Original Article

Correlation of serum lactate dehydrogenase, calcium and magnesium levels between healthy individuals and coronary artery disease patients: A case-control study

Palak Meena[1], Harmohinder Kumar Attri[2], Sat Pal Aloona[3], Jasvir Singh[4]

[1]Junior Resident, Department of Biochemistry, Government Medical College, Amritsar, India, [2]Associate Professor, Department of Biochemistry, Government Medical College, Amritsar, India, [3]Professor, Department of Medicine, Government Medical College, Amritsar, India, [4]Professor, Department of Biochemistry, Government Medical College, Amritsar, India

Abstract

Background: Coronary artery disease involves complex interactions between myocardial injury markers and mineral homeostasis. Magnesium, a physiological calcium antagonist, is underexplored relative to lactate dehydrogenase in the Indian population. The objective is to compare serum lactate dehydrogenase, calcium, and magnesium levels between coronary artery disease patients and healthy controls, and to evaluate their inter-relationships. **Material and Methods:** This case-control study enrolled 100 diagnosed coronary artery disease patients and 100 age- and gender-matched healthy controls. Serum lactate dehydrogenase was measured by kinetic method, calcium by orthocresolphthalein complexone method, and magnesium by xylidyl blue method. Statistical analysis used Student t test and Pearson correlation coefficient. **Results:** Coronary artery disease patients had significantly higher serum calcium (9.94 ± 0.42 versus 9.21 ± 0.38 milligram per decilitre, P less than 0.001) and lactate dehydrogenase (352.8± 68.4 versus 172.6 ± 22.4 units per litre, P less than 0.001), and lower magnesium (1.68 ± 0.24 versus 2.14 ± 0.28 milligram per decilitre, P less than 0.001). Hypomagnesemia was present in all 100 coronary artery disease patients. Significant correlations emerged in the disease group: negative correlation between magnesium and lactate dehydrogenase (r equals -0.586, P less than 0.001) and between calcium and magnesium (r equals -0.624, P less than 0.001). No significant correlations were found in controls. Hypertensive and diabetic patients showed the most severe biochemical abnormalities. **Conclusion:** Universal hypomagnesemia and its strong correlation with elevated lactate dehydrogenase highlight magnesium deficiency as a critical factor in coronary artery disease. Routine magnesium assessment should be mandatory in all such patients.

Keywords: Coronary artery disease, magnesium, lactate dehydrogenase, calcium, hypomagnesemia, case-control study.

Received: 05 April 2026 **Revised: 22 April 2026** **Accepted: 08 May 2026** **Published: 12 May 2026**

Introduction

Coronary artery disease is characterized by atherosclerotic plaque accumulation within epicardial arteries, compromising regional myocardial blood flow.[1] The clinical spectrum encompasses chronic stable angina and acute coronary syndromes including ST-segment elevation myocardial infarction, non-ST-segment elevation myocardial infarction, and unstable angina.[2] Indians face a threefold to fourfold higher risk compared to white Americans and sixfold higher risk relative to Chinese populations.[3] Calcium and magnesium homeostasis is fundamental for vascular function, metabolism, and intracellular signalling.[4] Serum calcium has been identified as an independent predictor of cardiovascular disease.[5]

Magnesium, the second most abundant intracellular cation, functions as nature's physiologic calcium blocker and participates in over 300 biochemical reactions.[6,7] Magnesium deficiency is linked to ischemic heart disease, sudden cardiac death, atherosclerosis.[8] A meta-analysis found that each 0.2 milligram per decilitre increase in circulating magnesium was associated with a 30 percent lower cardiovascular risk.[9] Lactate dehydrogenase is a cytoplasmic enzyme with highest concentrations in myocardium, and it's elevation in coronary artery disease reflects the magnitude of myocardial necrosis.[10,11]

Serum calcium and lactate dehydrogenase share an inverse relationship that correlate with disease severity, yet their tri-directional interplay with magnesium unexplored.[12,13] The present study addresses this gap.

