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Original Article

Correlation between Coronary Vascular Calcification and Intra-dialytic Blood Pressure Variation

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ABSTRACT

Objective: To study correlation between coronary artery calcification and intra-dialytic blood pressure variation.
Study Design: Comparative Cross-Sectional Study.
Place and Duration of Study: Department of Internal Medicine, Pakistan Emirates Military Hospital, Rawalpindi Pakistan, from Sep 2024 to Apr 2025.
Methodology: Individuals of either gender between 30 and 65 years of age with end-stage renal disease on maintenance hemodialysis were included. Group-A had coronary artery calcification, and Group-B had no coronary artery calcification. Coronary artery calcification was qualitatively measured by computed tomography Chest, while coronary artery calcium score was quantitatively measured using Agatston score. Coronary artery calcification was independent variable, and Intra-dialytic blood pressure variation was dependent variable. Spearman's rank correlation analysis was used to see a correlation between coronary artery calcification and intradialytic pressure variation.
Results: Median age of 90(100%) participants was 47.00 (39.75-53.00) years. There were 52(57.78%) males and 38(42.22%) females. Majority of patients in Group-A had severe disease risk 20(22.22%), followed by moderate disease risk 18(20.00%). Median coronary artery calcium score in Group-A was 379.50 (136.00-538.25) HU. Correlation analysis found no significant correlation between coronary artery calcium score and intra-dialytic blood pressure variability for both systolic and diastolic blood pressures. However, coronary artery calcium score was statistically correlated with serum calcium levels and intra-dialytic hypotension.
Conclusion: There was no correlation between coronary artery calcification and intra-dialytic blood pressure variability in dialysis-dependent end-stage renal disease patients.
Keywords: End-Stage Kidney Disease, Hypotension, Hemodialysis, Pathologic calcification, Spearman Rank Correlation Coefficient.

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INTRODUCTION

A decline in renal function characterises end-stage renal disease (ESRD). It is most commonly managed with renal replacement therapies like hemodialysis (HD) or peritoneal dialysis, and, in some instances, renal transplant is sought as treatment.[1] Up to 50% of individuals undergoing renal replacement therapy will experience intra-dialytic hypotension (IDH) or blood pressure variability, which was also variably defined by specific parameters like decrease in Blood Pressure (BP) or some attributable symptoms.[2] Intra-dialytic blood pressure variations have been reported to be associated with increased morbidity, mortality, and poor patient outcomes.[3,4]

Many mechanisms for vascular calcification have been proposed, such as abnormal differentiation of vascular smooth muscle cells and dysfunctions of calcification regulators/ pathways.[5] In a study by Mizuiri *et al.*, patients with both IDH and coronary artery calcium Score (CACS) of ≥1829 had lower 3-year cumulative survival from cardiovascular death (66.7%) than those with a CACS of ≥1829 (80.3%), IDH (88.5%), or neither (95.5%) (p<0.01). A multitude of factors contribute to, or increase vascular calcification.[6] The average real variability (ARV) in diastolic BP had the largest intraclass correlation coefficient (ICC 0.52, 95% Confidence Interval: 0.44-0.60), while the ARV in systolic blood pressure had the smallest intraclass correlation coefficient (ICC 0.39, 95% Confidence Interval: 0.30-0.49), hence no notable difference was found.[7] Yeo *et al.*, found no relationship between blood pressure variability and coronary artery calcification (CAC).[8] On the contrary, research by Cho *et al.*, found a significant relationship between vascular calcification and IDH.[9] These varying degrees of results and limited data available in our setups raise need for further research.

Considering aforementioned, this study was designed to investigate correlation between intra-dialytic blood pressure variability and coronary

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vascular calcification. The findings aim to emphasise significance of CAC and raise awareness among physicians and clinicians regarding managing early vascular calcification.

