The hypolipidemic activity of Ayurvedic medicine, Arogyavardhini vati in Triton WR-1339-induced hyperlipidemic rats: A comparison with fenofibrate

Gajendra Kumar, Amita Srivastava, Surinder Kumar Sharma, Yogendra Kumar Gupta
Department of Pharmacology, All India Institute of Medical Sciences, New Delhi, *Chairman, Ayurvedic Pharmacoepia Committee, Ministry of Health and Family Welfare, Government of India, India

ABSTRACT

Background: Hyperlipidemia is a major risk factor of coronary heart disease. Currently available hypolipidemic drugs have been associated with number of side effects. Arogyavardhini vati, an Ayurvedic polyherbal formulation has been used for liver disorders. Therefore, present study was designed to evaluate the effect of Arogyavardhini vati in Triton WR-1339-induced hyperlipidemia in rats. Objectives: Anti-hyperlipidemic activity evaluation of Arogyavardhini vati against Triton WR-1339-induced hyperlipidemia in rats. Materials and Methods: Overnight fasted male Wistar rats (150-200 g) were randomly divided into normal control group [4% Dimethyl Sulfoxide (DMSO), i.p.], positive control group (Triton WR-1339 in 4% DMSO, 400 mg/kg, i.p.), standard drug treated (fenofibrate 65 mg/kg, p.o. for 7 days after inducing hyperlipidemia) and Arogyavardhini vati treated (50, 100, 200 mg/kg, p.o. for 7 days after inducing hyperlipidemia). Rat doses were calculated by extrapolating the equivalent human dose (therapeutic dose, sub-maximum, and maximum dose). Serum total cholesterol, triglyceride, low-density lipoprotein (LDL), high-density lipoprotein HDL, liver malondialdehyde (MDA), and glutathione (GSH) levels were estimated at end of experiments. Results: Arogyavardhini vati significantly decreased serum cholesterol, triglyceride, LDL, and C-reactive protein (CRP) and significantly increased serum HDL in a dose-dependent manner. Decreased MDA and increased GSH levels in liver were observed at all doses of Arogyavardhini vati (50, 100, 200 mg/kg) and fenofibrate-treated groups when compared with Triton-treated group. Atherogenic Index (AI) level was significantly decreased in fenofibrate and Arogyavardhini vati (200 mg/kg) treated rats when compared with normal control. Conclusion: Arogyavardhini vati, a traditionally used Ayurvedic medicine may be a useful therapy for hypercholesterolemia through reducing oxidative stress (decreasing MDA and increasing GSH) and lipid levels.

Key words: Arogyavardhini vati, atherogenic index, hypolipidemia, oxidative stress, Triton WR-1339

INTRODUCTION

The scourge of cardiovascular diseases (CVDs) is the most prevalent cause of death.[1] According to National Commission on Macroeconomics and Health (NCMH), a Government of India undertaking, there would be around 62 million patients with coronary artery disease (CAD) by 2015 in India and of these, 23 million would be patients younger than 40 years of age.[2] CAD is due to atherosclerosis of large- and medium-sized arteries, and dyslipidemia has been found to be one of the most important contributing factors [National Cholesterol Education Program, The Adult Treatment Panel III (NCEP, ATP III)]. During the past three decades, dyslipidemia as a risk factor for CVD has increased markedly in India.[3]

Currently available hypolipidemic drugs (statins) have been associated with a number of side effects.[4] Patients on treatment with crystalline niacin or extended-release niacin showed significant elevation in ALT and risk of hepatotoxicity is much greater with slow-release niacin.[5] Increases in plasma creatinine from 15% to 20% are common in fibrate-treated patients and more significant increases can occur in patients with underlying renal disease.[6,7] Hence, there has been pursuit for new
safe and effective drug for dyslipidemia. Herbs have been used as a food and for medicinal purpose for centuries. Research interest has focused on various herbs that possess hypolipidemic effect that may be helpful adjunct in reducing the risks of CVD. *Arogyavardhini vati* is a polyherbal formulation mentioned in Ayurvedic formulary of India. It has been used for centuries with claimed efficacy and safety in treatment of jaundice, liver disorders and various skin disorders. It consists *Picrorhiza kurroa* (Kurk), *Terminalia chebula* (Haritaki), *Terminalia bellerica* (Bibhitaka), *Emblica officinalis* (Amalaki), *Asphaltum* (Silajatu), *Commiphora wightii* (Guggulu), *Ricinus communis* (Eranda), *Azadirachta indica* (Neem leaves) and metal including *sudha rasa* (detoxified mercury), *Gandhaka sudhha* (detoxified sulfur), *Lauha bhasma* (iron), *abhraka bhasma* (mica), *tamra bhasma* (copper). Safety of *Arogyavardhini vati* has been evaluated by Kumar et al. The findings of the study showed that *Arogyavardhini vati* in the doses equivalent to 10 times of the human dose, administered to rats for 28 days, do not have appreciable toxicological effects on brain, liver, and kidney.