Materials and Methods

This case-control study was conducted in the Department of Biochemistry in collaboration with the Department of Medicine.

Address for correspondence: Dr. Harmohinder Kumar Attri, Associate Professor, Department of Biochemistry, Government Medical College, Amritsar,Punjab, India.
E-mail: harmohinderattri@gmail.com

DOI:
10.21276/amit.2026.v13.i2.653

How to cite this article: Meena P, Attri HK, Aloona SP, Singh J. Correlation of serum lactate dehydrogenase, calcium and magnesium levels between healthy individuals and coronary artery disease patients: A case-control study. Acta Med Int. 2026;13(2):97-101.

The Institutional Ethics Committee approved the study (Reference No. 40781/D-26/2023 Batch, dated 26-11-2024). Written informed consent was obtained from all participants. Two hundred subjects were enrolled in current study. Group 1 comprised 100 newly diagnosed coronary artery disease patients including ST-segment elevation myocardial infarction and non- ST-segment elevation myocardial infarction, confirmed by clinical history, electrocardiography, and echocardiography. Group 2 comprised 100 age- and gender-matched healthy individuals with no history of coronary artery disease. Patients aged 30 to 79 years were included. Exclusion criteria comprised age below 30 or above 80 years, kidney disease, liver disease, tuberculosis, muscular dystrophy, pancreatitis, alcohol abuse, haemolytic anaemia, thyroid disorders, celiac disease, rickets, bone disorders, and any malignancy.

Detailed history including diabetes mellitus, hypertension, smoking, lifestyle, past angina or myocardial infarction, family history, and treatment was recorded. All subjects underwent systemic examination.

Fasting venous blood samples of 5 millilitre were collected from the antecubital vein under aseptic precautions into red and grey top vacutainers. Blood was allowed to clot for 30 minutes and centrifuged to separate serum.

Serum calcium was estimated by O-Cresol phthalein Complexone colorimetric end point method. Serum magnesium was estimated by colorimetric xylidyl blue end point method. Serum lactate dehydrogenase was measured by Deutsche Gesellschaft fur Klinische Chemie kinetic method.

Data were analysed using Statistical Package for Social Sciences software version 2021. Continuous variables were expressed as Mean ± Standard Deviation. Student t test compared group means. Pearson correlation coefficient assessed relationships between parameters. P value less than 0.05 was considered statistically significant.

Results

The mean age of coronary artery disease patients was 58.6 ± 14.2 years versus 57.8 ± 15.1 years in controls (P equals 0.694). Gender distribution was 58 percent males and 42 percent females in the disease group versus 55 percent males and 45 percent females in controls (P equals 0.672). Groups were well-matched [Figure 1].

Coronary artery disease patients showed significantly elevated serum calcium (9.94 ± 0.42 versus 9.21 ± 0.38 milligram per decilitre, P less than 0.001) and lactate dehydrogenase (352.8± 68.4 versus 172.6 ± 22.4 units per litre, P less than 0.001), with significantly lower magnesium (1.68 ± 0.24 versus 2.14 ± 0.28 milligram per decilitre, P less than 0.001). Mean magnesium in patients was below the normal range of 1.8 to 2.4 milligram per decilitre, and all 100 patients had hypomagnesemia [Table 1].

Serum magnesium declined progressively with age from 1.91 ± 0.08 milligram per decilitre at 30-40 years to 1.51 ± 0.10 milligram per decilitre at 71-79 years (P less than 0.001). Lactate dehydrogenase increased progressively from 281.5 ± 22.4 to 401.8 ± 62.4 units per litre (P less than 0.001). Calcium peaked in the 51-60 years age group at 10.08 ± 0.38 milligram per decilitre [Table 2].

Significant correlations emerged exclusively in patients, not in controls. In the disease group, strong negative correlations were found between calcium and magnesium (r equals -0.624, P less than 0.001) and between magnesium and lactate dehydrogenase (r equals -0.586, P less than 0.001). A moderate positive correlation was noted between calcium and lactate dehydrogenase (r equals +0.412, P equals 0.008). In controls, no significant correlations emerged between any parameters [Table 3].

