ORIGINAL ARTICLE

Carotid Intimal Media Thickness as an Indicator of Ischemic Heart Disease in Male Patients with Type 2 Diabetes and Metabolic Syndrome

Akshaya Janardhanan[1*], Subrahmanyam DKS[2], Santhosh Satheesh[3]

Received: 11 October 2024; *Accepted:* 17 July 2026

Abstract

Background: Metabolic syndrome (MetS) increases cardiovascular disease risk due to accelerated atherosclerosis. Carotid intima-media thickness (CIMT) is an effective, noninvasive screening tool for atherosclerosis. Hence, we sought to measure the CIMT of male patients with type 2 diabetes and MetS and attempted to correlate the CIMT values between patients with and without evidence of ischemic heart disease.

Materials and methods: This was a cross-sectional study conducted on diabetic patients who met the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria for MetS (specified for the Indian population), aged 45–60 years. Each participant completed the Rose questionnaire and was grouped as either symptomatic or asymptomatic. Further, all patients were subjected to biochemical tests, electrocardiography (ECG), CIMT, echocardiography (ECHO), and ankle-brachial pressure index (ABPI). Those who showed no evidence of ischemia on ECG and ECHO were subjected to exercise stress testing (treadmill test). Abnormal ECG, ECHO, and treadmill test results indicating ischemic heart disease were used to group patients into ischemic and nonischemic groups.

Results: A total of 128 patients who met the inclusion criteria were recruited. The values of CIMT ranged from 0.62 to 0.76 mm. The CIMT values between the ischemic and nonischemic groups were found to be similar. However, CIMT values were consistently higher in patients with MetS compared to the general population CIMT values based on prior studies in India across all age-groups. The Rose questionnaire served as a good screening tool, with a negative predictive value of 86% for the detection of ischemia in asymptomatic patients. Among the other parameters, the critical value of ABPI was found to be higher in the ischemic group [1.1 (1–1.12) vs 1 (0.85–1.075), $p = 0.004$].

Conclusion: While CIMT was not a reliable indicator of ischemic heart disease in patients with MetS, its consistently elevated values compared to those of the general population suggest that it could serve as a valuable marker of atherosclerosis. The ankle-brachial pressure index (ABPI) has consistently proven to be a reliable and repeatable indicator of ischemia. Due to the high incidence of silent ischemia in this study group (12.9%), further research on early markers of ischemia and atherosclerosis is warranted.

Keywords: Atherosclerosis, Cardiology, Carotid intimal media thickness, Metabolic syndrome, Treadmill test.

Journal of The Association of Physicians of India (2026): 10.59556/japi.74.1669

Introduction

Metabolic syndrome (MetS) is a complex of multiple atherosclerotic risk factors. The worldwide prevalence is estimated to be 30–35% among adults.[1] Over the years, insulin resistance and obesity have been repeatedly emphasized as the prerequisites of MetS. A chronic hyperglycemic milieu develops owing to insulin resistance, and diabetic vasculopathy develops. It can present with cardiovascular disease (CVD) due to advanced glycation end products, oxidative stress, and chronic low-grade inflammation.[2] Obesity adds to this by the deposition of cholesterol esters in vessel walls and endothelial dysfunction.[3]

The hazard ratio of cardiovascular risk is 1.2–1.6 in patients with diabetes and nearly 1.9–2.2 in patients with uncontrolled hypertension,[4,5] combined, projecting much higher numbers for cardiovascular mortality and morbidity attributed to MetS. Hence, the topic of early detection of MetS and, consequently, ischemic heart disease (IHD) has garnered a lot of interest in recent years.

Carotid intima-media thickness (CIMT) has been a noninvasive screening tool for atherosclerosis for decades. Multiple studies have shown a significant correlation between CIMT values and the risk of CVD. The relative risk of CVD increases by 15% for every 0.1 mm increase in CIMT.[6] This raises the hypothesis that increasing atherosclerotic risk factors will increase the CIMT and may help predict ischemia. Ischemia can be predicted by stress treadmill testing, which has a positive predictive value of >85% in high-risk groups, such as patients with diabetes.[7] Hence, in this study, we sought to measure the CIMT of male patients with type 2 diabetes and MetS and study its relationship with ischemia by comparing CIMT between patients with and without ischemia.