Endothelial dysfunction plays a vital role in triggering ischemic events in the development of CVD. Lipid peroxidation represents an early step of endothelial dysfunction. C-reactive protein (CRP), an acute phase protein, has been clinically used as a sensitive marker for systemic inflammation.

Therapies have been developed to lower hs-CRP concentrations and reduce the potential risk factor for CVDs. There are plethora of clinical and experimental studies showing that antioxidants such as vitamin E have been shown to reduce the oxidative susceptibility of lipoproteins and may have anti-atherosclerotic effects. In hypercholesterolemic animal models, vitamin E increased resistance to lipoprotein oxidation and preserved normal endothelial function. Epidemiologic studies also indicate an inverse association between the intake of vitamin E and coronary heart disease.

Hence, considering the antioxidant, anti-inflammatory and hypolipidemic property, the present study was designed to study the effect of *Arogyavardhini vati* in Triton WR-1339-induced hyperlipidemia in rats.

**MATERIALS AND METHODS**

**Experimental animal**

Male Wistar rats (150-200 g) were used in the present study. The animals were obtained from the Central Animal Facility, All India Institute of Medical Sciences, New Delhi and stock bred in the departmental animal house. The rats were group-housed in polyacrylic cages (38 × 23 × 10 cm) with not more than four animals per cage and maintained under standard laboratory conditions with natural dark and light cycle. They were allowed free access to standard dry diet (Ashirwad, Punjab, India) and tap water ad libitum. All experimental procedures described were reviewed and approved by the Institutional Animal Ethics Committee, All India Institute of Medical Sciences, New Delhi India (497/IAEC/09).

**Drugs preparation and duration of treatment**

*Arogyavardhini vati* was purchased from the GMP certified company (Maharshi Ayurveda Pharmaceutical Limited, New Delhi, India). Single batch of the drug was used in entire study duration (Batch No. AVV 013, Date of manufacturing: November 2009). Drug was prepared according the Ayurvedic literature and Ayurvedic pharmacopeia standards were followed. Drug was crushed, powdered, and dissolved in distilled water. Triton WR-1339 was purchased from Sigma-Aldrich (St. Louis, MO, USA) and dissolved in DMSO. Fenofibrate tablet was purchased from market (Intra Lab India Pvt. Ltd, Bangalore, India).

**Experimental design**

Overnight fasted rats were randomly divided into six groups of six animals each. The first group was given standard pellet diet, water and administered intraperitoneal injection of 4% DMSO. The second hyperlipidemic group received Triton WR-1339 dissolved in 4% DMSO (400 mg/kg body weight). After 72 h of Triton injection, this group received a daily dose of 4% DMSO (p.o.) for 7 days. Third group was administered with the standard fenofibrate (65 mg/kg, p.o.) for 7 days. The fourth, fifth, and sixth group was administered daily doses of *Arogyavardhini vati* (50, 100, 200 mg/kg, p.o.) for 7 days, after inducing hyperlipidemia. Human dose of *Arogyavardhini vati* is 500-2000 mg per day. Human equivalent rat dose of 500, 1000, and 2000 mg will be 50, 100, and 200 mg/kg (human to rat dose conversion factor is 6 and average human body weight is 60 kg). The doses of *Arogyavardhini vati* (50, 100, 200 mg/kg) in rat was calculated by extrapolating the equivalent human dose (therapeutic dose, sub-maximum, and maximum dose) and was administered orally between 10 and 11 a.m. daily for 7 days, in a volume not exceeding 1 ml/100 g rat weight. After 12 h of treatment, animals were anesthetized with diethyl ether and blood was withdrawn from retro-orbital sinus. The blood samples were immediately centrifuged (3000 rpm for 10 min) and serum was used to estimate the levels of total cholesterol, triglyceride, LDL, and HDL using semi-auto analyzer (Mini Techno, Newark, DE 19711, USA) according to the instruction of manufacturer of assay kits (Logitech India Pvt. Ltd., Delhi, India). The level of serum CRP was estimated by ELISA, according to the instruction of manufacturer of assay kits (Life Diagnostics Inc., Mill Valley, CA 94941, USA;
Cardiac risk was determined by estimating its atherogenic index (AI = TC/HDL-C) as stated by Malaspina. Animals were euthanized and liver was removed to determine the levels of MDA and GSH.