Among patients, 62 percent had hypertension and 48 percent had diabetes. Hypertensive patients had significantly higher calcium (10.02 versus 9.82 milligram per decilitre, P equals 0.018), lower magnesium (1.62 versus 1.78 milligram per decilitre, P equals 0.002), and higher lactate dehydrogenase (368.4 versus 328.6 units per litre, P equals 0.004) compared to normotensive patients [Table 4]. Diabetic patients had higher calcium (10.04 versus 9.86 milligram per decilitre, P equals 0.024), lower magnesium (1.60 versus 1.74 milligram per decilitre, P equals 0.006), and higher lactate dehydrogenase (372.8 versus 338.2 units per litre, P equals 0.008) compared to non-diabetic patients [Table 5]. Smoking, present in 44 percent, showed trends but no significant differences. No significant gender differences were observed in either group for any parameter.

Table 1: Comparison of Biochemical Parameters Between CAD and Control Groups

Parameter	CAD Group (n=100) Mean ± SD	Control Group (n=100) Mean ± SD	p-value
Serum Calcium (mg/dL)	9.94 ± 0.42	9.21 ± 0.38	<0.001
Serum Magnesium (mg/dL)	1.68 ± 0.24	2.14 ± 0.28	<0.001
Serum LDH (U/L)	352.8 ± 68.4	172.6 ± 22.4	<0.001

Table 2: Age-wise Distribution of Parameters in CAD Patients (n=100)

Age Group	n (%)	Serum Calcium (mg/dL) Mean ± SD	Serum Magnesium (mg/dL) Mean ± SD	LDH (IU/L) Mean ± SD
30-40 years	12	9.85 ± 0.28	1.91 ± 0.08	281.5 ± 22.4
41-50 years	18	9.96 ± 0.36	1.81 ± 0.12	311.8 ± 32.6
51-60 years	22	10.08 ± 0.38	1.71 ± 0.14	341.2 ± 42.8
61-70 years	28	9.98 ± 0.42	1.61 ± 0.12	372.4 ± 52.6
71-79 years	20	9.86 ± 0.44	1.51 ± 0.10	401.8 ± 62.4
p-value (trend)	-	0.042	<0.001	<0.001

Table 3: Correlation Between Parameters in CAD Patients vs. Healthy Controls

Parameter	CAD Patients (n=100)		Healthy Controls (n=100)	
	r-value	p-value	r-value	p-value
Calcium vs Magnesium	-0.624	<0.001	+0.186	0.124

Calcium vs LDH	+0.412	0.008	-0.142	0.216
Magnesium vs LDH	-0.586	<0.001	-0.168	0.158

Table 4: Comparison Based on Hypertension in CAD Patients

Risk Factor	Hypertensive (n=62) Mean ± SD	Normotensive (n=38) Mean ± SD	p-value
Serum Calcium	10.02 ± 0.42	9.82 ± 0.38	0.018
Serum Magnesium	1.62 ± 0.22	1.78 ± 0.24	0.002
Serum LDH	368.4 ± 68.2	328.6 ± 62.4	0.004

Table 5: Comparison Based on Diabetes Mellitus in CAD Patients

Risk Factor	Diabetic (n=48) Mean ± SD	Non-Diabetic (n) Mean ± SD	p-value
Serum Calcium	10.04 ± 0.44	9.86 ± 0.40	0.024
Serum Magnesium	1.60 ± 0.20	1.74 ± 0.26	0.006
Serum LDH	372.8 ± 70.4	338.2 ± 64.8	0.008

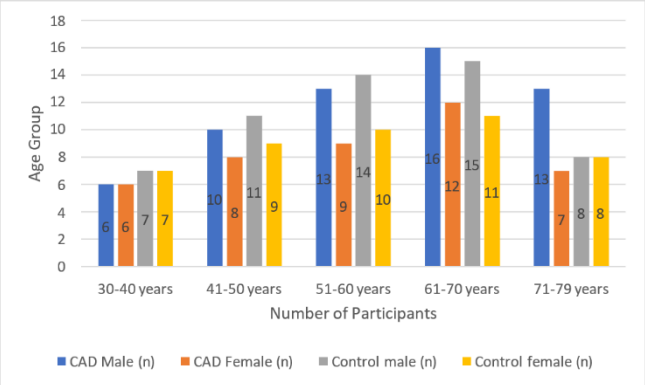

Figure 1: Age and gender distribution between coronary artery disease patients (n=100) and healthy controls (n=100) showing successful matching.

