEClot Fib Kit 10, manufactured by TECO GmbH, Germany (Kumar and Sivakanesan, 2008).

Table 1
Anthropometric data regarding controls and patients (mean ± SD).

	Control (*n*=165)	AMI patients (*n*=165)	*p*-value (95%CI)
Age (years)	60.5 ± 3.4	61.8 ± 3.8	0.0037 (61.26- 62.33)
Range (years)	(48-69)	(48-69)	
Height (m)	1.63 ± 0.04	1.64 ± 0.59	0.2919 (1.55-1.72)
Weight (kg)	68.34 ± 3.97	72.01 ± 5.37	<0.01 (71.25-72.76)
BMI (kg/m^2)	25.40 ± 1.20	26.16 ± 1.45	<0.01 (25.95-26.36)
Waist circumference (cm)	93.70 ± 3.63	100.77 ± 6.06	<0.01 (99.91-101.62)
Hip circumference (cm)	100.01 ± 3.16	105.72 ± 5.23	<0.01 (104.82-106.45)
Waist-hip ratio	0.93 ± 0.01	0.95 ± 0.01	<0.001 (0.94-0.95)
Mid arm circumference (cm)	29.70 ± 1.47	30.63 ± 1.87	<0.01 (30.36-30.89)
Biceps skin fold thickness (mm)	6.95 ± 1.05	7.5 ± 1.38	<0.001 (7.30-7.69)
Triceps skin fold thickness (mm)	11.97 ± 1.27	12.89 ± 1.69	<0.001 (12.65-13.12)
Systolic blood pressure (mmHg)	121.06 ± 4.19	134.32 ± 11.65	<0.05 (132.67-135.96)
Diastolic blood pressure (mmHg)	79.90 ± 3.64	86.04 ± 4.25	<0.05 (85.44-86.63)

Table 2
Lipid profiles in patients and controls (mean ± SD).

Variables	Controls (*n*=165)	Patients (*n*=165)	*p*-value (95%CI)
Age	60.55 ± 3.98	61.84 ± 3.80	0.0037 (61.26-62.42)
Cholesterol (mg/dl)	168.58 ± 12.16	186.44 ± 13.95	<0.001 (184.31-188.56)
HDL-cholesterol (mg/dl)	50.51 ± 6.78	41.27 ± 4.62	<0.001 (40.56-41.97)
Triglycerides (mg/dl)	107.84 ± 11.51	128.96 ± 12.19	<0.001 (127.10-130.82)
LDL-cholesterol (mg/dl)	83.59 ± 11.95	119.37 ± 14.05	<0.001 (17.22-21.51)
TC: HDL-C	3.39 ± 0.36	4.57 ± 0.58	<0.001 (4.48-4.65)
LDL:HDL-C	1.90 ± 0.31	2.93 ± 0.51	<0.001 (2.85-3.00)
TG: HDL-C	2.17 ± 0.35	3.16 ± 0.49	0.3149 (3.086-3.234)

Table 3
Distribution of lipid ratios in patients and controls (mean ± SD).

Ratio	Controls (*n*=165)	Patients (*n*=165)
	TC/HDL-C	
2-3	2.90 ± 0.09 (*n*=28)	-
3-4	3.44 ± 0.25 (*n*=129)	3.70 ± 0.20 (*n*=31)
4-5	4.19 ± 0.22 (*n*=8)	4.53 ± 0.27 (*n*=90)
5-6	-	5.26 ± 0.23 (*n*=44)
	TG/HDL-C	
1-2	1.77 ± 0.13 (*n*=56)	-
2-3	2.38 ± 0.23 (*n*=109)	2.65 ± 0.27 (*n*=59)
3-4	-	3.42 ± 0.26 (*n*=99)
4-5	-	4.22 ± 0.19 (*n*=7)
	LDL-C/HDL-C	
1-2	1.71 ± 0.17 (*n*=106)	1.86 ± 0.15 (*n*=5)
2-3	2.23 ± 0.21(*n*=59)	2.57 ± 0.27 (*n*=81)
3-4	-	3.32 ± 0.21 (*n*=74)
4-5	-	4.11 ± 0.12 (*n*=5)

All chemicals of analytical grade were obtained from Sigma-Aldrich New Delhi, India.

