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Original Article

PRETREATMENT WITH *NELUMBO NUCIFERA LEAF* EXTRACT AMELIORATES ON LIPIDS, LIPOPROTEINS, MARKER ENZYMES OF LIPID METABOLISM AND ECG PATTERN AGAINST ISOPROTERENOL INDUCED CARDIOTOXICITY

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ABSTRACT

The present study is undertaken to evaluate the effect of *Nelumbo nucifera* leaf extract (NNE) on the levels of lipids, lipoproteins, lipid metabolic enzymes and ECG pattern in isoproterenol (ISO) induced myocardial infarction (MI) in adult male Wister rats.

The effect of ISO (85 mg/kg) injected by subcutaneous at an interval of 24 hours for two days. Rats were pretreated orally for 21 days with NNE 400 mg/kg prior to ISO-induced myocardial infarction. Rats induced with ISO showed a significant increase in total, ester and free cholesterol levels in serum and heart tissue TG, FFA, PL, LDL, VLDL and significant decrease in HDL, LCAT, LPL when compared to normal control rats. Pretreatment with NNE to ISO-induced rats showed a significant decrease in the levels of lipids, LDL, VLDL and significant increase in HDL, LCAT, and LPL in serum and heart tissue when compared to ISO-induced rats.

Our results indicate that NNE possesses antihyperlipidaemic effect in rats with ISO-induced myocardial infarction. However, the exact underlying mechanism is yet to be investigated and examination of the efficacy of the bioactive constituents of the NNE on MI is desirable.

Keywords: Isoproterenol, Lipoproteins, Myocardial infarction, Nelumbo nucifera.

INTRODUCTION

In mammals, catecholamine cause deleterious effect on heart, which is associated with structural, functional and biochemical alterations. Isoproterenol (ISO), a synthetic catecholamine and α-adrenergic agonist, causes necrosis of rat heart muscle. ISO-induced myocardial infarction (MI) serves as a well standardized model to study the beneficial property of numerous drugs and cardiac function. Cardiac function depends on adequate delivery of oxygen and oxidizable substrate to generate sufficient amount of ATP to meet energy demand. Myocardial ischemia results in alterations of cardiac function and ultra structure, which leads to interruption of the mitochondria beside with the inactivation of the enzymes concerned with the energy metabolism of myocardium [1]. Nowadays research has been focused on medicinal plants and food products derived from medicinal plants that have been found to have certain preventive measures in the treatment of cardiovascular disease (CVD). Nelumbo nucifera has been reported to treat obesity, hepatotoxicity, arrhythmia and hyperlipidemia. Traditionally, leaves are used to treat diarrhea fever and inflammatory skin conditions. Young leaves used to treat rectal prolapsed, raktapitta, or bleeding disorders; alleviate thirst and inflammations and to promote strength, virility, and intellect [2].

In our previous communication, we have reported that *Nelumbo nucifera* leaf extract (NNE) possess cardioprotective effect by maintaining the activities of cardiac marker enzymes and other biochemical parameters, also reported that NNE posses free radical scavenging and antioxidant properties in ISO-induced rats [3,4]. Based on the previous reports, this report communicates the preventive role of NNE on mitochondrial lipid peroxides, TCA cycle and Myocardial infarction is the acute condition of necrosis of the myocardium that occurs as a result of imbalance between coronary blood supply and myocardial demand. Particularly the lack of blood supply is caused by closure of the artery (coronary artery) that supplies that particular part of the heart muscle with blood. The artery is closed or narrowed by a plaque that usually occurs in a coronary artery by atherosclerosis. Serum cholesterol and low density lipoprotein (LDL) cholesterol has consistently been shown to be a significant risk factor for CHD and other major CVD [5]. A high level of blood cholesterol is a major risk factor for CHD and also a secondary risk factor for stroke. Higher levels of LDL can slowly build up in the inner walls of the arteries that feed the heart and brain and narrow those arteries. An unhealthy cholesterol balance can lead to deposition of fat in the arteries called plaque. Plaque narrows the arteries and decreases blood flow to the heart, which can cause a heart attack [6].