METHODOLOGY

This comparative cross-sectional study was carried out at Department of Internal Medicine, Pakistan Emirates Military Hospital, Rawalpindi Pakistan, in collaboration with Department of Cardiology and Radiology, from September 2024 to April 2025, over 8 months. Ethical review was sought from Ethical Review Board of Pak Emirates Military Hospital; board approved research protocol vide certificate number A/28/ERC/27/2025. After explaining purpose and procedure of study, informed consent was obtained from all participants.

Inclusion Criteria: Patients of either gender between 30 and 65 years of age with ESRD as per KDIGO (Kidney Disease: Improving Global Outcomes) classification, who were on maintenance HD at least twice weekly for at least 3 months were included.

Exclusion Criteria: We excluded patients who had coronary artery disease, sepsis, received coronary artery stenting, were pregnant, or were planning to become pregnant. We also excluded patients taking calcium supplements or medications that affected calcium levels. Additionally, those who could not or did not want to participate in study were excluded.

Sample size was calculated using Select Statistical Calculator with a coronary artery calcification prevalence of 12.9%, a confidence interval of 95%, and a margin of error of 7%.[10] The required sample size was 89. Consecutive sampling technique was used. After assessing patients per inclusion and exclusion criteria, basic demographic details (gender, age) and clinical parameters (hemodialysis vintage and frequency, relevant history and examination) were documented. Patients were divided into Group-A and Group-B. Group-A included patients with coronary vascular calcification who met inclusion and exclusion criteria. Group-B included patients with no coronary artery calcification per inclusion and exclusion criteria. Investigations included serum creatinine, haemoglobin, and serum calcium. Coronary artery calcification was assessed qualitatively through computed tomography (CT) of chest. Additionally, coronary artery calcium score (CACS) was determined quantitatively using Agatston scoring method.[11] The patient flow diagram is given as Figure.

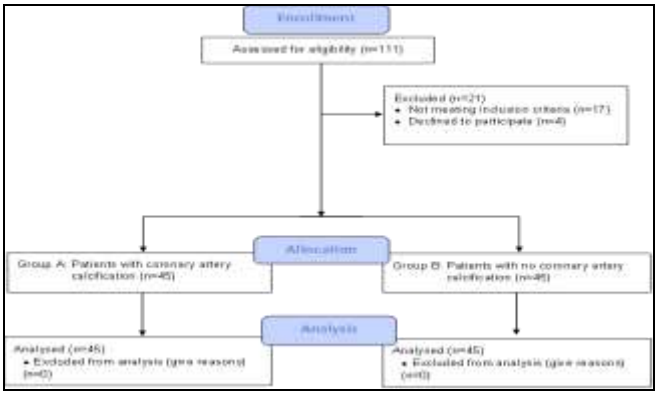

Figure: Patient Flow Diagram (n=111)

Hypotension was labelled when systolic blood pressure recorded below 90 mmHg or greater than 20 mmHg fall. A fall in systolic blood pressure was observed from the blood pressure at start of HD, or whether there was a requirement for fluid bolus administration. Intradialytic hypotension was defined as greater than two episodes of hypotension during HD over 10 sessions.

The statistical tool for analysis and computing was Statistical Package for Social Sciences (SPSS) version 25.0. Data distribution was checked using Shapiro-Wilk Test. Age, hemodialysis vintage, systolic blood pressure, diastolic blood pressure, CACS, serum creatinine, serum calcium, and serum albumin were not normally distributed, and median, along with interquartile range (IQR:25%-75%) was used for data presentation of these variables. Mean and standard deviation (SD) was used for haemoglobin as it was normally distributed. Gender, comorbid conditions, vascular access, epoetin alpha usage frequency, IDH, and CACS risk were represented using frequency and percentages. Spearman's rank correlation was utilized for establishing a correlation between age, hemodialysis vintage, systolic blood pressure, diastolic blood pressure, serum creatinine, serum calcium, serum albumin, and CACS. Pearson's correlation was used to analyse the relationship between haemoglobin and CACS. A *p*-value of ≤0.05 was considered significant.