RESULTS

Anthropometric parameters in the AMI patients and controls are shown in Table 1. The TC, TC/HDL-C, and TG levels were significantly higher in patients of both sexes compared with controls (Tables 2 and 3). LDL-C and LDL-C/HDL-C levels were higher in AMI patients than in controls (Table 3). The behavioral patterns and familial histories of cardiovascular disease are presented in Table 4. The distribution of risk factors and relative risk according to potential risk factors among cases and controls are presented in Table 5 and Table 6, respectively. The antioxidant and lipid peroxidation results are shown in Table 7. All antioxidants were significantly lower in patients than controls. The MDA and CD levels were higher in patients than controls. IscMA levels were higher in patients than controls (Table 7). Serum fibrinogen, ceruloplasmin, IscMA, and CRP levels were significantly higher and arylesterase activity was significantly lower in cases than controls (Table 8).

DICUSSION

CAD is a major cause of morbidity and mortality in developed and developing countries, including India (Reddy and Yusuf, 1998). Dyslipidemia is a major modifiable risk factor for CAD (Vasisht *et al*, 1990; Chopra *et al*, 1998; Malhotra *et al*, 2003).

CAD risk factors do not necessarily pre-

Table 4
Behavioral pattern in patients and controls.

		Control group	Study group
Hyperactive	Yes	39 (23.63)	68 (41.21)
	No	126 (76.36)	97 (58.78)
Triffle thinker[a]	Yes	30 (18.18)	99 (60.00)
	No	135 (81.81)	66 (40.00)
Irrelevant thinker	Yes	50 (30.30)	106 (64.24)
	No	115 (69.69)	59 (35.75)

Numbers in parentheses are percent unless otherwise mentioned.
[a]Triffle thinker: someone who worries about unnecessary small things.

Table 5
Distribution of risk factors among patients and controls.

	AMI cases (n=165)	Controls (n= 165)
Age (y)	61.84 ± 3.80	60.55 ± 3.98
BMI (kg/m^2)	26.16 ± 1.45	25.40 ± 1.20
Waist-to-hip ratio	0.95 ± 0.11	0.93 ± 0.08[a]
Alcohol intake (servings/d)	0.36 ± 0.68	0.15 ± 0.34[a]
Physical activity (MET-min/d)	56.23 ± 123.8	97.83 ± 174.8[a]
Current cigarette smokers (%)	14.45	3.6[b]
Current bidi[g] smokers (%)	23.67	12.31[c]
Family history of MI (%)	37.57	8.48[d]
Hypertension (%)	49.09	1.8[e]
Alcoholics (%)	47.87	20.60[f]

Values are in mean ± SD
[a,b,c,d,e,f]Significantly different from cases (t- test for matched data): [a,b,c] $p \leq 0.001$, [d,e] $p \leq 0.0001$, [f] $p \leq 0.003$
[g]bidi is a handrolled cigerette made of tobacco rolled in tendu or temburni leaves.

dict occurrence of AMI, since variation in risk factors is observed in South Asia due to varied dietary habits and life styles (Mishra *et al*, 2005). This finding prompted us to identify risk factors in the Indian population.

Anthropometric measurements in AMI patients revealed significant differences in waist : hip ratios and biceps skin fold thickness compared to controls. Heitman *et al* (2004) found the waist : hip ratio is a dominant, independent, predictive variable of CAD and CAD deaths in Australian men and women. Megnien *et al* (1999) found high hip circumference relative to weight and waist circumference were better predictors of a low incidence of CAD.

Among Indians, cardiovascular risk is high even when the prevalence of obesity is minimal (Megnien *et al*, 1999). In the present study the mean body mass index (BMI) and waist:hip ratio in the subjects were 26.56 and 0.96, respectively, showing a significantly higher BMI and weight : hip ratio in patients than controls. Therefore, the weight : hip ra-

Table 6
Relative risk for acute myocardial infarction by potential risk factors[a].