Isoproterenol, a synthetic catecholamine and β-adrenergic agonist, induced rats have used as a model for several cardiac dysfunctions [7]. The deleterious effects of ISO on heart is well known, and also associated not only with functional alterations, but also with numerous morphological and biochemical changes [8]. Ideally, animal models of human pathological conditions are mimic the cellular and physiological processes responsible for the pathological conditions in man [9] reported that the administration of ISO to rats produces "infarct-like" myocardial necrosis in the absence of significant coronary artery lesions. This observation led to the "relative hypoxia" was responsible for the observed cardiac necrosis [10]. Increased cardiac inotropy and chronotropy after adrenergic stimulation caused a relative imbalance between myocardial oxygen demand and blood flow, such that demand and supply [11].

Biologically active plant chemicals other than traditional nutrients that have a beneficial effect on human health have been termed “phytochemicals” [12]. Phytochemicals are naturally occurring, non-nutritive chemicals. They appear to work alone and in combination, and perhaps in conjunction, with vitamins and other nutrients in food to prevent, halt, or lessen disease. For example, onions and corn are rich in phytochemicals [13]. Free radical formation of ROS and subsequent oxidative stress have been correlated to many human disorders including those of the kidney, eye, lung, liver, nervous system, heart and cardiovascular system [14]. Therefore, make sure you eat a wide variety of fruits and herbs to get all of the possible health benefits from phytochemicals. Therefore, foods in our diet that can aid in prevention of these diseases are of major interest to both the scientific community and the general public.

Traditionally, leaves are used to treat diarrhea fever and inflammatory skin conditions; young leaves are taken with sugar to treat rectal prolapsed; useful in many varieties of raktapitta, or bleeding disorders; alleviate thirst and inflammations and to

promote strength, virility, and intellect. NNE has been reported to treat obesity, hepatotoxicity, arrhythmia and hyperlipidemia. *Nelumbo nucifera* seeds are commonly used as folk remedy in the treatment of tissue inflammation, cancer, antiemetic, given to children as diuretic and refrigerant. It is also used as a cooling medicine for skin diseases, leprosy and considered as antidote to poison. This study was undertaken to assess the efficacy of NNE in the treatment of MI.

MATERIALS AND METHODS

Plant Material

Leaves of *Nelumbo nucifera* were purchased from local market, Chennai, Tamil Nadu, India, and were authenticated by National Institute of Herbal Science Plant Anatomy Research Centre, West Tambaram, Chennai, Tamil Nadu, India. Authentication No: PARC/2010/596.

Preparation of Alcoholic Extract (NNE)

Alcoholic extract of the dried leaves of *Nelumbo nucifera* was prepared coarsely powdered and 1kg of this powdered plant material was extracted with the help of the soxhlet apparatus using methanol as a solvent. The solvent from the methanolic extract was removed under vacuum distillation; dried material (brown colored) yield 11.25% w/w with respect to dry was kept in a desiccators [3]. This methanolic extract was dissolved in distilled water for further experiments.

Chemicals

(±) Isoproterenol hydrochloride, reduced nicotinamide adenine dinucleotide (NADH), oxaloacetate, bovine serum albumin (BSA), N-phenyl-p-phenylenediamine, p-nitrophenyl-β-D-glucuronide, β-nitrophenyl-β-D-N-acetyl glucosaminide, sodium dodecyl sulphate (SDS) and α-N-benzoyl-DL- -p-nitroanilide hydrochloride (BAPNA), and phosphate buffered saline (PBS) were purchased from Sigma Chemical Company, St. Louis, MO, USA. Methanol was purchased from Anilax chemicals, USA. All other chemicals used for the experiment is of analytical grade.

Animals

Adult male albino rats of Wistar strain weighing 150-200g were purchased from Venkateswara Enterprises, Bangalore, Karnataka, India. The experiment was carried out according to the guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), New Delhi, India and approved by the Animal Ethical Committee (IAEC NO : P.Cog-1/06). They were housed in polypropylene cages (47x34x20 cm) lined with husk, renewed every 24 h under a 12:12 h light/dark cycle at around 22°C and had free access to tap water and food. The rats were fed on a standard pellet diet (Pranav Agro Industries Ltd., Maharashtra, India). The pellet diet consisted of 22.02% crude protein, 4.25% crude oil, 3.02% crude fibre, 7.5% ash, 1.38% sand silica, 0.8% calcium, 0.6% phosphorus, 2.46% glucose, 1.8% vitamins and 56.17% nitrogen free extract (carbohydrates). The diet provided metabolisable energy of 3, 600 kcal.