RESULTS

The study included 90 participants. Median age of participants was 47.00 (39.75-53.00) years. There were 52(57.78%) males and 38(42.22%) females. Arteriovenous fistula as vascular access was present in 59(65.56%) patients, while 53(58.89%) patients had hypertension. Details are shown in Table-I.

Table-I: Demographic characteristics of study population (n=90)

Variables	Total Population (n=90)	Groups	
		Group-A (n=45)	Group-B (n=45)
Median Age, years	47.00 (39.75-53.00)	49.00 (44.00-52.50)	45.00 (38.00-53.50)
Gender, n(%)			
Male	52(57.78%)	28(62.22%)	24(53.33%)
Female	38(42.22%)	17(37.78%)	21(46.67%)
Hypertension, n(%)	53(58.89%)	29(64.44%)	24(53.33%)
Diabetes Mellitus, n(%)	28(31.11%)	17(37.78%)	11(24.44%)
Vascular Access, n(%)			
Arteriovenous fistula	59(65.56%)	27(60.00%)	32(71.11%)
Double Lumen Catheter	8(8.89%)	4(8.89%)	4(8.89%)
Tunnelled Double Lumen Catheter	23(25.56%)	14(31.11%)	9(20.00%)

Majority of patients in Group-A had severe disease risk 20(22.22%) followed by moderate disease risk 18(20.00%). Participants had a median hemodialysis vintage of 16.00 (11.00-21.00) months. Median CACS was 379.50 (136.00-538.25) HU in Group-A. Mean haemoglobin (Hb) was 12.37±1.20 g/dL, and median albumin was 34.00 (31.00-37.00) g/L as shown in Table-II.

Table-II: Clinical characteristics of study population (n=90)

Variables	Total Population (n=90)	Groups	
		Group-A (n=45)	Group-B (n=45)
Hemodialysis Vintage, months	16.00 (11.00-21.00)	15.00 (10.50-20.50)	17.00 (11.50-21.00)
Epoetin Alpha Use, n(%)	32(35.56%)	20(44.44%)	12(24.67%)
SBP, mmHg			
Pre-Dialysis	120.00 (112.00-126.00)	120.00 (112.00-125.00)	120.00 (112.00-127.00)
Post-Dialysis	110.00 (100.00-124.00)	106.00 (95.00-116.00)	118.0. (104.00-127.50)
DBP, mmHg			
Pre-Dialysis	66.00 (64.00-69.00)	66.00 (63.50-69.00)	67.00 (64.50-70.00)
Post-Dialysis	64.00 (60.00-69.00)	60.00 (57.00-69.50)	65.00 (60.00-69.00)
IDH, n(%)	31(34.44%)	21(46.67%)	10(22.22%)
Median CACS, HU	-	379.50 (136.00-538.25)	-
CACS Risk, n(%)			
None	45(50.00%)	-	45(50.00%)
Mild	7(7.78%)	7(7.78%)	-
Moderate	18(20.00%)	18(20.00%)	-
Severe	20(22.22%)	20(22.22%)	-
Haemoglobin, g/dL	12.37±1.20	12.31±1.29	12.44±1.11
Serum Creatinine, µmol/L	397.00 (311.00-536.75)	358.00 (302.00-445.50)	495.00 (339.00-570.50)
Serum Calcium, mmol/L	2.60 (2.33-2.89)	2.70 (2.38-2.97)	2.57 (2.33-2.75)
Serum Albumin, g/L	34.00 (31.00-37.00)	34.00 (31.50-37.00)	35.00 (31.00-38.00)

IDH: Intradialytic hypotension; DBP: Diastolic blood pressure; SBP: Systolic blood pressure; CACS: Coronary artery calcium score

The correlation between coronary artery calcium score (CACS) and intra-dialytic blood pressure variability was assessed in 90 patients (Table-III). Age showed a weak positive correlation with CACS and intra-dialytic blood pressure variability (r=0.104), though this was not statistically significant (p=0.328), suggesting no meaningful influence. Similarly, dialysis vintage demonstrated a very weak negative correlation (r=–0.016, p=0.883), indicating no association. Serum creatinine demonstrated a weak negative correlation (r=–0.204) with borderline statistical significance (p=0.054), suggesting a possible trend toward lower creatinine being linked with higher vascular calcification, potentially reflecting reduced muscle mass or malnutrition, though this finding is not conclusive. However, serum calcium demonstrated a statistically significant positive correlation with CACS and blood pressure variability (r=0.268, p=0.011), suggesting that higher serum calcium levels may be associated with greater vascular calcification and hemodynamic instability during dialysis.

