

Short Research Article

***PREMNA INTEGRIFOLIA* L. ON ENZYMATIC BIOMARKERS IN ATHEROSCLEROSIS**

Abstract

Premna integrifolia L. belongs to family Verbenaceae and it is believed to prevent cardiovascular disease as per Ayurveda. In order to evaluate the cardiac biomarkers and treatment efficacy of hydroalcoholic extract (HAE) of root bark in atherosclerosis. Sixty Wistar rats were divided into six groups and ten animals in each group. Rats fed with high fat diet and various concentrations of HAE treatment were studied and standard drug, atorvastatin was compared with HAE. This extract showed a significant action against atherosclerosis in a dose dependent manner which was studied in terms of Lactate Dehydrogenase activity, HMG-CoA/Mevalonate ratio, collagen content in aorta, levels of transaminases, calcium and other marker enzymes indirectly involved in the cardio protection. Alteration in collagen deposition in aorta of histopathological evaluation was noticed in treated animals. Anti-atherosclerotic activity of HAE of *P. integrifolia* was due to its modulatory activity on cholesterol metabolism and our results contribute towards validation of the traditional use of *P. integrifolia* in high fat diet induced atherosclerosis.

Key words: *HMG-CoA reductase, Anti-atherosclerosis, Collagen, Aorta, Agnimantha, Lactate Dehydrogenase*

Hyperlipidemia is one of the important factors associated with atherosclerosis, hypertension, smoking, diabetes mellitus etc. Atherosclerosis is a multi-factorial disease induced by various factors on suitable genetic backgrounds. It is characterized by the vascular areas containing mononuclear proliferation of smooth muscle cells resulting in thickening and hardening of the arterial walls¹. The HMG-CoA reductase inhibitors play an important role in the reduction of lipid and lipoprotein levels. The most effective and widely used commercially available drugs for the treatment of hyperlipidemia are statins. Their primary site of action is in liver where they inhibit HMG-CoA reductase, the metabolic pathway that produces cholesterol and isoprenoids². Impaired perfusion from decreased cardiac output may be associated with marked elevations in serum aminotransferases. Bridging fibrosis or cardiac cirrhosis can result from prolonged hemodynamic abnormalities, resulting in an impaired hepatic function with impaired coagulation, and alteration in the metabolism of several cardiovascular drugs, which can lead to unwanted toxicity³. Today, the Indian Systems of Medicine are not only complementary but also competitive in the treatment of various diseases. Herbs and herbal based compounds have always been an important source of medicines for various diseases and have received considerable attention in recent years due to their diverse pharmacological actions. Plants have a significant role in maintaining human health and improving the quality of life. *Premna integrifolia* is a medicinal plant and popularly known as “Agnimantha” in Ayurvedic systems of medicine and this plant root is commonly used in Dasamula drug preparation of Ayurveda. Hence the present study is focused on identification of liver abnormalities and complex relationship between cardiac and hepatic function in atherosclerosis. The hydro alcoholic extract of root bark of *P. integrifolia* may gain knowledge on hepatic biomarkers which further improve our understanding on disease process with less or no side effects in rats fed with high fat diet.

47 **Materials and Methods**

48 ***Preparation of the Plant Extract***

49 The root bark was procured, authenticated and voucher specimen (00641/2014) was
 50 deposited in the Botany Department. The bark was shade dried and coarsely powdered. The
 51 powder was defatted with petroleum ether (60-80°C) and then extracted with hydro alcohol
 52 (60:40 v/v) in a Soxhlet extractor and dried under vacuum. The percentage yield of HAE was
 53 7.61% w/w and this extract was suspended in 0.5% sodium carboxyl methyl cellulose
 54 (SCMC) for the pharmacological screening.

55 ***Induction of Atherosclerosis***

56 Experiment was conducted on 60 (30M+30F) Wistar rats of 6-8 weeks of age and purchased
 57 from King's Institute of Preventive Medicine, Guindy, India. Rats were randomly divided in
 58 to 6 groups and 10 animals (5M+5F) in each group and maintained in individual cage under
 59 controlled temperature, humidity and illumination conditions with water and diet *ad libitum*.
 60 High fat diet consisted of 2g of cholesterol, 8.0g of saturated fat and 0.1g of calcium
 61 (BYCALVIT-500 (Biochem Pharmaceutical Industries Ltd., Mumbai, India) mixed
 62 thoroughly with 90g of powdered standard commercial pellet diet along with weekly
 63 challenge of oral Vitamin D₃ (3,00,000IU) through per oral route⁴. Extract, vehicle and
 64 standard drug were administered daily through intra gastric route for 30 days.