Experimental Design

In this experiment, a total of 24 male albino Wistar rats were randomly divided into four groups of six rats each. Isoproternol (85 mg/kg) was dissolved in normal saline and injected subcutaneously to rats at an interval of 24 hours for 2 days [3]. Group I: Normal control rats, Group II: Rats were orally treated with NNE 400 mg/kg alone daily for 21 days using an intra gastric tube, Group III: Rats were subcutaneously injected with ISO alone (85 mg/kg) at an interval of 24 h for 2 days (on 20th and 21st days), Group IV: Rats were pretreated with NNE 400mg/kg daily for 21 days and then subcutaneously injected with ISO (85 mg/kg) for 2 days. At the end of the experimental period, after 12 h of second ISO injection, (i.e. on 16th day) all the rats were anesthetized and then sacrificed by cervical decapitation. Blood was collected and subsequently plasma and serum were separated by centrifugation. The heart tissue was excised immediately from the animals, washed off blood with ice-chilled physiological saline and stored for further biochemical estimations. A known weight of the heart tissue was homogenized in 5 ml of 0.1 M Tris–HCl (pH-7.4) buffer solution. The homogenate was centrifuged at 3000 rpm for 5 min and the supernatant was used for the estimation of various biochemical parameters.

Biochemical Estimations

Lipids were extracted by the method [15]. Cholesterol was estimated by the method [16]. The ester and free cholesterol levels were estimated by the method [17]. Triglycerides levels were estimated by the method [18]. Free fatty acids levels were estimated by the method [19]. Phospholipids levels were estimated by the method [20]. The phosphorus content was estimated by the method [21]. High-density lipoprotein (HDL) cholesterol was estimated using a commercial kit purchased from Qualigens Diagnostics (72201) (Mumbai, India). Very low-density lipoprotein (VLDL) and low-density lipoprotein (LDL) fractions were calculated as VLDL = triglycerides/5 and LDL = total cholesterol − (HDL cholesterol + VLDL cholesterol), respectively. LCAT was assayed by the method [22] with the modifications. The lipoprotein lipase was assayed by method [23].

Electrocardiography

Standard ECG was recorded by Students Physiograph (INCO, India) under thiopentone anaesthesia (30 mg/kg body weight i.p.,) needle electrodes were placed subcutaneously in the extended limbs of the supine animals. Standard lead II was used to record ECG at a paper speed of 100 mm/sec and sensitivity set at 1.

Statistical Analysis

Statistical analysis was done by one-way analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT). Using SPSS Software package version 9.05. The results were expressed as + SD from eight rats in each group, and mean P values <0.05 were considered as significant.

RESULTS

Effect of NNE on the levels of lipids

The levels of total, ester and free cholesterol in serum and the heart in normal and ISO-induced rats are shown in Table 1. Rats induced with ISO showed a significant increase in total, ester and free cholesterol levels when compared to normal control rats. Pretreatment with NNE to ISO-induced rats showed a significant decrease in the levels of total, ester and free cholesterol in serum and the heart when compared to ISO-alone induced rats.

Effect of NNE on the levels of lipoproteins

Tables 2 & 3 present the levels of triglycerides (TG), free fatty acids (FFA) and phospholipids (PL) in serum and the heart in normal and ISO-induced rats. ISO-induced rats showed a significant increase in the levels of TG, FFA and PL in serum with a significant decrease in PL in the heart when compared to normal control rats. Pretreatment with NNE to ISO-induced rats significantly minimized the alterations in these parameters when compared to ISO-alone induced rats. Table 4 shows the levels of high density lipoproteins (HDL), low density lipoprotein (LDL), and very low density lipoprotein (VLDL) in serum in normal and ISO-induced rats. Rats treated with ISO showed a significant increase in LDL and VLDL levels, with a significant decrease in HDL levels when compared to normal rats. Pretreatment with NNE to ISO-induced rats showed a significant decrease in the levels of LDL and VLDL with subsequent increase in the levels of HDL cholesterol.