Materials and Methods

Study Design

We conducted a cross-sectional study in which 132 patients were screened for eligibility, and 128 were recruited from the general medicine department of a tertiary care hospital. The study duration was 2.5 years.

The inclusion and exclusion criteria are given in Table 1.

Study Procedure

After enrollment based on the screening criteria, all consenting participants were administered the Rose questionnaire in their language of preference and were divided into those with and without angina. All participants were also subjected to biochemical tests, electrocardiography (ECG), CIMT, echocardiography (ECHO), and ABPI. Biochemical investigations were collected from each participant following a minimum of 8 hours of overnight fasting. Triglycerides and high-density lipoprotein (HDL) were measured. Glycated hemoglobin (HbA1c) and urine protein-creatinine ratio (PCR) were performed routinely as part of their outpatient department (OPD) diabetic workup. ECG was performed and analyzed for ischemic changes using the Minnesota Code and manual reading. Two-dimensional (2D)

[1]Junior Resident, Department of General Medicine; [2]Professor, Department of Medicine; [3]Professor, Department of Cardiology, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India; *Corresponding Author

How to cite this article: Janardhanan A, DKS S, Satheesh S. Carotid Intimal Media Thickness as an Indicator of Ischemic Heart Disease in Male Patients with Type 2 Diabetes and Metabolic Syndrome. J Assoc Physicians India 2026;74(8):39–43.

© The Author(s). 2026 Open Access. This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (https://creativecommons.org/licenses/by-nc/4.0/).

ECHO with color flow was performed to look for any regional wall motion abnormalities or thinning of wall segments suggestive of ischemia. ABPI was measured using a handheld Doppler.

Those who showed no evidence of ischemia on ECG and ECHO were subjected to exercise stress testing (treadmill test). During the stress test, patients were made to run for up to 9 minutes to the third stage of the standard Bruce protocol. Peak exercise on the treadmill test (TMT) was defined as the point at which the subject attained the predetermined heart rate (220—age in years) or exhaustion, whichever occurred earlier. TMT was considered inconclusive if the patient was unable to complete the second stage of TMT, was unable to achieve the target heart rate, or failed to achieve the minimum metabolic equivalents (METs). A positive TMT was defined as ≥2 mm rapidly upsloping or ≥1 mm horizontal ST depression in concordant leads that persisted beyond stage III of the Bruce protocol. Based on the TMT results, patients were reclassified into ischemic and nonischemic groups.

The CIMT values were measured for all recruited patients. CIMT was measured in the distal 1 cm during diastole by ECG gating on the GE Color Doppler Vivid P3 system. The maximum and minimum values generated by the machine were noted on both sides and compared between the two groups.

Statistical Analysis

For sample size calculation, the software OpenEpi version 2.0 was used. The normality of the data was assessed using the Shapiro–Wilk test. The continuous data were expressed as the mean with standard deviation or the median with interquartile range, based on the distribution. Intergroup comparisons were performed using Student's *t*-test or the Kruskal–Wallis test, based on the number of groups. The categorical variables were assessed using the Chi-squared test. A *p*-value of <0.05 was considered statistically significant. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS), IBM SPSS version 28.

Figure 1 shows the key for the terms used in the recruitment flow diagram. This is followed by the recruitment flow diagram (Fig. 2).