Table-III: Correlation between coronary artery calcium score and intra-dialytic blood pressure variability (n=90)

Variables	Correlation	*p*-value
Age, years	0.104	0.328
Dialysis Vintage, months	-0.016	0.883
Haemoglobin, g/dL	-0.146	0.170
Serum Albumin, g/L	-0.004	0.967
Serum calcium, mmol/L	0.268	0.011
Serum Creatinine, µmol/L	-0.204	0.054
Pre-systolic blood pressure, mmHg	-0.066	0.536
Post-systolic blood pressure, mmHg	-0.305	0.003
Pre-diastolic blood pressure, mmHg	-0.170	0.110
Post-diastolic blood pressure, mmHg	-0.172	0.106
Δ Systolic Blood Pressure, mmHg	0.175	0.098
Δ Diastolic Blood Pressure, mmHg	0.040	0.710
Intra-Dialytic Hypotension, mmHg	0.265	0.012

DISCUSSION

The ESRD patients develop coronary artery calcification (CAC) earlier than general population; this can be due to disturbances in calcium homeostasis, increased inflammation, and secondary hypoparathyroidism, which is associated with renal failure. Blood pressure variation during hemodialysis was associated with an increased risk of cardiac events.[12] In this study, sample population belonged to a slightly aged group of 47.00 (39.75-53.00) years. Median coronary calcification score was 379.50 (136.00-538.25) HU. When CACS was classified according to Agatston criteria, 20(22.22%) had severe disease risk, while 18(20.00%) had moderate disease risk. Correlation between blood pressure variability and coronary artery calcification yielded no statistical significance. However, serum calcium levels were positively correlated (r=0.418, p=0.011) with post-dialysis systolic blood pressure (r=-0.305, p=0.003) were correlated, signifying that an increase in serum calcium levels may increase CAC.

The correlation and association between CAC and intra-dialytic blood pressure variability is complex, poorly understood and at times contradictory. A study by Yeo et al. found no association between CACS and blood pressure variability, but they found that pulse pressure was

wide in calcified coronary artery patients.[8] In coherence, this study showed that the CACS was not associated with blood pressure variability. The serum calcium was positively correlated, and post-dialysis systolic blood pressure had a negative correlation. This highlights the complex interaction between CACS and blood pressure. The wider pulse pressure can be attributed to increased arterial stiffness that occurs secondary to calcium deposits in arteries. These differences can be attributed to different sample population demographic and clinical features. In another study, researchers found no correlation between arterial calcification, either coronary or aortic, and central aortic systolic pressure.[13] Vascular calcification was linked to cardiovascular functional problems, such as peripheral artery and left ventricular failure, which may raise risk of IDH.[14] In this study, we found no association between CACS and change in systolic blood pressure (SBP) or diastolic blood pressure (DBP), similar to findings of Yeo *et al.,* but IDH was found to be significantly correlated with CACS.