Effect of NNE on the levels of lipid metabolic enzymes

Table 5 shows the activities of lecithin cholesterol acyl transferase (LCAT) and lipoprotein lipase (LPL) in plasma of normal and ISO-induced rats. Rats induced with ISO, showed a significant decrease in the activities of both LCAT and LPL in plasma. Pretreatment with *NNE* to ISO-induced rats showed a significant increased the activities of these enzymes in plasma when compared to ISO-alone induced rats.

Table 1: Effect of *Nelumbo nucifera* leaf extract (NNE) on total, ester and free cholesterol in serum and the heart in normal and Isoproterenol (ISO)-induced myocardial infarction (MI) in rats.

Groups	Normal control	Normal + NNE (400 mg/kg)	ISO (85 mg/kg) control	NNE (400 mg/kg) + ISO
Serum (mg/dL)				
Total Cholesterol	92.5 ± 6.14[a]	90.4 ± 7.13[a]	162.1 ± 10.1[b]	105.3 ± 5.55[c]
Ester Cholesterol	60.1 ± 3.11[a]	58.4 ± 2.52[a]	90.3 ± 5.08[b]	72.1 ± 4.28[c]
Free Cholesterol	33.6 ± 3.61[a]	31.7 ± 2.70[a]	53.7 ± 4.05[b]	34.7 ± 2.66[c]
Heart (mg/g wet tissue)				
Total Cholesterol	8.53 ± 0.39[a]	8.14 ± 0.33[a]	13.41 ± 0.88[b]	10.0 ± 0.61[c]
Ester Cholesterol	5.19 ± 0.31[a]	5.05 ± 0.30[a]	8.42 ± 0.38[b]	6.54 ± 0.42[c]
Free Cholesterol	3.34 ± 0.25[a]	3.14 ± 0.28[a]	5.15 ± 0.37[b]	3.65 ± 0.30[c]

Each value is mean ± S.D. for 6 rats in each group. Values not sharing a common superscript (a, b and c) differ significantly with each other (P<0.05, DMRT).

Table 2: Effect of *Nelumbo nucifera* leaf extract (NNE) on serum triglycerides (TG), free fatty acids (FFA) and phospholipids (PL) in normal and Isoproterenol (ISO)-induced myocardial infarction (MI) in rats.

Groups	TG (mg/dL)	FFA (mg/dL)	PL (mg/dL)
Normal control rats	46.5 ± 3.65[a]	29.6 ± 1.92[a]	69.6 ± 3.02[a]
Normal rats + NNE (400 mg/kg)	44.3 ± 3.07[a]	28.1 ± 1.44[a]	68.7 ± 3.49[a]
ISO control rats	71.9 ± 5.39[b]	49.2 ± 3.63[b]	91.5 ± 6.75[b]
NNE (400 mg/kg) + ISO	52.4 ± 2.93[c]	33.76 ± 2.05[c]	74.5 ± 4.08[c]

Each value is mean ± S.D. for 6 rats in each group. Values not sharing a common superscript (a, b and c) differ significantly with each other (P<0.05, DMRT).

Table 3: Effect of *Nelumbo nucifera* leaf extract (NNE) on the heart triglycerides (TG), free fatty acids (FFA) and phospholipids (PL) in normal and Isoproterenol (ISO)-induced myocardial infarction (MI) in rats.

Groups	TG (mg/g wet tissue)	FFA (mg/g wet tissue)	PL (mg/g wet tissue)
Normal control rats	4.19 ± 0.30[a]	0.319 ± 0.02[a]	32.6 ± 2.34[a]
Normal rats + NNE (400 mg/kg)	4.07 ± 0.23[a]	0.327 ± 0.02[a]	32.4 ± 1.18[a]
ISO control rats	6.79 ± 0.41[b]	0.625 ± 0.04[b]	19.5 ± 1.54[b]
NNE (400 mg/kg) + ISO	4.76 ± 0.23[c]	0.381 ± 0.03[c]	27.3 ± 1.83[c]

Each value is mean ± S.D. for 6 rats in each group. Values not sharing a common superscript (a, b and c) differ significantly with each other (P<0.05, DMRT).

