



Review Article

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AYURVEDIC DIETARY MANAGEMENT OF CARDIOVASCULAR DISORDERS DUE TO ELEVATED SERUM HOMOCYSTEINE WITH REFERENCE TO RASONA (*ALLIUM SATIVUM*): A REVIEW

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ABSTRACT

Cardiovascular disorders remain the leading cause of global morbidity and mortality with emerging metabolic risk factors receiving increasing attention. Among these, elevated plasma homocysteine, known as hyperhomocysteinemia, has been recognized as an independent and modifiable risk factor for cardiovascular diseases. Increased homocysteine levels contribute to endothelial dysfunction, atherosclerosis, thrombosis, and accelerated vascular aging¹⁴ through mechanisms such as oxidative stress, reduced nitric oxide bioavailability, inflammation, and disturbances in methylation pathways. Conventional management strategies primarily focus on supplementation with folic acid, vitamin B₆, and vitamin B₁₂; however, the role of dietary and lifestyle interventions in long-term cardiovascular protection continues to be an area of active research. Ayurveda, the traditional system of medicine, emphasizes disease prevention and health promotion through proper dietary regulation (Ahara), lifestyle discipline (Vihara), and rejuvenative therapy (Rasayana). Rasayana therapy aims to enhance tissue nourishment (Dhatu-poshana), improve metabolic efficiency (Agni), delay the aging process, and prevent degenerative changes, which conceptually correlate with mechanisms involved in cardiovascular pathology due to elevated serum homocysteine. This review aims to explore the biochemical basis of cardiovascular pathology due to elevated serum homocysteine and to analyze Ayurvedic dietary management strategies with special reference to Rasona (*Allium sativum*), a commonly used dietary and medicinal herb. By integrating classical Ayurvedic concepts with contemporary biomedical and nutritional evidence, this article attempts to provide a comprehensive perspective for the preventive and supportive management of cardiovascular disorders associated with elevated homocysteine levels.

Keywords: Cardiovascular disorder (CVDs), Homocysteine, Low density lipoprotein (LDL), HMG-CoA, Rasona (*Allium Sativum*).

INTRODUCTION

Cardiovascular disorders¹ (CVDs) and their associated metabolic risk factors represent a major global public health challenge, accounting for a significant proportion of premature mortality and long-term disability worldwide. While traditional risk factors such as hypertension, dyslipidemia, diabetes mellitus, smoking, and obesity⁴ are well recognized, increasing attention has recently been directed toward metabolic and biochemical factors that contribute to vascular injury. Among these emerging risk factors, elevated serum homocysteine¹¹ has gained considerable importance because of its potential role in the development and progression of cardiovascular diseases¹.

Homocysteine¹¹ is a sulfur-containing, non-proteinogenic amino acid that is formed as an intermediate during the metabolism of methionine. Under normal physiological conditions, homocysteine is rapidly metabolized through two major pathways: remethylation and trans-sulfuration. These metabolic processes require folate, vitamin B₁₂, and vitamin B₆ as essential cofactors for the proper conversion and clearance of homocysteine. Deficiency of these micronutrients, genetic polymorphisms affecting metabolic enzymes, advancing age, renal dysfunction, and unfavorable dietary patterns may lead to the accumulation of homocysteine in the circulation.



Figure 1: *Allium sativum*

Hyperhomocysteinemia

Elevated serum homocysteine, a condition known as hyperhomocysteinemia, has been associated with a wide range of cardiovascular disorders including coronary artery disease, cerebrovascular accidents, peripheral arterial disease, and venous thrombosis. Increased homocysteine levels exert several detrimental effects on the cardiovascular system, particularly on endothelial function. Homocysteine reduces nitric oxide bioavailability, thereby impairing endothelial-dependent vasodilation and promoting vascular stiffness. In addition, the auto-oxidation of homocysteine generates reactive oxygen species (ROS), which can induce lipid peroxidation and endothelial injury. These processes contribute to the acceleration of atherosclerosis and compromise vascular integrity, highlighting the significance of homocysteine as an important target for preventive and supportive cardiovascular care.¹²

Cardiovascular pathology

Elevated homocysteine levels have also been shown to enhance platelet aggregation, increase the expression of pro-coagulant factors, and stimulate smooth muscle cell proliferation within the vascular wall. These changes contribute to inflammatory responses and promote thrombus formation, thereby increasing the risk of cardiovascular events.