	No. of cases	No. of controls	Age- and sex-adjusted RR[e] (95% CI)[b]	Multivariate RR (95% CI)[c]
Cigarette smoking				
Never smoked	120	136	1.0	1.0
> 10 cigarettes/d	36	6	7.8 (4.9-13.5)	7.4 (4.3-15.2)
Bidi smoking[d]				
Never smoked	120	136	1.0	1.0
> 10 bidis/d	49	8	8.2 (5.2-14.2)	6.5 (3.9-12.9)
BMI (kg/m^2)				
20-24.9	30	51	1.0	1.0
≥ 25	135	114	2.7 (1.8-4.1)	2.9 (1.6-5.1)
Waist-to-hip ratio				
≤ 0.95	52	137	1.0	1.0
> 1.0	113	28	3.9 (2.1-6.3)	2.8 (1.6-5.7)
Family history of MI				
No	97	151	1.0	1.0
Yes	62	14	2.1 (1.6-2.7)	2.7 (1.8-3.8)
History of hypertension				
No	136	142	1.0	1.0
Yes	29	23	2.1 (1.7-3.2)	1.9 (1.4-2.9)
Education level				
Highest level of education	25	27	1.0	1.0
None	101	132	3.1 (1.3-5.1)	3.6 (1.0-6.2)
Type of family				
Split	20	64	1.0	1.0
Joint	145	101	4.5 (1.5-2.9)	3.9 (1.2-2.6)
Financial status				
Lower class	10	19	1.0	1.0
Middle class	119	131	3.4 (4.3-6.7)	2.8 (3.7-5.9)
Higher class	36	15	4.7 (4.9-7.2)	3.8 (3.1-4.7)
Exercise				
Non-exerciser	82	58	1.0	1.0
≥ 145 MET-min/d	83	107	0.76 (0.4-0.8)	0.68 (0.4-0.7)
Household income				
> 10,000 rupees/month	155	146	1.0	1.0
< 5,000 rupees/month	10	19	1.8 (1.2-2.7)	1.7 (1.0-3.1)
Hindu religion				
No	33	12	1.0	1.0
Yes	132	153	0.8 (0.6-1.1)	0.9 (0.7-1.3)

[a] MET, metabolic equivalent. Relative risk estimates were obtained by using conditional logistic regression analysis controlled for matching factors (age, sex, and hospital) and then additional potential risk factors.

[b] Also adjusted for hospital.

[c] Covariates controlled for in the multivariate model were as follows: age, sex, hospital, cigarette smoking [never, current (≤ 10 cigarettes/d, > 10 cigarettes/d)], bidi smoking [never, current (≤ 10 bidis/d, > 10 bidis/d)]; BMI, in kg/m^2 (20-24.9,≥ 25); waist-to-hip ratio (≤ 0.95, > 1.0), physical exercise (none, < 145 MET-min/d, ≥ 145 MET-min/d), history of hypertension (no, yes), history of diabetes (no, yes), history of high cholesterol (no, yes), family history of CAD (no, yes), education (none, primary school, middle, secondary, higher secondary, college, graduate or professional), household income (< 5000, 5000-10,000, 10,000-15,000, > 10,000 rupees/month), and Hindu religion (no, yes).

[d] Bidis are small hand-rolled cigarettes made of tobacco wrapped in tendu or temburni leaves.

[e] RR is relative risk.

Table 7
Antioxidant status and lipid peroxidation in controls and patients (mean ± SD).

	Control (*n*=165)	AMI patients (*n*=165)	*p*-value (95%CI)
Serum albumin (mg/dl)	4.4 ± 0.3	4.2 ± 0.3	<0.001 (4.17-4.28)
Serum uric acid (mg/dl)	5.8 ± 1.2	4.3 ± 0.9	<0.01 (4.18-4.45)
Serum ascorbic acid (mg/dl)	5.3 ± 1.2	2.8 ± 0.7	<0.0001 (2.70-2.89)
Serum total bilirubin (mg/dl)	0.8 ± 0.2	0.7 ± 0.2	<0.001 (0.62-0.69)
Serum superoxide dismutase (U/gHb)	1,826.5 ± 31.9	813.9 ± 208.9	<0.02 (784.42-843.37)
Serum glutathione peroxidase(U/gHb)	61.3 ± 3.9	42.6 ± 6.3	<0.001 (41.71-43.48)
Serum catalase (k/gHb)	256.2 ± 26.7	193.1 ± 35.9	<0.001 (188.03-198.16)
Serum lipoprotein (a) (mg/dl)	3.0 ± 1.1	10.9 ± 2.2	<0.0001 (10.58-11.21)
Serum malondialdehyde (nmol/l)	5.7 ± 1.0	14.8 ± 1.7	<0.02 (11.55-15.06)
Serum conjugated dienes (μmol/l)	31.0 ± 2.7	48.3 ± 5.5	<0.001 (47.44-49.11)