65 ***Experimental Protocol for Atherosclerotic study***

66 Rats fed with

67 Group-I: Standard pellet diet (n=10)

68 Group-II: HFD (n=10)

69 Group-III: HFD+100 mg/kg.b.wt. of HAE (n=10)

70 Group-IV: HFD+200 mg/kg.b.wt. of HAE (n=10)

71 Group-V: HFD+500 mg/kg.b.wt. of HAE (n=10)

72 Group-VI: HFD +10 mg/kg.b.wt. of Atorvastatin (n=10)

73 **Biochemical Analysis**

74 At the end of experimental period, 4 mL of blood was collected in a vacutainer from retro-
 75 orbital plexus under mild ether anesthesia. Serum was separated by centrifugation (Remi C-
 76 24) at 4°C for 10 minutes at 3000 rpm. Tissues such as liver and aorta were removed. Liver
 77 was used for biochemical assays and aorta was preserved in 10% formalin for histopathology
 78 study of collagen deposition in aorta with Picrosirius red staining⁵. The serum biochemical
 79 parameters such as artate amino transferase (AST), Alanine amino transferase (ALT),
 80 Alkaline phosphatase (ALP), Lactate dehydrogenase (LDH) and Creatinine phosphor kinase
 81 (CPK), Bilirubin total and Calcium (Arsenazo, III-colorimetric) were assayed by Clinical
 82 chemistry fully autoanalyser (XL-640; Transasia) using kits of system pack from ERBA.
 83 Instrument was calibrated with XL-Multical (Erba XL SysPack-Level 1-14441) and quality
 84 control (Biorad) was run before started the analysis. Liver biochemical parameters AST &
 85 ALT⁶, Acid Phosphatase (ACP) & ALP⁷, LDH⁸, HMG-CoA/Mevalonate ratio⁹, Collagen¹⁰
 86 and Total protein¹¹ were estimated by UV-Visible spectrophotometer (Perkin-Elmer XE2-
 87 201) by standard procedures.

88 **Sttical analysis**

89 Statistical analysis was carried out using Graph pad Prism 5.0. All the values were expressed
 90 as meaD (n=10). Groups of data were compared with the analysis of variance (ANOVA)
 91 followed by Dunnett's test for multiple comparison. Values were considered statistically
 92 significant when $P < 0.05$.

93 **Results**

94 The serum ALT activity was 1.6 fold increase in Gp-II ($p < 0.001$) when compared to Gp-I.
 95 1.45 fold decrease was observed in Gp-V ($p < 0.01$) when compared to Gp-II. The activity of
 96 AST was increased by 1.34 fold in Gp-II and 1.0 fold in Gp-III when compared to Gp-I. The