Accelerated Vascular Aging

Disruption of methylation reactions and increased oxidative stress associated with elevated homocysteine levels may lead to DNA damage and premature degeneration of vascular tissues. These mechanisms collectively contribute to accelerated vascular aging¹⁴ and progressive cardiovascular dysfunction.

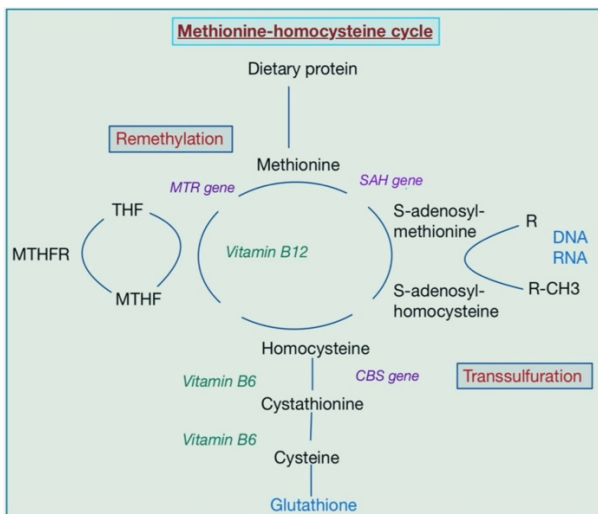


Figure 2: Methionine-Homocysteine Cycle

RATIONALE

Considering the growing burden of cardiovascular diseases and the limitations associated with single-nutrient interventions, there is an increasing need for integrative approaches that combine biochemical correction with long-term dietary and lifestyle modifications. In this context, exploring Ayurvedic dietary management through the concept of Rasayana offers a scientifically plausible and culturally relevant strategy for addressing cardiovascular disorders associated with elevated serum homocysteine.

India has experienced a significant rise in cardiovascular diseases over the past few decades². Conditions such as coronary artery disease (CAD), myocardial infarction, hypertension, cardioembolic stroke, and heart failure have emerged as major contributors to morbidity and mortality in the country. Currently, cardiovascular diseases account for approximately 28–30% of total deaths in India², making them the leading cause of mortality.

Given this increasing disease burden, there is a growing need for preventive and supportive strategies that focus not only on pharmacological management but also on long-term dietary and lifestyle regulation. Ayurveda, with its emphasis on Ahara (diet), Vihara (lifestyle), and Rasayana therapy, offers a holistic framework that may contribute to cardiovascular health and metabolic balance.

Therefore, this review aims to bridge classical Ayurvedic knowledge with contemporary biomedical understanding, highlighting the potential role of Rasona (*Allium sativum*)-based

dietary management in the prevention and supportive management of cardiovascular disorders associated with elevated serum homocysteine levels.

DISCUSSION

In recent decades, the incidence of cardiovascular diseases such as myocardial infarction and stroke has increasingly been reported even among younger individuals without classical risk factors such as hypertension²² or severe coronary obstruction. Emerging evidence suggests that elevated serum homocysteine plays a significant role as an independent metabolic risk factor in the development of cardiovascular disorders.