Table 8
Other biochemical parameters in controls and patients (mean ± SD).

	Control (*n*=165)	AMI patients (*n*=165)	*p*-value (95%CI)
Plasma fibrinogen (mg/dl)	237.5 ± 17.4	357.8 ± 23.2	<0.0001 (354.52-361.07
Serum ceruloplasmin (mg/dl)	20.4 ± 2.3	51.5 ± 2.4	<0.0001 (51.16-51.83)
Serum arylesterase activity (kU/l)	98.4 ± 6.2	69.7 ± 10.0	<0.0001 (68.28-71.11)
Serum ischemia modified albumin (U/ml)	81.9 ± 3.9	97.5 ± 11.7	<0.001 (95.84-99.15)
Serum C-reactive protein (mg/dl)	1.1 ± 0.3	3.0 ± 1.1	<0.0001 (2.84-3.15)

tio is a better predictor of CAD than BMI. This is a good, non-invasive tool for indentifying risk for AMI.

The mean total cholesterol level in AMI patients (186.44 ± 13.95 mg/dl) was significantly (p<0.001) higher than in controls (168.58 ± 12.16 mg/dl). The mean HDL-C level in AMI patients was significantly lower (p<0.001) than the controls. The mean TG level in AMI patients (129 mg/dl) was significantly higher than in controls (107.8 mg/dl). The mean LDL-C level in patients (119.4 mg/dl) was significantly higher than in controls (83.6 mg/dl). TC/HDL-C ratio in AMI patients (4.6) was significantly (p<0.001) higher than controls (3.4).

Previous lipid profile studies conducted in AMI patients found higher TC, TG, LDL-C and lower HDL-C levels in patients than controls (Mishra *et al*, 2001; Das *et al*, 2002; Goswami *et al*, 2003; Kharb *et al*, 2003; Malhotra *et al*, 2003; Burman *et al*, 2004; Rajashekhar *et al*, 2004; Sivaraman *et al*, 2004; Rani *et al*, 2005; Shinde *et al*, 2005; Yadhav *et al*, 2006; Patil *et al*, 2007). Higher TC/HDL-C, LDL-C/HDL-C and TG/HDL-C ratios were seen in patients than controls.

The present study reveals the importance of assessing lipid ratios, even in normolipidemic subjects, since it is an atherogenic factor in the development of myocardial infarction and other coronary complications. The practice of computing the ratio should be implemented in a normal health check-up package.

It appears than CAD is not always associated with elevated TC levels. The major

concern with this observation is that subjects with a normal total cholesterol level can still develop CAD, therefore, analysis of other risk factors is important assess risk. Our results show that AMI patients have significantly higher TC levels than those without CAD even though the values are in the normal range.

Endogenous antioxidants were lower in the AMI patients than the controls. The enzyme antioxidants were also significantly lower in patients than controls.

Studies conducted in AMI patients found significantly lower albumin ($p<0.0001$) and bilirubin ($p<0.0001$) levels (Olusi *et al*, 1999; Djousse *et al* 2003), lower uric acid levels (Brand *et al*, 1985; Jing and Alderman, 2000; Niskanen *et al*, 2004) and ascorbic acid levels (Nyyossen *et al*, 1997; Das *et al*, 2002; Kurl *et al*, 2002; Bhakuni *et al*, 2005a) in AMI patients than controls.