Observations and Results

This study included 128 patients. The median age of the study population was 53.5 years, with an average duration of diabetes of 6 years and a median glycated hemoglobin (HbA1c) level of 8.7. Though the age bracket was 45–60 years, nearly half of the population was aged 54 years and above. Thirty-five percent of the patients had diabetes for <5 years, and 33.5% had diabetes for 5–10 years; hence, patients with early diabetes comprised the majority of the participants. Among the 95 participants who had hypertension, 47.6% had been diagnosed <5 years earlier. Eighty percent of the study population had dyslipidemia, with triglycerides (TG) having a median value of 151.5 mg/dL and high-density lipoprotein (HDL) having a mean value of 39.42 mg/dL. The median ABPI was found to be 1.05. The baseline characteristics of all recruited patients are given in Table 2.

On comparison of the baseline characteristics between the two groups, four parameters showed statistically significant differences. Waist circumference and triglyceride levels were lower in the ischemic group, whereas the HbA1c and ABPI were higher in the ischemic group. Confounding factors for atherosclerotic ischemia, such as anemia and smoking, were also compared between the two groups, and there was no statistically significant difference. The proportion of silent ischemia was 12.9%. Plaques were present in 7.8% of the patients. A comparison of all characteristics studied between the ischemic and nonischemic groups is given in Table 3.

The higher values were consistently observed for the left CIMT, for both the maximum and average values, ranging from 0.62 to 0.76 mm. The median of the entire data set was 0.70 mm (0.60–0.825). There was a steady increase in the CIMT values as the number of criteria for MetS increased, but it was not statistically significant. Average CIMT values were higher than the general population values, 0.632 ± 0.156 mm vs 0.582 ± 0.08 mm, as reported in the SCORE-India trial.[9]

Table 1: Recruitment criteria

Inclusion criteria	*Exclusion criteria*
Males aged 45–60 years with type 2 diabetics with the presence of any 2 of the following four conditions: Increased waist circumference (males ≥90 cm and for females ≥80 cm) Hypertriglyceridemia ≥150 mg/dL Low HDL (male ≤40 mg/dL and for females ≤50 mg/dL) Elevated blood pressure (systolic blood pressure ≥130 mm hg and/or diastolic blood pressure ≥85 mm hg or Rx for hypertension)	Chronic kidney disease Connective tissue disorders Diagnosed cases of human immunodeficiency virus infection Intensive long-term statin therapy (≥20 mg/day Atorvastatin or 5 mg/day Rosuvastatin consistently for 1 year)[8] Prior diagnosis of acute coronary syndrome (unstable angina/ non-ST elevation myocardial infarction/ST elevation myocardial infarction)

Ischemic changes on ECG - Major Q waves, ST-T changes, New onset LBBB

Ischemic changes on ECHO -Regional Wall Motion Abnormalities (RWMA), thinned out segments, reduced ejection fraction

Unfit - Unable to complete 1st stage of TMT

Inconclusive - Unable to complete 2nd stage of TMT, inability to achieve target Heart Rate or minimum Metabolic Equivalents (METS)

Positive -> 2mm rapidly up-sloping or ≥ 1 mm horizontal ST depression in concordant leads that persist beyond stage III Bruce protocol.

Negative - No ST-T changes throughout the 9 minutes of Stress testing

F/U-Follow up

Fig. 1: Key to the flow diagram

Table 2: Baseline characteristics (all data sets are nonnormal in distribution except HDL and Hb)

Parameter	*Mean ± SD/median (IQR)*
Age (in years)	53.5 (47–57)
Duration of diabetes (in years)	6 (4–10)
Duration of hypertension (in years) (95)	3 (1–6)
Waist circumference (in cm)	98 (90–102)
TG (mg/dL) (115)	151.5 (115–247)
HDL (mg/dL) (116)	39.42 (±10.39)
HbA1C (%) (98)	8.7 (7.4–10.3)
Urine PCR (81)	0.20 (0.14–0.55)
ABPI	1.05 (0.98–1.12)
Hb (mg/ dL) (83)	12.59 ± 2.385

Hb, hemoglobin; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; PCR, protein creatinine ratio; TAG, triacylglycerol