Homocysteine

Homocysteine¹¹ is a sulfur-containing, non-proteinogenic amino acid produced during the metabolism of methionine. Under normal physiological conditions, it is metabolized through remethylation and transsulfuration pathways, which require essential cofactors including vitamin B₆, vitamin B₉ (folate), and vitamin B₁₂. Deficiency of these nutrients, along with genetic, metabolic, and lifestyle-related factors, can impair homocysteine metabolism and result in its accumulation in the circulation. Elevated homocysteine¹¹ levels contribute to cardiovascular pathology through mechanisms such as oxidative stress, endothelial dysfunction, inflammation, platelet activation, and accelerated atherosclerosis.

Etiological factor (Nidana)

From the modern biomedical perspective, hyperhomocysteinemia is considered a multifactorial metabolic condition influenced by nutritional deficiencies, genetic polymorphisms, metabolic disorders, and lifestyle factors.

Nutritional deficiency of folic acid, vitamin B₆, and vitamin B₁₂ is the most common cause of elevated homocysteine levels. These vitamins act as essential cofactors in homocysteine metabolism. Inadequate dietary intake, malabsorption, aging, and restrictive diets⁴ may therefore contribute to its accumulation.

Genetic factors also play a significant role. Polymorphisms in enzymes involved in folate metabolism, particularly methylenetetrahydrofolate reductase (MTHFR), can impair the conversion of homocysteine to methionine, resulting in elevated circulating levels.

In addition, several metabolic and systemic disorders—including **renal dysfunction, hypothyroidism, diabetes mellitus, and chronic inflammatory states**—may interfere with homocysteine clearance. Aging is also associated with reduced vitamin absorption and declining enzymatic efficiency.

Lifestyle³ and dietary habits further influence homocysteine metabolism. High intake of processed foods⁶, diets⁴ rich in methionine (such as excessive red meat consumption), smoking, alcohol intake, physical inactivity⁵, psychological stress⁷, and irregular sleep³ patterns have been associated with increased homocysteine levels and vascular damage.

Ayurvedic Perspective

Although homocysteine is not described as a biochemical entity in classical Ayurvedic texts, its pathological manifestations can be understood through fundamental Ayurvedic concepts such as Mandagni (low appetite) Ama (Toxins) formation, Dhatu-kṣaya, and Srotodushti.

Mandagni (impaired digestive and metabolic fire) is considered the primary cause of metabolic disturbances in Ayurveda.

Impaired digestion and assimilation of nutrients may result in qualitative and quantitative nutritional deficiencies, which may conceptually correlate with disturbances in amino acid metabolism observed in hyperhomocysteinemia.

The accumulation of Ama (Toxins) representing toxic and incompletely metabolized substances, may obstruct physiological channels (Srotas) and lead to systemic metabolic disturbances. Elevated homocysteine levels producing oxidative stress and endothelial injury may be interpreted as a biochemical counterpart of Ama (Toxins)-induced pathology.

Furthermore, degeneration of vascular tissues may be correlated with Rasa and Rakta Dhatu dushti, while chronic nutritional deficiency and oxidative stress may contribute to Dhatu-kṣaya and Vata aggravation, which are commonly associated with degenerative cardiovascular disorders.

Lifestyle Factors Influencing Homocysteine Levels

Modern lifestyle patterns also play an important role in homocysteine metabolism. Irregular sleep patterns, Lack of exercise⁵, unhealthy dietary habits, and excessive consumption of processed⁶ or high-fat⁴ foods may contribute to metabolic imbalance and increased homocysteine levels. Chronic stress⁹ and sleep deprivation³ can influence endocrine responses and increase oxidative stress, thereby aggravating cardiovascular risk.

Role of Rasona (Allium sativum) as Ayurvedic and Dietary management

Ayurvedic management emphasizes a preventive, corrective, and rejuvenative approach, focusing on restoring metabolic balance and improving tissue nourishment. Dietary regulation (Ahara), lifestyle modification (Vihara), and rejuvenative therapy (Rasayana) play an important role in maintaining cardiovascular health.