Coronary artery disease was significantly correlated with serum calcium levels and has been proposed as an independent marker of coronary artery disease. It was found to be inversely related to coronary artery disease (CAD) and as a predictor of mortality.[15,16,17] In present study, serum calcium levels had a positive correlation with CACS. It can be indirectly inferred that serum calcium levels as also correlated with CAD. In contrast, serum calcium levels showed a negative correlation with coronary artery disease in research conducted in Peshawar, Pakistan.[18] They also found age as a likely marker of disease severity. However, in this study, serum calcium levels showed a positive correlation with CACS, indicating that higher serum calcium levels were associated with higher CACS. Moreover, age had no statistically significant relation with CACS. Similar to our findings, a significant relationship was found between coronary artery calcification and circulating serum calcium levels.[19,20] CACS was associated with increased cardiovascular mortality, a higher score (>1000) had a higher associated risk for cardiovascular events, and was found to be adequate to identify individuals requiring blood pressure control.[21]

LIMITATION OF STUDY

There were certain limitations in this study. Firstly, it had a limited sample size. Secondly, it was a single centre study and had inherent bias of being cross-sectional thus limiting its generalizability. Moreover, this study cannot predict the cause-and-effect phenomenon due to its study design. We propose conducting a comprehensive multi-centre study aimed at rigorously investigating and establishing a causal relationship between two factors under investigation. This expansive approach will help provide more definitive insights into how these factors interact and influence one another across diverse settings and populations.

CONCLUSION

Coronary artery calcium score had no correlation with blood pressure variability in hemodialysis dependent end-stage renal disease (ESRD) patients. However, serum calcium levels had a negative correlation with coronary artery calcification while intra-dialytic hypotension had positive correlation.

Conflict of Interest: None.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

MFS & SS: Data acquisition, data analysis, critical review, approval of the final version to be published.

MSS & MEW: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

HS: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Wouk N. End-Stage Renal Disease: Medical Management. Am Fam Physician 2021; 104(5): 493-499.
2. Kim IS, Kim S, Yoo TH, Kim JK. Diagnosis and treatment of hypertension in dialysis patients: a systematic review. Clin Hypertens 2023; 29(1): 24. https://doi.org/10.1186/s40885-023-00240-x
3. Flythe JE, Xue H, Lynch KE, Curhan GC, Brunelli SM. Association of mortality risk with various definitions of intradialytic hypotension. J Am Soc Nephrol 2015; 26(3): 724-734. https://doi.org/10.1681/ASN.2014020222
4. Zhi M, Zeng Y, Chen C, Deng S, Liu Y, Huang Y, et al. The relationship between intradialytic hypotension and health-related quality of life in patients undergoing hemodialysis: a cross-sectional study. Sci Rep 2025; 15(1): 11532. https://doi.org/10.1038/s41598-025-96286-y
5. War FA, Aggarwal M, Sharma S. Vascular Calcification in Chronic Kidney Disease Patients on Hemodialysis: Prevalence and Correlation with Vascular Disease Events. Indian J Clin Pract 2023; 34(1): 15-24.
6. Mizuiri S, Nishizawa Y, Doi T, Yamashita K, Shigemoto K, Usui K, et al. Coronary artery calcification is a risk factor for intradialytic hypotension in patients undergoing hemodialysis. Hemodial Int 2022; 26(3): 335-344. https://doi.org/10.1111/hdi.13016