97 AST activity was decreased by 1.3 fold in Gp-IV ($p<0.05$) and 1.48 fold in Gp-V ($p<0.001$)
 98 compared to Gp-II. The activity of ALP was 1.42 fold increase in Gp-II ($p<0.05$) when
 99 compared to Gp-I (Table 1). The serum LDH activity was increased by 2.16 fold in Gp-II
 100 ($p<0.0001$), 1.73 fold in Gp-III ($p<0.0001$) and 1.49 fold in Gp-III ($p<0.01$) compared to Gp-
 101 I. The activity was decreased by 1.25 fold in Gp-III ($p<0.05$), 1.44 fold in Gp-IV ($p<0.0001$),
 102 1.97 fold in Gp-V ($p<0.0001$) and 1.75 fold in Gp-VI ($p<0.0001$) when compared to Gp II.
 103 The LDH activity was decreased by 1.97 fold in Gp-V ($p<0.0001$) and 1.75 fold in Gp-VI
 104 ($p<0.01$) when compared to Gp-III. The CPK activity was increased by 1.69 fold in Gp-II
 105 ($p<0.001$) compared to Gp-I and 1.5 fold decreased in Gp-IV ($p<0.01$), 1.71 fold in Gp-V
 106 ($p<0.001$) and 1.45 fold in Gp-VI ($p<0.05$) when compared to Gp-II. The collagen content in
 107 liver was significantly increased in Gp-II ($p<0.0001$) and III ($p<0.001$) when compared to
 108 Gp-I. The level was significantly decreased in Gp-IV ($p<0.05$), V ($p<0.001$) and VI ($p<0.01$)
 109 when compared to Gp-II. A significant reduction was noticed in Gp-V ($p<0.01$) and VI
 110 ($p<0.05$) when compared to Gp-III. A significant reduction in calcium content of Gp-III
 111 ($p<0.05$), IV & V ($p<0.01$) when compared to Gp-II (Table 2). 
 112 The level of bilirubin total was elevated by 35% in Gp-II compared to Gp-I. 22.7% decreased
 113 in Gp-III, 25.58% in Gp-IV, 28.57% in Gp-V and 31.71% in Gp-VI when compared to Gp-II
 114 (Fig.1). The level of calcium was significantly increased in Gp-II ($p<0.0001$) and III ($p<0.05$)
 115 when compared to Gp-I. The level of calcium was significantly decreased in Gp-IV ($p<0.05$)
 116 and V ($p<0.01$) when compared to Gp-II (Fig.2). The activity of liver ALT was significantly
 117 increased in Gp-II ($p<0.001$) compared to Gp-I. Gp-V showed a significant decrease ($p<0.01$)
 118 in activity than Gp-II. The activity of liver AST was significantly increased in Gp-II and III
 119 ($p<0.05$) when compared to Gp-I. Gp-IV ($p<0.05$) and V ($p<0.001$) showed a significant
 120 decrease in AST activity when compared to Gp-II. The activity of ALP was significantly high
 121 in Gp-II ($p<0.05$) when compared to Gp-I. The activity of ALP in liver was decreased but no

significant difference was found in all other groups when compared to Gp-II (Table 3). The activity of ACP in liver was significantly increased in Gp-II ($p<0.01$), III ($p<0.05$) when compared to Gp-I and significant decrease was observed in Gp-V ($p<0.05$) when compared to Gp-II. The activity of LDH in liver was significantly increased in Gp-II, III, IV ($p<0.0001$) and VI ($p<0.05$) when compared to Gp-I and significant decrease was noticed in Gp-III, IV, V and VI ($p<0.0001$) when compared to Gp-II. A significant decrease was observed in Gp-IV and VI ($p<0.01$) and V ($p<0.0001$) when compared to Gp-III. HMG CoA/mevalonate ratio was decreased in Gp-II ($p<0.01$) compared to Gp-I. A significant improvement was noticed in Gp-IV, VI ($p<0.01$), V ($p<0.001$) when compared with Gp-II (Table 4).

Discussion

Measurement of LDH activity in blood is considered to be a diagnostic marker for certain cardiovascular diseases and it is a sensitive measure of myocardial infarction¹². When inadequate end-organ perfusion and tissue hypoxia is persistent or when acute shock develops this protecting mechanism against hypoxic liver damage is overwhelmed. Hepatocellular injury ensues, accompanied by sharp elevation of the serum aminotransferases, LDH and occasionally functional renal impairment. Ischemic hepatitis is usually benign and self-limited. Aspartate transaminase level is used as a diagnostic marker for myocardial infarction. In pathological conditions, the enzymes such as CPK, LDH, AST and ALT leaks from the necrotic heart cells to blood, which are important measure of cardiac injury. These enzymes are not specific for myocardial injury individually; however, evaluation of these enzymes together may be an indicator of myocardial damage^{13,14}. CPK is another important enzyme in energy metabolism in body which maintains the high concentration of intracellular ATP through phosphorylation and it is considered as important index for atherosclerosis¹⁵. Higher activities of these enzymes in serum have been found in response to oxidative stress induced by high fat diet¹⁶. Impaired perfusion from low cardiac output results in