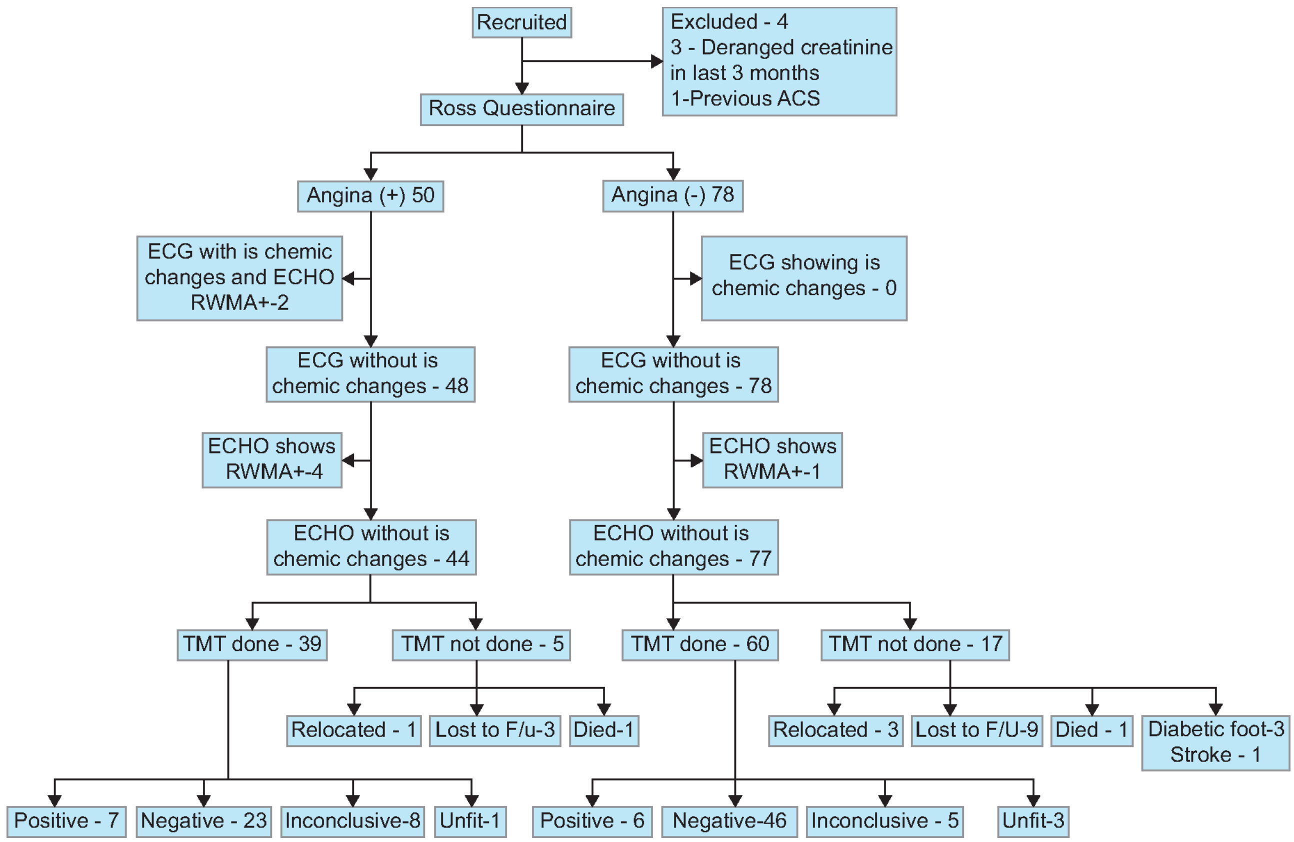

Fig. 2: Recruitment flow diagram

Table 3: Comparison of the baseline characteristics between the ischemic and nonischemic groups