Measurements of MDA and GSH levels in liver
Malondialdehyde, an indicator of lipid peroxidation was determined by the method of Ohkawa et al.[21] The concentration was expressed in nmol/g-wet tissue. Glutathione was measured according to the method of Ellman and concentration was expressed as mg/g-wet tissue.[22]

Statistical analysis
Data are expressed as mean ± standard error of the mean (SEM). A one-way analysis of variance (ANOVA), followed by Tukey’s test was used for statistical analysis. SPSS (version 16) statistical software was used for the analysis of data and P < 0.05 was taken as the level of significance.

RESULTS

Effect of Arogyavardhini vati in Triton WR-1339-induced dyslipidemia on rat’s serum lipid levels
The serum total cholesterol, triglycerides, LDL, and HDL levels were measured in normal and Triton WR-1339-induced rats [Table 1]. There was significant increase in serum total cholesterol, triglycerides, and LDL levels and decreased HDL levels in Triton-induced hyperlipidemic rats. Administration of Arogyavardhini vati at doses of 50, 100, 200 mg/kg and standard drug fenofibrate (65 mg/kg) significantly decreased serum total cholesterol, triglycerides, and LDL, and increased HDL when compared with Triton-induced hyperlipidemic rats (P < 0.001). There were no statistically significant differences in the level of serum total cholesterol, triglycerides, LDL, and HDL in fenofibrate-treated rats as well as normal control rats.

Effect of Arogyavardhini vati in Triton WR-1339-induced dyslipidemia on rat’s serum C-reactive protein levels
CRP level was increased in Triton-treated rats. Feno

brate-treated rats showed significant decrease in CRP levels when compared with Triton-treated rats; however levels were raised when compared with normal control. There was no significant change in the level of CRP at low dose of Arogyavardhini vati (50 mg/kg) when compared with Triton-treated rats. However, significant decrease in the level of CRP was observed at higher doses (100 and 200 mg/kg) of Arogyavardhini vati (P < 0.001). There was no statistical significant difference in the level of CRP at maximum dose of Arogyavardhini vati (200 mg/kg) when compared with fenofibrate-treated rats [Table 1].

Effect of Arogyavardhini vati in Triton WR-1339-induced dyslipidemia on rat’s liver MDA and GSH levels
There was significant decrease in liver MDA and increased GSH level observed at all doses of Arogyavardhini vati (50, 100, 200 mg/kg) and fenofibrate (65 mg/kg) treated rats when compared with Triton-treated rats (P < 0.001). A significant increased MDA and decreased GSH levels in liver of Triton-treated rats (P < 0.001) was observed when compared with normal control. There was significant decrease in MDA and increased GSH was observed in a dose-dependent manner [Table 2].

DISCUSSION
Hyperlipidemia is a well known risk factor for CVDs. Atherosclerotic CAD is one of the major causes of premature death globally and it is expected to be the most important cause of mortality in India.[23] There are several lines of evidence with respect to the fact that HDL...
cholesterol is inversely related to total body cholesterol and a reduction of plasma HDL cholesterol concentration may accelerate the development of atherosclerosis leading to ischemic heart diseases, by impairing the clearing of cholesterol from the arterial wall.[24]

Triton WR-1339 has commonly been used for screening of hypolipidemic drugs.[25] There is plethora of studies which has investigated the plants for their acute hypolipidemic activity in Triton WR-1339-induced hyperlipidemic animals.[26-28] Triton WR-1339 injection results increase in plasma cholesterol and triglycerides due to increase in VLDL secretion by the liver accompanied by a strong reduction of VLDL-C and LDL-C catabolism.[29] Fenofibrate (65 mg/kg) treated group was taken as positive control because it is a reduction of plasma HDL cholesterol concentration may be mediated through above mechanisms.