Discussion

This study reveals a distinct biochemical triad in coronary artery disease: elevated calcium, depressed magnesium, and elevated lactate dehydrogenase. The universal hypomagnesemia and its correlation with myocardial injury markers carry significant clinical implications.

The 100 percent prevalence of hypomagnesemia in this cohort far exceeds Western reports. Kieboom and colleagues in the Rotterdam Study found that only 15 percent of participants had magnesium below 1.8 milligram per decilitre, which was associated with a 36 percent higher coronary heart disease risk and 54 percent higher sudden cardiac death risk.[14] The mean magnesium of 1.68 milligram per decilitre in the present patients is 0.46 milligram per decilitre lower than controls, implying a substantially elevated cardiovascular risk based on the meta-analysis where each 0.2 milligram per decilitre increase was associated with 30 percent lower risk.[9]

Rooney and colleagues in the Atherosclerosis Risk in Communities study involving 14000 participants over 27 years found that serum magnesium decreased by approximately 0.1 milligram per decilitre per decade and each 0.1 milligram per decilitre decrease was associated with a 15 percent increased risk of incident coronary artery disease.[15] The present study showed a decline of 0.4 milligram per decilitre from the youngest to the oldest group over approximately four decades, closely matching their reported rate of decline.

Magnesium deficiency promotes coronary vasoconstriction, elevates intracellular calcium, generates oxygen radicals, promotes proinflammatory mediators, and alters membrane permeability.[16] In India, low consumption of magnesium-rich foods including seeds, nuts, and whole grains, and high intake of refined carbohydrates may contribute to widespread deficiency. Chrysant highlighted that hypomagnesemia is strongly associated with hypertension and cardiovascular diseases through multiple mechanisms including endothelial dysfunction and increased vascular reactivity.[17]

A key theoretical finding is that significant correlations between parameters emerge only in the disease state. In healthy controls, calcium, magnesium, and lactate dehydrogenase vary independently within narrow homeostatic ranges. In disease, these systems become coupled and dysregulated. This aligns with the Network Medicine concept where disease creates new pathological interactions between independent biomarkers.[18]

The negative correlation between calcium and magnesium (r equals -0.624) confirms physiological competition between these cations. Iseri and French in their classic paper described magnesium as nature's physiologic calcium blocker, demonstrating that magnesium competes with calcium for binding sites on voltage-gated channels, receptor-operated channels, and intracellular calcium-binding proteins.[7]

The strong negative correlation in the present study provides clinical evidence supporting this competitive mechanism and suggests that this competition is particularly pronounced in coronary artery disease.

The negative correlation between magnesium and lactate dehydrogenase (r equals -0.586) is the most clinically significant finding, indicating that lower magnesium is associated with greater myocardial damage. Liu and Dudley demonstrated that magnesium deficiency creates a proinflammatory, prooxidant state through nuclear factor kappa B activation and increased inflammatory cytokine production including tumour necrosis factor alpha and interleukin-6.[16]

The present correlation provides clinical evidence supporting these mechanisms, with magnesium status explaining approximately 34 percent of lactate dehydrogenase variance.

Li and colleagues in 2024 provided a novel immunological mechanism linking elevated lactate dehydrogenase to poorer outcomes. They demonstrated that higher serum lactate dehydrogenase levels correlated negatively with natural killer cell proliferation capacity and that natural killer cells from patients with high lactate dehydrogenase had reduced cytotoxic

activity and impaired interferon gamma production.[19] This dual role of lactate dehydrogenase as a marker of tissue injury and immune dysfunction represents an emerging paradigm in cardiovascular immunometabolism.