cardiogenic ischemic hepatitis. The hall mark findings of ischemic hepatitis are severe jaundice with high bilirubin level and elevated liver function tests. Increase in LDH tends to be massive and ALT/LDH ratio may help distinguishing ischemic injury from other forms of acute hepatitis^{17,18}. There was a significant restoration of these enzymes on administration with different concentrations of HAE of *P. integrifolia*. The activity of AST, ALT, CPK and LDH was inversely proportional to the concentration of HAE extract. Liver plays a central role in the absorption, distribution and elimination of majority of drugs. Collagen is a family of proteins consists of several genetically different molecular species and is closely involved in tissue organization, function, differentiation and development¹⁹. The unique distribution of hydroxyl proline within the collagen can easily be studied²⁰. Hepatic impairment can alter the pharmacokinetic profiles of cardiovascular drugs, which can lead to unwanted toxicity. On treatment with HAE, reversibility of changes was noticed when compared to high fat fed rats (Fig.3).

Liver function tests abnormalities were common in patients with chronic heart failure. Elevated total Bilirubin remained one of the strongest independent predictors of poor prognosis. An intracellular cation has significant role in the regulation of normal physiology and biochemistry of cardiac and smooth muscles. Flavonoids, have been found to suppress the intracellular high Ca^{2+} ion in a dose dependent manner, as well as the release of pro-inflammatory mediators such as tumor necrosis factor- α ²¹. Studies revealed that tannins, triterpenoids and flavonoid are the major phytoconstituents of *P. integrifolia*^{22,23}. HAE have an essential phytoconstituents including flavonoid might help in the reduction of intracellular calcium levels in the drug treated groups.

Elevated transaminases should be seriously considered in patients with cardiac disease and also elevation of each cholestatic liver function tests were significantly associated with the degree of tricuspid incompetence²⁴. During hepatic impairment, the bioavailability is double

and the total plasma clearance is halved. Marked decrease in liver transaminases, ACP and ALP levels demonstrate the cardio protective effect of *P. integrifolia*. HAE has cardioprotective activity along with hepatoprotective activity which was evident in liver marker enzymes in extract treated groups. Due to the presence of flavonoid, a secondary metabolite in HAE could enhance the antioxidant defense mechanisms and prevents muscle cell damage. LDH is less specific than AST and ALT as a marker of hepatocyte injury, but LDH may disproportionately elevated after an ischemic liver injury. The activity of LDH was reported to be high in rats fed with high fat diet induced obesity²⁵. The HAE might protect the cell by reducing the activities of these marker enzymes. HMG-CoA reductase activity was indirectly measured in terms of HMG CoA/Mevalonate ratio in liver tissue⁹. Inhibitors of HMG-CoA reductase are used to lower serum cholesterol levels and improve the survival of individuals at risk of atherosclerotic vascular disease²⁶. Their primary site of action is in liver where they inhibit HMG-CoA reductase, the metabolic pathway that produces cholesterol and isoprenoids²⁷. Atorvastatin treated rats showed a significant reduction in the ratio of HMG-CoA/Mevalonate which might be due to the inhibition of HMG-CoA reductase activity by HAE. The most effective and widely used drugs for the treatment of hyperlipidemia are the atorvastatin and this drug competitively inhibit HMG-CoA reductase enzyme in liver that converts HMG-CoA to mevalonate an early precursor for cholesterol biosynthesis. Hence this enzyme might competitively inhibited by the HAE which was evident from the lipid and lipoprotein status. In conclusion, all HMG-CoA reductase inhibitor undergo extensive hepatic metabolism. Active liver disease or persistent unexplained elevations in serum transaminases to above 3 times the upper limit of normal, the use of statins is contraindicated as they may worsen liver function²⁸. Therefore the cardio tonic action of the HAE might attribute to the phytoconstituents present in it. From the above findings, HAE of *P. integrifolia* modulates enzyme activity in a dose-dependent manner and further research is required on which active

principle is mainly involved in the anti-atherosclerotic activity of high fat diet-induced atherosclerosis.