Table4: Effect of *Nelumbo nucifera* leaf extract (NNE) on serum low density lipoprotein (LDL), very low density lipoprotein (VLDL) and high density lipoprotein (HDL) in normal and Isoproterenol (ISO)-induced myocardial infarction (MI) in rats.

Groups	LDL (mg/dL)	HDL (mg/dL)	VLDL (mg/dL)
Normal control rats	60.3 ± 4.13[a]	24.9 ± 1.16[a]	10.1 ± 0.43[a]
Normal rats + NNE (400 mg/kg)	59.4 ± 3.27[a]	25.4 ± 1.72[a]	10.4 ± 0.52[a]
ISO control rats	105.4± 7.76[b]	15.5 ± 0.62[b]	17.6 ± 0.74[b]
NNE (400 mg/kg) + ISO	70.6 ± 5.42[c]	22.1 ± 0.97[c]	12.4 ± 0.67[c]

Each value is mean ± S.D. for 6 rats in each group. Values not sharing a common superscript (a, b and c) differ significantly with each other (P<0.05, DMRT).

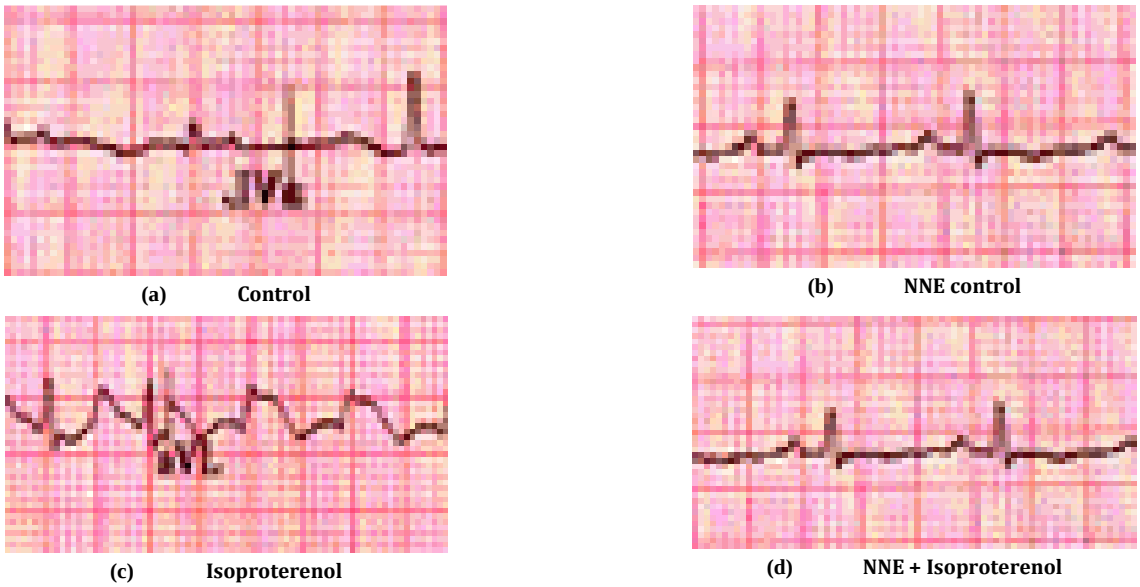
Table 5: Effect of *Nelumbo nucifera* leaf extract (NNE) on the activities of lecithin cholesterol acyl transferase (LCAT)) and lipoprotein lipase (LPL) in the plasma of normal and Isoproterenol (ISO)-induced myocardial infarction (MI) in rats.

Groups	LCAT (mmoles of cholesterol esterified/h/ml plasma)	LPL (mmoles of glycerol liberated/h/ml plasma)
Normal control	42.1 ± 2.77[a]	62.4 ± 3.21[a]
Normal rats + NNE (400 mg/kg)	43.6 ± 2.25[a]	63.5 ± 4.15[a]
ISO control	16.5 ± 1.92[b]	35.4 ± 2.44[b]
NNE (400 mg/kg) + ISO	34.3 ± 2.06[c]	53.1 ± 3.74[c]

Each value is mean ± S.D. for 6 rats in each group. Values not sharing a common superscript (a, b and c) differ significantly with each other (P<0.05, DMRT).