Gao and colleagues found that lactate dehydrogenase correlated significantly with infarct size measured by cardiac magnetic resonance imaging and that patients with enzyme levels greater than 350 units per litre had 2.5 times higher 30-day mortality.[20]

In the present study, patients aged 61-70 years had lactate dehydrogenase of 372.4 units per litre and those aged 71-79 years had 401.8 units per litre, both exceeding their high-risk threshold.

Zhu and colleagues found that higher lactate dehydrogenase levels were independently associated with increased arterial stiffness and higher 10-year cardiovascular disease risk with an odds ratio of 1.21 for values above the median.[21] These findings complement the present observations, suggesting that lactate dehydrogenase elevation may represent a risk marker across the cardiovascular disease continuum.

Pescatore and colleagues demonstrated that elevated extracellular calcium above 10 milligram per decilitre promotes osteogenic differentiation and calcification through activation of the calcium-sensing receptor and Wnt/beta-catenin signalling in vascular smooth muscle cells.[22]

The present finding that the 51-60 years group had calcium of 10.08 milligram per decilitre suggests this age group may be at particular risk for vascular calcification.

Hypertensive and diabetic patients showed the worst biochemical profiles. Gommers and colleagues demonstrated that hypomagnesemia in diabetes results from osmotic diuresis- induced urinary loss, reduced intestinal absorption due to autonomic neuropathy, and impaired tubular reabsorption, creating bidirectional worsening of insulin resistance.[23] Rosique-Esteban and colleagues emphasized that dietary magnesium intake is inversely associated with cardiovascular disease risk across multiple epidemiological studies.[24] Diabetic patients in the present study had the highest calcium, lowest magnesium, and highest lactate dehydrogenase, identifying this subgroup at highest risk.

The single-centre design limits generalizability. The case-control design precludes causal inference. Serum magnesium reflects only approximately 1 percent of total body stores. Dietary intake and medication effects were not assessed. Long-term outcome data are unavailable. Randomized controlled trials are needed to confirm the therapeutic benefit of magnesium repletion.[25]