It has been well established that nutritional supplements such as herbal medicinal products, vitamin E, etc., plays an important role in the etiology of hyperlipidemias and atherosclerosis. Our present study clearly shows that Arogyavardhini vati significantly lowered serum total cholesterol, triglycerides, and LDL levels, and increased HDL in a dose-dependent manner (50, 100, 200 mg/kg) [Table 1].

The treatment with *Arogyavardhini vati* also reduced the AI which is an important and sensitive indicator to determine the cardiac risk [Figure 1]. The results of present study are in accordance with several studies.[26-28] There are several components of *Arogyavardhini vati* which are known to have hypolipidemic effects, i.e., Picrorrhiza kurroa, Terminalia chebula, Terminalia bellirica, Emblica officinalis, and Guggulu.[30-33]

The mechanisms by which *Arogyavardhini vati* exerted the beneficial effects is presently not clear. Picrorrhiza kurroa, a major component *Arogyavardhini vati* has choleretic effect.[36] Amla which is another component has HMG CoA reductase inhibitory activity.[37] Ellagitannins and the ellagic acid obtained on hydrolysis of these tannins (by lipases and/or esterases) are inhibitors of squalene epoxidase, a rate-limiting enzyme of cholesterol biosynthesis.[38] These inhibitory activities may explain the beneficial effects of *Arogyavardhini vati* on lipid parameters. Inflammation is known to reduce HDL,[39] and the enhancement of HDL observed in the present study may arise from the control of inflammation by *Arogyavardhini vati*. The serum CRP level which is a marker of systemic infection was significantly reduced at the end of the treatment in our study which are also reported in literature.[10] Therefore, it is likely that a reduction in serum lipid levels observed in the present study by *Arogyavardhini vati* may be mediated through above mechanisms.

Lipid peroxidation is the most commonly used parameters for assessing oxidative damage in the human body.[40] In this process LDL-C and other lipid containing molecules may be oxidized in the blood stream, exerting adverse effects on a variety of processes like inhibiting antithrombin III activity, producing procoagulant activity, enhancing platelet aggregation, modulating vascular responses, and acting as mitogen.[41]

The formation and activation of atherosclerotic lesion is a multi-faceted process involving many determinants, including oxidative modification of LDL. Oxidized LDL causes foam cell formation, leukocyte adhesion to the endothelium, cytotoxicity, and vascular endothelial dysfunction leading to impaired EDNO synthesis and biological activity.[42] In
the present study, *Arogyavardhini vati* administration caused a significant reduction of liver MDA and increased GSH level [Table 2]. Lowering of oxidative stress with concomitant lowering of cholesterol indicated that there was reduced oxidative stress after administration of *Arogyavardhini vati* in a dose-dependent manner. The results of present study indicate antiatherosclerotic roles of *Arogyavardhini vati* which can indirect effect due to enhanced lipid metabolism by liver. This study showed that the liver antioxidants induced by *Arogyavardhini vati* may have protective effect against LDL oxidation, thereby preventing or slowing the events leading to the initiation of atherosclerosis. The observation made from this study showed that *Arogyavardhini vati* possesses a stronger antioxidant potential.

**CONCLUSION**

*Arogyavardhini vati* may be a useful therapy for hypercholesterolemia through reducing oxidative stress (decreasing MDA and increasing GSH) and lipid levels (decreasing serum total cholesterol, triglyceride, LDL levels and increasing serum HDL level). The results of the present animal study pave the path to conduct clinical study and *Arogyavardhini vati* was found to be safe and efficacious in dyslipidemia patients.

**ACKNOWLEDGMENT**

The financial support by Central Council for Research in Ayurveda and Siddha (CCRAS), Department of AYUSH, Ministry of Health and Family Welfare, Government of India for this research work is duly acknowledged (F. No. Z31014/04/2009/EMR-CCRAS).