Effect of NNE on ECG

Fig. 1 (a) shows a near normal ECG pattern with a normal elevation in ST segment. Fig. 1 (b) Nelumbo nucifera leaf extract pretreated rats exhibited a near normal ECG pattern with a slight elevation in ST segment. Fig. 1 (c) represents transmural MI (Q wave development) or infarct expansion (recurrent ST elevation or depression, and pseudo-normalization of inverted T waves), persistent ST segment elevation. Fig. 1 (d) shows NNE attenuated ST segment and fewer abnormal Q waves.



(a) Control **(b) NNE control**

(c) Isoproterenol **(d) NNE + Isoproterenol**

Fig. 1: Effect of Nelumbo nucifera leaf extract (NNE) on the ECG pattern of control and experimental groups.

DISCUSSION

Lipid profile is generally considered as a reflection of the tissue metabolism and the permeability of cell membrane to various ions, which in turn depends on lipid composition [24]. Maintenance of cholesterol homeostasis is one of the very important processes in the prevention of CVD. Unregulated accumulation of cholesterol in tissues leads to atherogenesis and hypercholesterolaemia, which is an important risk factor for the development of CVD. Hyperlipidaemia has been implicated in MI, which is the leading cause of death among world population. In the present study, rats intoxicated with ISO, showed increase in the levels of total cholesterol, TG, FFA, in serum and heart and decreased level of phospholipids (PL) in heart. ISO induced elevation in cholesterol levels could be due to increase in biosynthesis and decrease in its utilization. ISO induces free radical formation, which may cause cholesterol accumulation in tissues by increasing cholesterol biosynthesis and by decreasing cholesterol ester hydrolysis and by reducing cholesterol efflux [25]. Increased levels of cholesterol leads to increased membrane fluidity, regulates the membrane permeability alters internal viscosity and also the internal chemical composition. Hypertriglyceridemia is one of the risk factors for the development of MI. The significant increase in serum and the heart TG in ISO-induced rats might be due to decrease in the activity of lipoprotein lipase (LPL), resulting in the decreased uptake of TG from the circulation. Hypertriglyceridaemia and increased levels of cholesterol in plasma might be responsible for altered cardiovascular functions, which are often reported in ISO-induced MI.

Cell membranes are rich sources of PL, which upon and degradation results in membrane dysfunction leading to cell injury. These PL are important for the maintenance of cellular integrity, microviscosity and survival. The altered levels of PL might be due to enhanced membrane degradation and the increased peroxidation of membrane PL and release FFA by the action of phospholipase A2 [26]. Ca2+ increases the activity of phospholipase A2. The increased levels of FFA in ISO-induced rats might be due to the indirect effect of Ca2+. The higher levels of FFA in serum and the heart in ISO-induced rats might be due to increased lipolysis [3,4]. The increase in FFA levels can increase the synthesis of other major lipids and activate NADPH or NADH dependent microsomal peroxidation [27]. In this study, we have observed an increase in the levels of FFA in serum and the heart and PL in serum with subsequent decrease in PL levels in the heart.

Nelumbo nucifera leaf extract pretreatment to rats induced with ISO, showed a significant decrease in the levels of cholesterol, TG, FFA in serum and heart and PLs in serum and significantly increased the levels of PLs in the heart of ISO-induced rats. Many of the active constituents present in the NNE posses lipid lowering property. These lipid lowering property along with fee radical scavenging and antioxidant properties could be responsible for its positive modulation of lipid levels in ISO-induced rats. Lipoproteins are independent risk factor for the development of CVD. An inverse relationship exists between HDL cholesterol levels and body cholesterol. HDL inhibits the uptake of LDL by the arterial wall and facilitates the transport of cholesterol from peripheral tissue to the liver, where it is catabolised and excreted from the body [28]. Lipid peroxides plays an important role in lipoprotein modification, which makes them susceptible to atherosclerosis, which could be the reason for acute MI mediated cardiotoxicity by ISO [29].