Reference

1. Alexander RW, Hypertension and the pathogenesis of atherosclerosis. Oxidative stress and the mediation of arterial inflammatory response: A new perspective, *Hypertension*, 25 (1995) 155.
2. Brown MS & Goldstein JL, Multivalent feedback regulation of HMG-CoA reductase, a control mechanism coordinating isoprenoid synthesis and cell growth, *J Lipid Res*, 21 (1980) 505.
3. Jessup M, Abraham WT, Casey DE, Feldman AM, Francis GS, Ganiats TG, Konstam MA, Mancini DM, Rahko PS, Silver MA, Stevenson LW & Yancy CW, 2009 Focused update: ACCF/AHA Guidelines for the diagnosis and management of heart failure in adults: *Circulation*, 119 (2009) 1977.
4. Altman RF, A simple method for rapid production of atherosclerosis in rats. *Experientia*, 29 (1973) 256.
5. Wagsater D, Paloschi V, Hanemaaijer R, Hultenby K, Bank RA, Franco-Cereceda A, Lindeman JHN & Eriksson P, Impaired collagen biosynthesis and cross-linking in aorta of patients with bicuspid aortic valve. *J Am Heart Assoc*, 156 (2013) 1.
6. Reitman S & Frankel S, A colorimetric method for the determination of serum glutamic oxaloacetic and glutamic pyruvic transaminases. *Am J Clin Pathol*, 28 (1957) 56.
7. Kind PRN & King, EJ, Estimation of plasma phosphatase by determination of hydrolysed phenol with amino antipyrin, *J Clin Pathology*, V7 (1954) 322.
8. Nieland A, Lactic acid dehydrogenase of heart muscle. In: *Methods in Enzymology*. (Academic Press, New York), Vol. 1 1955, 394.
9. Venugopala A & Ramakrishna S, Indirect assessment of hydroxyl methyl glutaryl coenzyme-A reductase (NADPH) activity in liver, *Clin Chem*, 21 (1975) 1523.
10. Edwards CA & O'Brien WD, Modified assay for determination of hydroxyproline in a tissue hydrolyzate, *Clin Chim Acta*, 104 (1980) 161.
11. Lowry OH, Rosebrough NJ, Farr AL & Randall RJ, Protein measurements with the folin phenol reagent. *J Biol Chem*, 193 (1951) 265.

- 239 12. Stegink LD & Vestling CS, Rat liver lactate dehydrogenase. Amino-terminal and
240 acetylation status, *J Biol Chem*, 241 (1966) 4923.
241
- 242 13. Al-Shabanah O, Mansour M, El-Kashef H & Al-Bekairi A, Captopril ameliorates
243 myocardial and hematological toxicities induced by adriamycin, *Biochem Mol Biol Int*,
244 45 (1998) 419.
245
- 246 14. Chopra S, Pillai KK, Husain SZ & Giri DK, Propolis protects against doxorubicin-
247 induced cardiomyopathy in rats. *Exp Mol Pathol*, 62 (1995) 190.
248
- 249 15. Brancaccio P, Maffulli N & Limongelli FM, Creatine kinase monitoring in sport
250 medicine, *Br Med Bull*, 81-82 (2007) 209.
251
- 252 16. Demori I, Voci A, Fugassa E & Burlando B, Combined effects of high-fat diet and
253 ethanol induce oxidative stress in rat liver, *Alcohol*, 40 (2006) 185.
254
- 255 17. Gitlin N & Serio KM, Ischemic hepatitis: widening horizons, *Am J Gastroenterol*, 87
256 (1992) 831.
257
- 258 18. Cassidy WM & Reynolds TB, Serum lactic dehydrogenase in the differential diagnosis of
259 acute hepatocellular injury, *J Clin Gastroenterol*, 19 (1994) 118.
260
- 261 19. Fujiwara S & Nagai Y, Bovine renal cortex type I collagen; High contents of 3-and 4-
262 hydroxy prolines, *J Biochem*, 89 (1981) 1397.
263
- 264 20. Pihlajaniemi T, Mylly R & Krivirikko KI, Proly 4-hydroxylase and its role in collagen
265 synthesis, *J Hepatol*, 13 (1991) S2.
266
- 267 21. Kempuraj D, Madhappan B, Kristodoulou S, Boucher W, Cao J & Papadopoulou N,
268 Flavonols inhibit proinflammatory mediators, intracellular calcium ion levels and protein
269 kinase C theta phosphorylation in human mast cells, *Br J Pharmacol*, 145 (2005) 934.
270
- 271 22. Sudo H, Takushi A & Ide T, 10-O-acylated iridoid glucosides from leaves of *Premna*
272 *subscandens*, *Phytochem*, 46 (1997) 1231.
273
- 274 23. Chin YW, Jones WP & Bachman I, Cytotoxic clerodane diterpenoids from leaves of
275 *Premna tomentosa*, *Phytochem*, 67 (2006) 1234.
276
- 277 24. Alvarez AM & Mukherjee D, Liver Abnormalities in Cardiac Diseases and Heart Failure,
278 *Int J Angiol*, 20 (2011) 135.
279
- 280 25. Noeman SA, Hamooda HE & Baalash AA, Biochemical study of oxidative stress markers
281 in the liver, kidney and heart of high fat diet induced obesity in rats. *Diabetol Metab*
282 *Syndr*, 3 (2011) 3.