The above studies found the risk for AMI was higher in those with lower endogenous antioxidant levels due to enhanced utilization during oxidative stress in patients. Although, uric acid is a well established antioxidant, at times it can act as a pro-oxidant, which may increase the risk of AMI. Aulinskas *et al* (1983) established the role of ascorbic acid as an up regulator of LDL-C receptors, facilitating the clearance of LDL-C. The low levels of ascorbic acid in AMI patients in the present study may be due to enhanced utilization of ascorbic acid during oxidative stress in patients.

The enzymatic antioxidants superoxide dismutase, catalase and glutathione peroxidase were lower in AMI patients than controls. The findings of the present study agree with earlier studies (Das *et al*, 2002; Rajasekhar *et al*, 2004; Senthil *et al*, 2004; Bhakuni *et al*, 2005b; Gupta and Chari, 2006; Patil *et al*, 2007) which found lower activities of superoxide dismutase, catalase and glutathione peroxidase. Other studies (El-Badry *et al*, 1995; Kharb, 2003; Rajasekhar *et al*, 2004; Senthil *et al*, 2004; Shinde *et al*, 2005; Gupta and Chari, 2006) also reported lower glutathione peroxidase activity in patients than controls. These findings support the hypothesis of decreased antioxidant levels due to oxidative insult in AMI patients. The low levels of both endogenous and enzyme antioxidants in the circulation may be due to increased utilization to scavenge toxic lipid peroxides.

The mean MDA and CD levels in AMI patients were higher than controls. Other studies (Burman *et al*, 2004; Rajasekhar *et al*, 2004) also observed higher lipoprotein (a) levels in AMI patients, however Nascetti *et al* (1996) observed no changes in lipoprotein (a) levels in CAD and concluded lipoprotein (a) is not an independent risk factor in CAD patients. Numerous studies (Das *et al*, 2002; Kharb, 2003; Senthil *et al*, 2004; Shinde *et al*, 2005; Bhakuni *et al*, 2005b; Gupta and Chari, 2006) reported higher levels of MDA in myocardial infarct patients.

The levels of ceruloplasmin, CRP, fibrinogen, and IscMA, were higher and arylesterase activity were lower in AMI patients than controls. Several studies (El-Badry *et al*, 1995; Giurgie *et al*, 2005; Awadallah *et al*, 2006) found significantly higher ($p<0.001$) levels of ceruloplasmin and other studies (Berton *et al*, 2003; Bhagat *et al*, 2003; Sivaraman *et al*, 2004; Boncler *et al*, 2006; Kulsoom and Nazrul, 2006) found higher levels of C-reactive protein in AMI patients. Shukla (2006) stated elevated levels of ceruloplasmin were a risk factor for AMI patients. The reactive oxygen species disrupts copper binding to ceruloplasmin, thus impairing its antioxidant property and further promoting oxidative pathology. Studies conducted regarding plasma fibrinogen levels in AMI patients (Bar-Or *et al*, 1999; Auxter, 2003; Harkut *et al*, 2004; Sivaraman

et al, 2004; Coppola *et al*, 2005; Chawla *et al*, 2006; Beg *et al*, 2007) reported an increase in plasma fibrinogen levels, as seen in the present study. Studies regarding arylesterase activity in AMI patients (Aviram *et al*, 1999; Ayub *et al*, 1999; Richard *et al*, 2000; Azizi *et al*, 2002; Jarvik *et al*, 2002; Sarkar and Madhusudhan, 2006; Singh *et al*, 2007) found lower activity similar to the current study. Elevated CRP levels in patients with unstable angina and AMI may induce production by monocytes of the tissue factor which initiates the coagulation process. CRP along with fibrinogen act as chemotactic factors. Fibrinogen is responsible for the adhesion of macrophages to the endothelial surface for migration into the intima. Elevated C-reactive protein levels have been found to be related to the occurrence of cardiovascular complications, such as sudden cardiac death and AMI (Pepys and Hirschfield, 2003).

We conclude that apart from the lipid profile, other factors may increase the risk for future myocardial events, and may need to be monitored. We recommend increasing dietary antioxidant intake in persons who have known risk factors to reduce the risk for AMI. It may also be important to check inflammatory markers, such as CRP and IscMA at regular periods beginning during the early forties as a cost effective method of singling out subjects who need to be monitored to avoid AMI.

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