High levels of LDL cholesterol have a positive correlation with MI, whereas high levels of HDL cholesterol have negative correlation [30]. An increase in serum LDL and VLDL fractions, along with a decrease in HDL cholesterol, were observed in ISO-treated rats. These changes could be due to enhanced lipid biosynthesis by cardiac cyclic AMP [31]. Further hypertriglyceridemia and hypercholesterolemia were associated with oxidative modification of LDL, protein glycation, glucose auto oxidation, thus leading to excess production of lipid peroxidation products, which may cause elevation of oxidative stress in myocardial injury. oxidatively modified LDL rather than unmodified LDL is responsible for atherogenesis. Oxidized LDL promotes the production of several cytokines, immune cell chemoattractant proteins and growth factors. In addition, they increase the platelet aggregation, which aggravates the lesion and cause arterial wall thickening [32]. Pretreatment with NNE to ISO-induced rats minimized the alterations in serum lipoprotein levels by increasing HDL and decreasing LDL and VLDL-cholesterol levels. Similar findings were reported earlier in ISO-induced rats [3, 4]. Pretreatment with NNE positively altered the levels of lipoporteins in serum of ISO-induced rats. Decreased levels of cholesterol by NNE treatment might be associated to the decreased levels of lipoproteins. The factors causing MI involving a multifarious array of circulating blood proteins, lipoproteins and cells, and their interaction with the cells and matrix proteins of the arterial wall. Lecithin cholesterol acyltransferase (LCAT) is a HDL associated enzyme, which plays a crucial role in the extracellular cholesterol metabolism and reverse cholesterol transport. LCAT catalyzes the sterification of cholesterol with FFAs along with LPL that is responsible for HDL synthesis. Decreased activity of LCAT in ISO-induced rats responsible to promotes the free cholesterol accumulation in cell membranes.

Further, the lowered HDL concentration can be attributed to the decreased LPL and LCAT activities in plasma [37].

Lipoprotein lipase (LPL) is produced mainly by the adipose tissues, heart, and muscles and to some extent by macrophages. LPL hydrolyses the circulating TG rich lipoproteins such as VLDL and chylomicrons. Decrease in the activity of LPL results in the accumulation of VLDL in circulation. Decreased LPL activity leads to increased TG and decreased HDL levels, which are risk factors for the development of atherosclerosis [28]. Increased oxidative stress causing decreased LPL activity was implicated in the disturbance of lipid metabolism. Because ROS not only damages or changes the function of proteins but also act as subcellular messengers to influence the gene expression, it is reasonable to assume that the change in redox state accounts for the change of LPL activity.

We have observed decreased activities of lecithin cholesterol acyl transferase (LCAT) and LPL in plasma of ISO-induced rats. NNE pretreatment significantly increased the activities of LCAT and LPL in plasma of ISO-induced rats. The increased activities of LCAT and LPL may contribute in the regulation of circulatory lipid levels. The lipid lowering ability of NNE related to the presence of flavonoids and alkaloids, which could be due to inhibition of cholesterol biosynthesis. These properties might also be due to its antioxidant property.

Nelumbo nucifera leaf extract pretreated rats exhibited a near normal ECG pattern with a slight elevation in ST segment. Cardioprotective derivatives may be responsible for the maintenance of near normal ECG pattern might be attributed to the protective effect of NNE in preventing free radical mediated myocardial damage and thereby eliminating the acute fatal complications by protecting the membrane damage against ISO-induced infarction. NNE pretreatment also shows the inhibition of necrosis and reduced inflammation in ISO induced rats. The free radical scavenging, antioxidant, lipid lowering and membrane stabilizing properties of NNE could responsible for these effects on histology of the myocardium.

CONCLUSION

The biochemical findings of our present study indicate that Nelumbo nucifera pretreatment significantly decreased the levels of lipids in ISO-induced MI in rats. This could be due to cholesterol lowering effect of Nelumbo nucifera by inhibiting the activity of HMG-CoA reductase. Nelumbo nucifera also exhibits cardioprotective effect in ISO-induced MI. Thus, Nelumbo nucifera protects the myocardium against the accumulation of lipids in ISO-induced MI in rats.

Conflict of interest statement

We declare that we have no conflict of interest.

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