**REFERENCES**

1. Chaturvedi V, Bhargava B. Health care delivery for coronary heart disease in India: Where are we headed? Am Heart Hosp J 2007;5:32-7.
2. Indrayan A. Forecasting vascular disease cases and associated mortality in India. Reports of the National Commission on Macroeconomics and Health. India: Ministry of Health and Family Welfare; 2005. Available from: http://www.whoindia.org/EN/Section102/Section201_888.htm. [Last accessed 2012 Jun 18].
3. Ramachandran A, Snehalatha C, Satyavani K, Sivasankari S, Vijay V. Metabolic syndrome in urban Asian Indian adults: A population study using modified ATP III criteria. Diabetes Res Clin Pract 2003;60:199-204.
4. Farmer JA, Torre-Amione G. Comparative tolerability of the HMG-CoA reductase inhibitors. Drug Saf 2000;23:197-213.
5. McKenney JM, Proctor JD, Harris S, Chinchilli VM. A comparison of the efficacy and toxic effects of sustained- vs immediate-release niacin in hypercholesterolemic patients. JAMA 1994;271:672-7.
6. Ellen RL, McPherson R. Long-term efficacy and safety of fenofibrate and a statin in the treatment of combined hyperlipidemia. Am J Cardiol 1998;81:60B-5.
7. Lipscombe J, Lewis GF, Cattran D, Bargman JM. Deterioration in renal function associated with fibrate therapy. Clin Nephrol 2001;55:39-44.
8. Ayurvedic Formulary of India. Part I and II. Ministry of Health and Family Welfare, Govt. of India; 2005.
9. Kumar G, Srivastava A, Sharma SK, Gupta YK. Safety evaluation of an Ayurvedic medicine, *Arogyavardhini vati* on brain, liver and kidney in rats. J Ethnopharmacol 2012;140:151-60.
10. Pepys MB, Hirschfeld GM. C-reactive protein: A critical update. J Clin Invest 2003;111:1805-12.
11. Kluft C, de Maat MP, Gevers Leuven JA, Potter van Loon BJ, Mohrslacht MF. Statins and C-reactive protein. Lancet 1999;353:1274.
12. Lagrand WK, Visser CA, Hermens WT, Niessen HW, Verheught FW, Wobink GJ, et al. C-reactive protein as a cardiovascular risk factor: More than an epiphenomenon? Circulation 1999;100:96-102.
13. Libby P, Ridker PM. Novel inflammatory markers of coronary risk: Theory versus practice. Circulation 1999;100:1148-50.
14. Jialal I, Grundy SM. Effect of combined supplementation with alpha-tocopherol, ascorbate, and beta carotene on low-density lipoprotein oxidation. Circulation 1993;88:2780-6.
15. Reaven PD, Khouw A, Beltz WF, Pathasarathy S, Wittzum JL. Effect of dietary antioxidant combinations in humans. Protection of LDL by vitamin E but not by beta-carotene. Arterioscler Thromb 1993;13:590-600.
16. Verlangieri AJ, Bush MJ. Effects of d-alpha-tocopherol supplementation on experimentally induced primate atherosclerosis. J Am Coll Nutr 1992;11:131-8.
17. Andersson TL, Matz J, Ferns GA, Anggård EE. Vitamin E reverses cholesterol-induced endothelial dysfunction in the rabbit coronary circulation. Atherosclerosis 1994;111:39-45.
18. Kushi LH, Folsom AR, Prineas RJ, Mink PJ, Wu Y, Bostick RM. Dietary antioxidant vitamins and death from coronary heart disease in postmenopausal women. N Engl J Med 1996;334:1156-62.
19. Rollapa JM, Virmanto J, Haukkka JK, Heinonen OP, Alabans D, Taylor PR, et al. Effect of vitamin E and beta carotene on the incidence of angina pectoris. A randomized, double-blind, controlled trial. JAMA 1996;275:693-8.
20. Malaspina JP, Bussière H, Le Calve G. The total cholesterol/ HDL cholesterol ratio: A suitable atherogenesis index. Atherosclerosis 1981;40:373-5.
21. Ohkawa H, Ohishi N, Yagi K. Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. Anal Biochem 1979;95:351-8.