Conclusion

Coronary artery disease patients exhibit a distinct biochemical profile of elevated calcium, profoundly depressed magnesium, and elevated lactate dehydrogenase. Universal hypomagnesemia and the strong negative correlation between magnesium and lactate dehydrogenase highlight magnesium deficiency as a critical, underrecognized factor in disease pathophysiology. Significant correlations emerge exclusively in the disease state, suggesting breakdown of homeostatic mechanisms and creation of pathological interactions. Routine serum magnesium assessment should be mandatory in all coronary artery disease patients, and magnesium supplementation in deficient patients may represent a cost-effective strategy.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Libby P, Theroux P. Pathophysiology of coronary artery disease. Circulation. 2005;111(25):3481-8.
2. Bhatt DL, Lopes RD, Harrington RA. Diagnosis and treatment of acute coronary syndromes: a review. JAMA. 2022;327(7):662-75.
3. Enas EA, Garg A, Davidson MA, Nair VM, Huet BA, Yusuf S. Coronary heart disease and its risk factors in first-generation immigrant Asian Indians to the United States of America. Indian Heart J. 1996;48(4):343-53.
4. Blaine J, Chonchol M, Levi M. Renal control of calcium, phosphate, and magnesium homeostasis. Clin J Am Soc Nephrol. 2015;10(7):1257-72.
5. Reid IR, Birstow SM, Bolland MJ. Calcium and cardiovascular disease. Endocrinol Metab. 2017;32(3):339-49.
6. Swaminathan R. Magnesium metabolism and its disorders. Clin Biochem Rev. 2003;24(2):47-66.
7. Iseri LT, French JH. Magnesium: nature's physiologic calcium blocker. Am Heart J. 1984;108(1):188-93.
8. DiNicolantonio JJ, OKeefe JH, Wilson W. Subclinical magnesium deficiency: a principal driver of cardiovascular disease and a public health crisis. Open Heart. 2018;5(1):e000668.
9. Del Gobbo LC, Imamura F, Wu JH, de Oliveira Otto MC, Chiuve SE, Mozaffarian D. Circulating and dietary magnesium and risk of cardiovascular disease: a systematic review and meta-analysis of prospective studies. Am J Clin Nutr. 2013;98(1):160-73.
10. Geng YJ, Libby P. Progression of atheroma: a struggle between death and procreation. Arterioscler Thromb Vasc Biol. 2002;22(9):1370-80.
11. Kavsak PA, Worster A, Shortt C, Ma J, Clayton N, Sherbino J, et al. Performance of high- sensitivity cardiac troponin and lactate dehydrogenase in the emergency department. Clin Chem. 2017;63(8):1350-7.
12. Stoner RE, Williams JB, Connor TB, Brager SH. Inverse relationship between serum calcium concentration and serum lactic dehydrogenase activity. Metabolism. 1971;20(5):464- 73.
13. Peppes V, Rammos G, Manios E, Koroboki E, Rokas S, Zakopoulos N. Correlation between myocardial enzyme serum levels and severity of coronary artery disease. Clin Interv Aging. 2008;3(4):699-710.
14. Kieboom BC, Kiefte-de Jong JC, Stricker BH, Rivadeneira F, Franco OH, Hoorn EJ, et al. Serum magnesium and the risk of death from coronary heart disease and sudden cardiac death. J Am Heart Assoc. 2016;5(1):e002707.
15. Rooney MR, Pankow JS, Sibley SD, Selvin E, Reis JP, Michos ED, et al. Serum magnesium and the incidence of coronary artery disease over a median 27 years of follow-up in the Atherosclerosis Risk in Communities Study. Am J Clin Nutr. 2020;111(1):52-60.
16. Liu M, Dudley SC Jr. Magnesium, oxidative stress, inflammation, and cardiovascular disease. Antioxidants. 2020;9(10):907.
17. Chrysant SG, Chrysant GS. Association of hypomagnesemia with cardiovascular diseases and hypertension. Int J Cardiol Hypertens. 2019;1:100005.

18. Loscalzo J, Barabási AL, Silverman EK, editors. Network Medicine: Complex Systems in Human Disease and Therapeutics. Cambridge, MA: Harvard University Press; 2017.
19. Li XJ, Li L, Gao Q, Lai B, Liu X, Zhong Z, et al. Proliferation capability of natural killer cells upon cytokines stimulation correlated negatively with serum lactate dehydrogenase level in coronary artery disease patients. Front Immunol. 2024;15:1436747.
20. Gao L, Hu C, Chen X, Yang Y, Yao Y, Li L, et al. Serum lactate dehydrogenase and its association with infarct size and 30-day mortality in patients with acute ST-elevation myocardial infarction. J Geriatr Cardiol. 2019;16(7):533-40.
21. Zhu W, Ma Y, Guo W, Lu J, Li X, Wu J, et al. Serum level of lactate dehydrogenase is associated with cardiovascular disease risk as determined by the Framingham Risk Score and arterial stiffness in a health-examined population in China. Int J Gen Med. 2022;15:11-7.
22. Pescatore LA, Gamarra LF, Liberman M. Multifaceted role of calcium in vascular smooth muscle cell differentiation and calcification. Arterioscler Thromb Vasc Biol. 2019;39(7):1307- 16.
23. Gommers LMM, Hoenderop JGJ, Bindels RJM, de Baaij JHF. Hypomagnesemia in type 2 diabetes: a vicious circle? Diabetes. 2016;65(1):3-13.
24. Rosique-Esteban N, Guasch-Ferré M, Hernández-Alonso P, Salas-Salvadó J. Dietary magnesium and cardiovascular disease: a review with emphasis in epidemiological studies. Nutrients. 2018;10(2):168.
25. Houston M. The role of magnesium in hypertension and cardiovascular disease. J Clin Hypertens. 2011;13(11):843-7.