Dietary measures that promote Agni-deepana and Ama-pachana help improve digestion and metabolic efficiency. Freshly prepared foods, whole grains, green gram, leafy vegetables, milk, ghee, fruits such as Amalaki, and adequate hydration are recommended as Pathya (beneficial foods), whereas processed foods⁶, excessive meat intake, alcohol, smoking, and fried foods are considered Apathya (harmful).

Lifestyle measures such as regular physical activity⁵, yoga, pranayama, stress⁷ management, and adequate sleep³ can help reduce oxidative stress and improve endothelial function.

Among Rasayana substances, Rasona (Allium sativum) occupies an important place in Ayurvedic therapeutics. Garlic contains bioactive compounds such as organosulfur compounds and S-allyl¹⁰ cysteine, along with essential micronutrients including vitamin B₆ and folates. These compounds possess antioxidant, lipid-lowering, antithrombotic, and cardioprotective properties. Evidence suggests that Rasona may help reduce serum homocysteine levels, inhibit cholesterol synthesis through HMG-CoA¹⁰ reductase inhibition, decrease platelet aggregation, and prevent atherosclerotic plaque formation.

Integrative Perspective: A Preventive Management

Hyperhomocysteinemia represents a metabolic and degenerative process that closely parallels Ayurvedic concepts of Mandagni, Ama(toxins) accumulation, Dhatu-kṣaya, and Vata aggravation. While modern medicine primarily focuses on biochemical correction through vitamin supplementation, Ayurveda provides a broader preventive framework emphasizing digestion, nutrition, lifestyle balance, and rejuvenation.

Therefore, an integrative approach combining dietary modification, lifestyle regulation, and Rasayana-based nutritional interventions such as Rasona (Allium sativum) may offer a sustainable strategy for the prevention and supportive management of cardiovascular disorders associated with elevated serum homocysteine levels.

Consequences of Untreated Hyperhomocysteinemia

Untreated hyperhomocysteinemia¹² can lead to progressive multisystem complications due to its sustained toxic effects on vascular endothelium, blood components, and metabolic homeostasis. Elevated homocysteine levels induce oxidative stress, endothelial dysfunction, inflammation, and pro-thrombotic states, which collectively contribute to the development and progression of cardiovascular and systemic disorders. From an Ayurvedic perspective, this pathological progression can be interpreted as chronic impairment of Agni, accumulation of Ama(toxins), progressive Dhatu-kṣaya, and aggravation of Vata, ultimately resulting in degenerative and life-threatening conditions.

Oxidative Stress and Endothelial Dysfunction

Persistently elevated homocysteine causes continuous oxidative stress and endothelial injury¹⁷. It reduces nitric oxide bioavailability, impairs vasodilation, and increases vascular stiffness. Additionally, homocysteine promotes the generation of reactive oxygen species (ROS), leading to lipid peroxidation and endothelial cell damage¹⁷. These processes compromise microvascular circulation and result in impaired tissue perfusion and chronic ischemia. Ayurvedic correlation: Continuous Rasavaha and Raktavaha Srotodushti leading to impairedp nourishment of Hrdayavaha Dhamanis.

Accelerated Atherosclerosis and Arterial Degeneration

Homocysteine contributes to the oxidation of low-density lipoproteins (LDL), proliferation of vascular smooth muscle cells, and increased collagen deposition in the arterial wall. These changes promote the early onset and rapid progression of atherosclerosis¹⁹, resulting in thickening and hardening of arteries and narrowing of coronary, cerebral, and peripheral vessels. Ayurvedic interpretation: Meda and Rakta Duṣṭi with dominant Vata involvement.

Increased Risk of Coronary Artery Disease and Myocardial Infarction

Chronic hyperhomocysteinemia is strongly associated with an increased risk of coronary artery disease, stable and unstable angina, coronary thrombosis, and acute myocardial infarction. Homocysteine enhances platelet aggregation and activates the coagulation cascade, which increases the likelihood of sudden vascular occlusion.