26. Endo A, The discovery and development of HMG-CoA reductase inhibitors. *J Lipid Res*, 33 (1992) 1569.
27. Adnan F, Sadiq M & Jehangir A, Anti-hyperlipidemic effect of Acacia Honey (Desi Kikar) in cholesterol-diet induced hyperlipidemia in rats, *Biomedica*, 27 (2011) 62.
28. Go AS, Lee WY, Yang, J, Lo JC & Gurwitz JH, Statin therapy and risks for death and hospitalization in chronic heart failure, *JAMA*, 296 (2006) 2105.

Table 1: Assay of Serum Alanine transaminase, Aspartate transaminase and Alkaline Phosphatase

Group	Alanine transaminase (mg pyruvate liberated/ mg protein at 37°C for 30 minutes)	Aspartate transaminase (mg pyruvate liberated/ mg protein at 37°C for 60 minutes)	Alkaline phosphatase (µg phenol liberated/ mg protein at 37°C for 15 minutes)
Gp-I	0.584±0.086	0.389±0.117	0.482±0.082
Gp-II	0.944±0.260 ^{a***}	0.524±0.046 ^{a*}	0.687±0.147 ^{a*}
Gp-III	0.798±0.167	0.415±0.072 ^{a*}	0.581±0.185
Gp-IV	0.728±0.166 ^{a,b}	0.398±0.088 ^{b*}	0.522±0.097
Gp-V	0.649±0.134 ^{b**}	0.353±0.057 ^{b***}	0.515±0.129
Gp-VI	0.719±0.162	0.421±0.089	0.544±0.091

[Values are mean ± SD; n=10; * p<0.05; ** p<0.01; *** p<0.001]

^aResults were compared with Gp-I; ^bCompared with Gp-II

Table 2: Assay of Serum Lactate Dehydrogenase and Creatine Phosphokinase

Group	Lactate Dehydrogenase (IU/L)	Creatine Phosphokinase (IU/L)	Collagen (µg/mg protein)
Gp-I	249.90±42.46	166.50±44.4	38.83±16.25
Gp-II	539.78±89.82 ^{a****}	282.43±35.5 ^{a***}	92.51±24.67 ^{a****}
Gp-III	432.70±78.02 ^{a****; b*}	231.28±58.7	82.07±26.17 ^{a****}
Gp-IV	374.20±63.54 ^{a**; b****;}	188.48±85.7 ^{b**}	76.52±41.40 ^{b*}
Gp-V	273.56±58.79 ^{b****; c****}	165.49±35.5 ^{b***}	38.95±22.94 ^{b****; c**}
Gp-VI	309.22±61.24 ^{b****; c**}	195.09±57.0 ^{b*}	40.07±29.66 ^{b****; c*}

[Values are mean ± SD; n=10; * p<0.05; ** p<0.01; *** p<0.001; **** p<0.0001]

^aResults were compared with Gp-I; ^bCompared with Gp-II; ^cCompared with Gp-III

Table 3: Assay of Liver Alanine Transaminase, Aspartate Transaminase, Alkaline Phosphatase