22. Ellman GL. Tissue sulfhydryl groups. Arch Biochem Biophys 1959;82:70-7.
23. Verlecar XN, Jena KB, Chainy GB. Biochemical markers of oxidative stress in Perna viridis exposed to mercury and temperature. Chem Biol Interact 2007;176:219-26.
24. Kanungo SK, Panda DS, Swain SR, Barik BB, Tripathi DK. Comparative evaluation of hypolipidemic activity of some marketed herbal formulations in Triton induced hyperlipidemic rats. Pharmacol Online 2007;3:211-21.
25. Schurr PE, Schultz JR, Parkinson TM. Triton-induced hyperlipidemia in rats as an animal model for screening hypolipidemic drugs. Lipids 1972;7:68-74.
26. Khanna AK, Rivzi F, Chander R. Lipid lowering activity of *Phyllanthus niruri* in hyperlipemic rats. J Ethnopharmacol 2002;82:19-22.
27. Cignarella A, Nastasi M, Cavalli F, Puglisi L. Novel lipid-lowering properties of *Vaccinium myrtillus* L. leaves, a traditional antiadibiotic treatment, in several models of rat dyslipidaemia: A comparison with ciprofibrate. Thromb Res 1996;84:311-22.
28. Harnafi H, Bouanani N, Aziz M, Serghini Caid H, Ghalim N, Amrani S. The hypolipidaemic activity of aqueous Erica multiflora flowers extract in Triton WR-1339 induced hyperlipidaemic rats: A comparison with fenofibrate. J Ethnopharmacol 2007;109:156-60.
29. Otway S, Robinson DS. The effect of a non-ionic detergent (Triton WR 1339) on the removal of triglyceride fatty acids from the blood of the rat. J Physiol 1967;190:309-19.
30. Lee HS, Yoo CB, Ku SK. Hypolipemic effect of water extracts of *Picrorhiza kurroa* in high fat diet treated mouse. Fitoterapia 2006;77:579-84.
31. Vivekanandan P, Gobianand K, Priya S, Vijayanakshi P, Karthikeyan S. Protective effect of picroliv against hydrazine-induced hyperlipidemia and hepatic steatosis in rats. Drug Chem Toxicol 2007;30:241-52.
32. Maruthappan V, Shree KS. Hypolipidemic activity of haritaki (*Terminalia chebula*) in atherogenic diet induced hyperlipidemic rats. J Adv Pharm Technol Res 2010;1:229-35.
33. Saravanan S, Srikanth R, Manikandan S, Jeya Parthasarathy N, Sheela Devi R. Hypolipidemic effect of triphala in experimentally induced hypercholesteremic rats. Yakugaku Zasshi 2007;127:385-8.
34. Akhtar MS, Ramzan A, Ali A, Ahmad M. Effect of Amla fruit (*Emblica officinalis* Gaertn.) on blood glucose and lipid profile of normal subjects and type 2 diabetic patients. Int J Food Sci Nutr 2011;62:609-16.
35. Nohr LA, Rasmussen LB, Straand J. Resin from the mukul myrrh tree, guggul, can it be used for treating hypercholesterolemia? A randomized, controlled study. Complement Ther Med 2009;17:16-22.
36. Shukla B, Visen PK, Patnaik GK, Dhawan BN. Choleretic effect of picroliv, the hepatoprotective principle of *Picrorhiza kurroa*. Planta Med 1991;57:29-33.
37. Anila L, Vijayalakshmi NR. Flavonoids from *Emblica officinalis* and *Mangifera indica* -effectiveness for dyslipidemia. J Ethnopharmacol 2002;79:81-7.

How to cite this article: Kumar G, Srivastava A, Sharma SK, Gupta YK. The hypolipidemic activity of Ayurvedic medicine, *Arogyavardhini vati* in Triton WR-1339-induced hyperlipidemic rats: A comparison with fenofibrate. J Ayurveda Integr Med 2013;4:165-70.

Source of Support: Central Council for Research in Ayurveda and Siddha (CCRAS), Department of AYUSH, Ministry of Health and Family Welfare, Government of India for this research work is duly acknowledged (F. No. Z31014/04/2009/EMR-CCRAS), Conflict of Interest: None declared.