Parameters	*Nonischemic group*	*Ischemic-group*	*p-value*
Age (in years)	53 (45–57)	53.5 (47.5–57)	0.3910
Duration of diabetes (in years)	6 (3–10)	6.5 (4–15)	0.372
Duration of hypertension (in years) (95)	1 (0–4)	1 (0–5.5)	0.87
Waist circumference (in cm)	99 (92–105)	92 (88.5–98)	0.005
TG (mg/dL) (74)	164 (119–274)	120 (95.5–158.5)	0.0158
HDL (mg/dL) (83)	40.34 ± 9.84	39.4 ± 11.88	0.64
HbA1C (%) (98)	8.3 (7.3–9.6)	10.1 (7.7–11.3)	0.044
Urine PCR (59)	0.2 (0.14–0.41)	0.14 (0.085–0.28)	0.13
ABPI	1.1 (1–1.12)	1 (0.85–1.075)	0.004
CIMT right average (mm)	0.62 (0.53–0.75)	0.61 (0.54–0.715)	0.742
CIMT right maximum (mm)	0.72 (0.6–0.87)	0.75 (0.62–0.8)	0.660
CIMT left average (mm)	0.66 (0.55–0.75)	0.655 (0.5–0.715)	0.423
CIMT left maximum (mm)	0.72 (0.64–0.88)	0 .735 (0.65–0.84)	0.255
Ex/smokers (%)	22.2	20.0	1.00
Hb (63)	12.51 ± 2.53	13.12 ± 0.911	0.216

The sensitivity and specificity ranged between 45 and 55%, and the positive predictive value (PPV) was 25% for CIMT in predicting any evidence of ischemia. Given the rising burden of MetS and ischemic heart disease, these cutoff values may serve as credible screening tools; however, there was no statistically significant difference in CIMT values between the ischemic and nonischemic groups. Based on our data, the sensitivity of the Rose questionnaire as a screening tool for evidence of ischemia was 65%, with a good negative predictive value of 86%. Additionally, the ABPI value differed significantly between the ischemic and nonischemic groups, with a good sensitivity of 90.65% for predicting ischemic heart disease at an absolute cutoff value of 0.9.

Figure 3 shows the receiver operating characteristic (ROC) curve for the CIMT cutoff value of 0.75 mm on the right side. Figure 4 shows the ROC curve for ABPI as an indicator of ischemia, with a cutoff value of 0.9, where the ABPI curve demonstrates a high sensitivity of 90.6% for predicting ischemia.

Discussion

Our study consisted of men aged 45–60 years with MetS, with ECG, ECHO, and treadmill test (TMT) as the predictors of ischemia. TMT has lower overall test accuracy for the identification of coronary artery disease and a

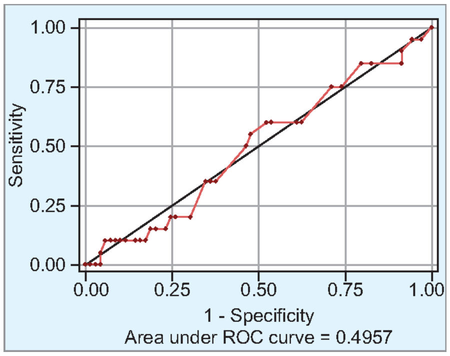

Fig. 3: Receiver operating characteristic (ROC) curve for CIMT cutoff of 0.75 mm at the right maximum values

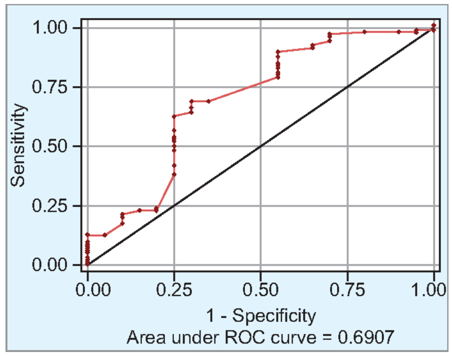

Fig. 4: Receiver operating characteristic (ROC) curve for ABPI as an indicator of ischemia, with a cutoff of 0.9 (sensitivity, 90.65%; specificity, 35%)