7. DeBarmore B, Lin FC, Tuttle LA, Olsson E, Hinderliter A, Klein JL, et al. Association of ambulatory blood pressure variability with coronary artery calcium. J Clin Hypertens 2018; 20(2): 289-296. https://doi.org10.1111/jch.13171
8. Yeo S, Moon JI, Shin J, Hwang JH, Cho I, Kim SH. Impacts of Coronary Artery Calcification on Intradialytic Blood Pressure Patterns in Patients Receiving Maintenance Hemodialysis. Chonnam Med J 2020; 56(1): 27-35. https://doi.org/10.4068/cmj.2020.56.1.27
9. Cho A, Lee YK, Oh J, Yoon JW, Shin DH, Jeon HJ, et el. The relationship between intradialytic hypotension and vascular calcification in hemodialysis patients. PLoS One 2017; 12(10): e0185846. https://doi.org/10.1371/journal.pone.0185846
10. Kim SY, Hong YA, Yoon HE, Chang YK, Yang CW, Kim SY, et al. Vascular calcification and intradialytic hypotension in hemodialysis patients: Clinical relevance and impact on morbidity and mortality. Int J Cardiol 2016; 217: 156-160. https://doi.org/10.1016/j.ijcard.2016.04.183
11. Agatston AS, Janowitz WR, Hildner FJ, Zusmer NR, Viamonte M Jr, Detrano R. Quantification of coronary artery calcium using ultrafast computed tomography. J Am Coll Cardiol 1990; 15(4): 827-832. https://doi.org/10.1016/0735-1097(90)90282-t
12. Liu Q, Wang W, Wu X, Lv J, Cai S, Li Y. Intra-dialytic blood pressure variability is a greater predictor of cardiovascular events in hemodialysis patients. BMC Nephrol 2023; 24(1): 113. https://doi.org/10.1186/s12882-023-03162-w
13. Freercks RJ, Swanepool CR, Turest-Swartz KL, Carrara HR, El Moosa S, Lachman AS, et al. Vascular calcification is not associated with increased ambulatory central aortic systolic pressure in prevalent dialysis patients. Cardiovasc J Afr 2014; 25(1): 4-8. https://doi.org/10.5830/CVJA-2013-081
14. Vishnu A, Choo J, Wilcox B, Hisamatsu T, Barinas-Mitchell EJ, Fujiyoshi A, et al. Brachial-ankle pulse wave velocity is associated with coronary calcification among 1131 healthy middle-aged men. Int J Cardiol 2015; 189: 67–72. https://doi.org/10.1016/j.ijcard.2015.04.020
15. Wang M, Yan S, Peng Y, Shi Y, Tsauo JY, Chen M. Serum calcium levels correlates with coronary artery disease outcomes. Open Med (Wars) 2020; 15(1): 1128-1136. https://doi.org/10.1515/med-2020-0154
16. Lu X, Wang Y, Meng H, Chen P, Huang Y, Wang Z, et al. Association of admission serum calcium levels and in-hospital mortality in patients with acute ST-elevated myocardial infarction: an eight-year, single-center study in China. PLoS One 2014; 9(6): e99895. https://doi.org/10.1371/journal.pone.0099895
17. Grandi NC, Brenner H, Hahmann H, Wüsten B, März W, Rothenbacher D, et al. Calcium, phosphate and the risk of cardiovascular events and all-cause mortality in a population with stable coronary heart disease. Heart 2012; 98(12): 926-933. https://doi.org/10.1136/heartjnl-2011-300806
18. Azam MH, Danish N, Wahab MA, Rehman AU, Naeem S, Muhammad SK. The Relationship between Serum Calcium Levels and Angiographic Severity of Coronary Artery Disease in Patients with Chronic Coronary Syndrome. Pak Heart J 2024; 57(03): 194-200. https://doi.org/10.47144/phj.v57i3.2822
19. Azam MH, Danish N, Wahab MA, Rehman A, Naeem S, Muhammad SK. The Relationship between Serum Calcium Levels and Angiographic Severity of Coronary Artery Disease in Patients with Chronic Coronary Syndrome. Pak Heart J 2024; 57(3): 194-200. https://doi.org/10.47144/phj.v57i3.2822
20. Kwak SM, Kim JS, Choi Y, Chang Y, Kwon MJ, Jung JG, et al. Dietary intake of calcium and phosphorus and serum concentration in relation to the risk of coronary artery calcification in asymptomatic adults. Arterioscler Thromb Vasc Biol 2014; 34(8): 1763-1769. https://doi.org/10.1161/ATVBAHA.114.303440
21. Peng AW, Dardari ZA, Blumenthal RS, Dzaye O, Obisesan OH, Iftekhar Uddin SM, et al. Very high coronary artery calcium (≥1000) and association with cardiovascular disease events, non-cardiovascular disease outcomes, and mortality: results from Multi-Ethnic Study of Atherosclerosis. Circulation 2021; 143(16): 1571-1583. https://doi.org/10.1161/CIRCULATIONAHA.120.050545