Group	Alanine transaminase (mg pyruvate liberated/ mg protein at 37°C for 30 minutes)	Aspartate transaminase (mg pyruvate liberated/ mg protein at 37°C for 60 minutes)	Alkaline phosphatase (µg phenol liberated/ mg protein at 37°C for 15 minutes)
Gp-I	0.584±0.086	0.389±0.117	0.482±0.082
Gp-II	0.944±0.260 ^{a***}	0.524±0.046 ^{a*}	0.687±0.147 ^{a*}
Gp-III	0.798±0.167	0.415±0.072 ^{a*}	0.581±0.185
Gp-IV	0.728±0.166	0.398±0.088 ^{b*}	0.522±0.097
Gp-V	0.649±0.134 ^{b**}	0.353±0.057 ^{b***}	0.515±0.129
Gp-VI	0.719±0.162	0.421±0.089	0.544±0.091

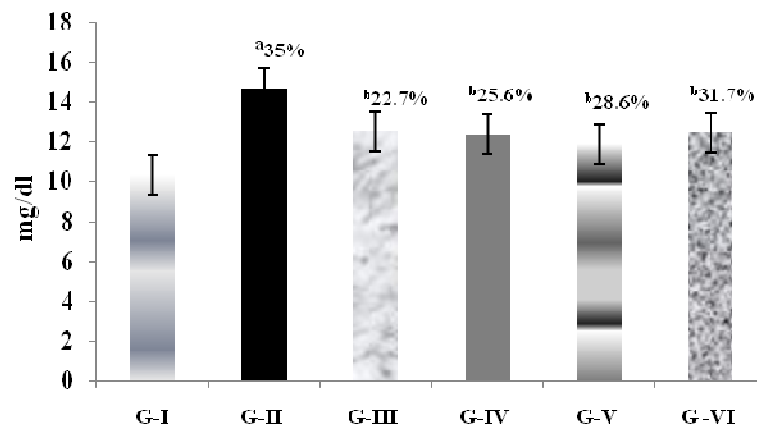
[Values are mean ± SD; n=10; * p<0.05; ** p<0.01; *** p<0.001]
^aResults were compared with Gp-I; ^bCompared with Gp-II

Table 4: Assay of Liver Acid Phosphatase, Lactate dehydrogenase and HMG CoA/ Mevalonate Ratio

Group	Acid phosphatase (µg phenol liberated/mg protein at 37°C for 60 minutes)	Lactate dehydrogenase (µmoles/mg protein)	HMG CoA/ Mevalonate Ratio
Gp-I	0.209±0.052	85.36±12.91	1.161±0.110
Gp-II	0.408±0.076 ^{a**}	808.89±103.89 ^{a****}	1.404±0.144 ^{a**}
Gp-III	0.366±0.138 ^{a*}	440.39±123.91 ^{a,b****}	1.204±0.105
Gp-IV	0.336±0.152	300.15±56.01 ^{a,b****; c**}	1.158±0.150 ^{b**}
Gp-V	0.241±0.123 ^{b*}	143.42±70.97 ^{b****; c****}	1.056±0.139 ^{b****}
Gp-VI	0.263±0.112	195.66±66.72 ^{a*; b****; c**}	1.108±0.130 ^{b**}

[Values are mean ± SD; n=10; * p<0.05; ** p<0.01; *** p<0.001; **** p<0.0001]
^aResults were compared with Gp-I; ^bCompared with Gp-II; ^cCompared with Gp-III