Ayurvedic correlation: Vataja Hrūdyā roga (cardiac dysfunction) progressing to Praṇavaha Srotodushti if untreated.

Cerebrovascular Complications

Elevated homocysteine significantly increases the risk of cerebrovascular disorders, including ischemic stroke, transient ischemic attacks, and silent cerebral infarctions. Long-term exposure to high homocysteine levels may also contribute to cognitive impairment, vascular dementia, and decline in memory and executive functions.

Ayurvedic interpretation: Praṇavaha and Manovaha Srotodushti (mental retardation and dementia) and with chronic Vata Prakopa.

Thromboembolic Disorders

Hyperhomocysteinemia has strong pro-thrombotic properties¹⁸. Untreated cases may lead to conditions such as deep vein thrombosis, pulmonary embolism, and recurrent pregnancy loss associated with placental insufficiency. These complications may occur even in individuals without significant lipid abnormalities. Ayurvedic view: Raktagata Vata with Srotorodha and increased Rukshata.

Hypertension and Cardiac Dysfunction

Sustained endothelial dysfunction²¹ and arterial stiffness contribute to impaired blood pressure i.e hypertension²² regulation. Increased vascular resistance and afterload may lead to progressive cardiac dysfunction and left ventricular hypertrophy and eventually chronic heart failure. Ayurvedic correlation: Hrudaya Daurbalya (Low Ejection fraction) due to chronic Dhatu-kshaya (nutritional deficiency) and depletion of Ojas (low immunity).

Systemic Oxidative Stress and Accelerated Aging

Elevated homocysteine levels are associated with mitochondrial dysfunction²¹, DNA damage, impaired methylation reactions, and premature cellular senescence. Clinically, these processes manifest as early aging¹⁴, fatigue, reduced immunity, and impaired tissue repair.

Ayurvedic interpretation: Jara-pravṛtti (premature aging) associated with Rasa-kṣaya (malnutrition or nutritional deficiency) and dominant Vata aggravation.

Interaction with Other Metabolic Disorders

Elevated homocysteine can exacerbate complications in patients with metabolic disorders such as diabetes mellitus, metabolic syndrome, and chronic kidney disease. The coexistence of these conditions produces synergistic effects that significantly increase cardiovascular morbidity and mortality.

Ayurvedic view: Samsarga of Kapha and Pitta with Vata, leading to complex forms of Srotodushti (oxidative stress).

Reduced Quality of Life and Increased Mortality

If left untreated, the cumulative effects of hyperhomocysteinemia and its complications can significantly impair quality of life²⁰. Patients may experience reduced physical capacity, psychological stress⁹, recurrent hospitalizations, and an increased risk of premature mortality.

From a preventive medicine perspective, untreated hyperhomocysteinemia represents a missed opportunity for early cardiovascular risk reduction and timely intervention.

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CONCLUSION

Hyperhomocysteinemia is a clinically significant and modifiable risk factor contributing to cardiovascular diseases through endothelial dysfunction, oxidative stress, inflammation, and thrombogenesis. From an Ayurvedic perspective, this condition can be correlated with Mandagni (Low appetite), Ama(toxins) accumulation, Srotodushti (oxidative stress), Dhatu-kshaya (nutritional deficiency), and Vata predominance, leading to impaired tissue nourishment and vascular dysfunction.

Rasona (*Allium sativum*), a commonly used dietary component, exhibits cardioprotective effects due to its organosulfur compounds and essential micronutrients. Its antioxidant, hypolipidemic, antithrombotic, and endothelial-protective properties may help reduce homocysteine levels and improve vascular health.

An integrative approach involving Ayurvedic dietary management, lifestyle modification, and Rasayana-based interventions such as Rasona may serve as a safe and effective strategy for the prevention and supportive management of cardiovascular disorders. However, further well-designed clinical studies are required to validate these findings and to establish standard therapeutic protocols.

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