Fig. 1: Estimation of Bilirubin Total in Serum

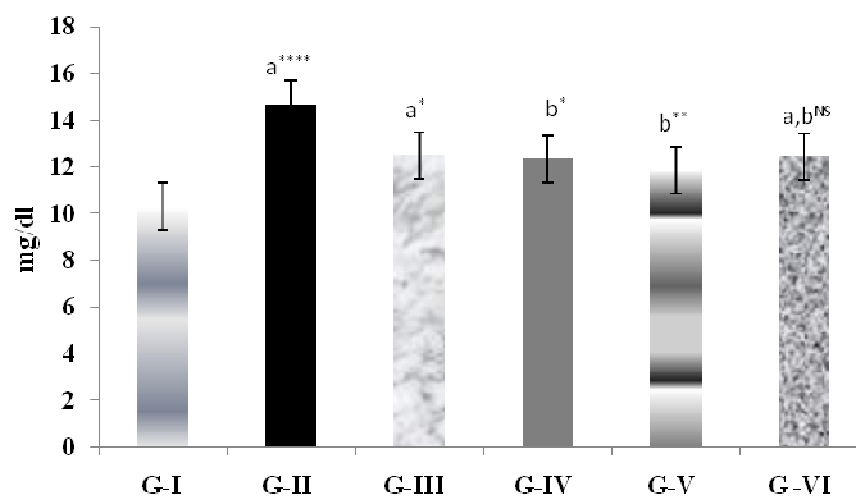


[Values are mean $\pm$ SD; n=10; ^aResults were compared with Gp-I; ^bCompared with Gp-II]

335

336

Fig. 2: Estimation of Calcium in Serum



337

338

[Values are mean $\pm$ SD; n=10; *p<0.05; **p<0.01; ****p<0.0001]

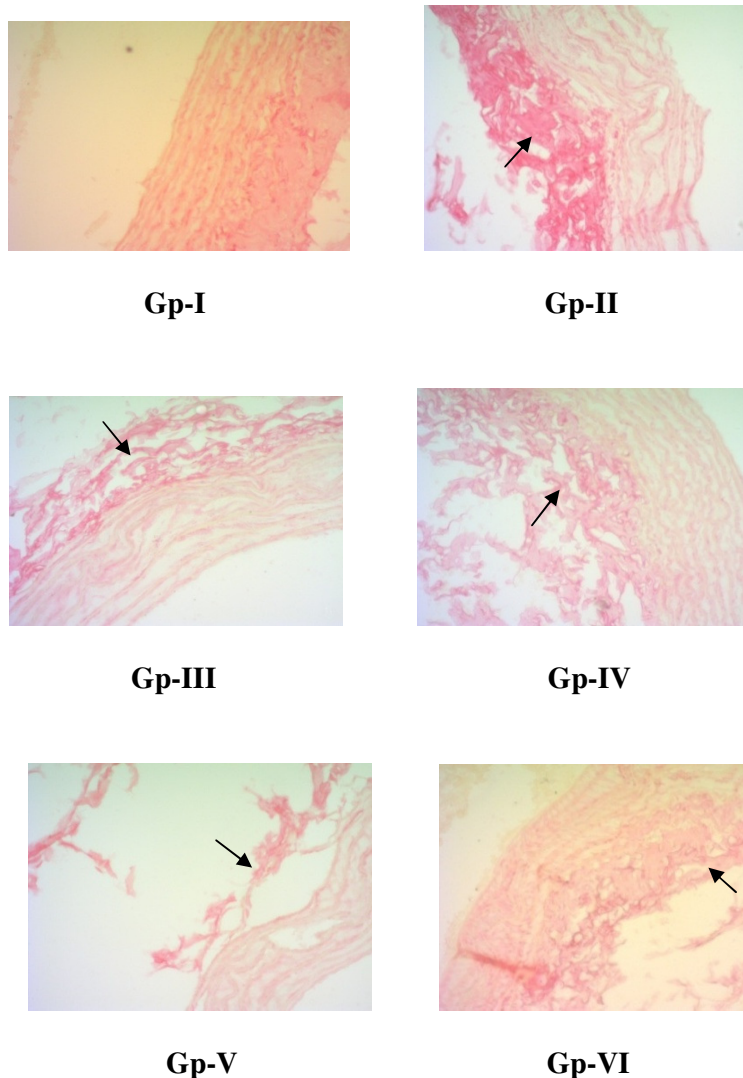
339

^aResults were compared with Gp-I; ^bCompared with Gp-II

340

341

Fig. 3: Histopathology of Collagen Deposition in Aorta



Legend for Fig. 3

- Gp-I : No collagen accumulation
- Gp-II : Well defined collagen accumulation with mineralization
- Gp-III : Moderate accumulation of collagen with less demineralization
- Gp-IV : Mild collagen accumulation with marked demineralization
- Gp-V : Mild collagen accumulation with severe demineralization
- Gp-VI : Moderate collagen accumulation with less demineralization