Table 4: Indian studies with CIMT values in MetS or diabetic patients

Study	*Study population*	*CIMT values (mm)*
PRISM study[15]	338 diabetic males and females, evaluated for silent ischemia	0.7133 ± 0.022 in TMT positive vs 0.6624 ± 0.029 0.001 in TMT negative
Sethia et al.[16]	200 males and females, case control between MetS and non-MetS	MetS 0.81 ± 0.23 non-MetS 0.66 ± 0.13 ($p < 0.005$)
Jose et al.[17]	116 males and females in 45–60 years	MetS 0.699 ± 0.108 vs non-MetS 0.586 ± 0.083 ($p < 0.001$)
Abhishek et al.[18]	100 males and females patients with MetS	0.90 (0.50–1.30)
Current study	128 male diabetics with MetS	MetS with ischemia (0.72) vs MetS without ischemia (0.735) ($p = 0.225$)

Table 5: Comparison of CIMT values in our study with the general population

Age (in years)	*MetS patients*		*General population (SCORE study)[9]*
40–49 (45)	Average 0.632 ± 0.156	Maximum 0.752 ± 0.203	0.582 ± 0.08
50–59 (83)	0.696 ± 0.192	0.808 ± 0.211	0.646 ±.14

poor positive predictive value (PPV) in women; hence, women were excluded.[10,11]

Among the various parameters assessed, four were found to be statistically significant between the ischemic and nonischemic groups. The glycated hemoglobin (HbA1c) levels were significantly higher in the ischemic group. The National Health and Nutrition Examination Survey (NHANES) study demonstrated that, among persons with known diabetes, the cardiovascular disease (CVD) risk increased progressively in concordance with HbA1c values.[11] The ABPI was statistically significant ($p < 0.004$) between the ischemic and nonischemic groups. This mirrors worldwide data, which state that a critical ABPI value doubles the 10-year cardiovascular mortality.[12] One peculiar finding was a statistically significant difference in the waist circumference and triglyceride levels between the ischemic and nonischemic groups, with lower values in the ischemic group. This can be explained by the obesity paradox, given that CVD rates have been consistently demonstrated to be higher in normal-weight patients with diabetes compared to obese patients with diabetes.[13] In fact, the PROactive study demonstrated that for every 1% body weight loss, the hazard ratio for CVD was 1.13.[14]

Carotid intima-media thickness values between the two groups, though not statistically higher, showed a PPV of 25% at a cutoff value of 0.75 mm for the detection of ischemia. Considering the high morbidity and mortality of the disease and the rising burden, this predictive value of CIMT may streamline the screening process for CVD and help in the early identification of a significant population. Our median CIMT values ranged from 0.62 to 0.76 mm. The CIMT values generated in various Indian studies for patients with MetS are given in Table 4.

The Seattle Heart Watch study stated that TMT in asymptomatic individuals was not predictive of combined adverse cardiovascular events; however, in patients with one or more risk factors and two or more abnormal features on exercise testing, there was a nearly 30-fold increase in CVD risk.[19] Given that our study included men with diabetes aged 45 years and above, with at least two additional atherosclerotic comorbidities, all asymptomatic individuals with a positive TMT, as indicated by ischemic ST depressions at moderate metabolic equivalents (METs), had an increased risk of CVD and were initiated on lipid-lowering therapy. Table 5 shows a comparison of CIMT values in our study with those of the general population.

Our study had a few limitations. The major limitation of the study was the inability to classify the inconclusive TMT patients into ischemic and nonischemic groups. Further structured workup in the form of contrast computed tomography (CT) angiography or stress perfusion imaging could have been helpful. Also, a large number of patients were lost to follow-up owing to logistical reasons.

Conclusion

CIMT is a noninvasive, cost-effective screening tool for atherosclerosis, as our study consistently showed higher values in patients with MetS compared to the general population. However, it had a poor predictive value for ischemia (as evidenced by Q waves or ST-T changes on ECG, regional wall motion abnormalities on ECHO, or a positive TMT) in high-risk individuals, and there was no statistically significant difference between those with and without evidence of ischemia. ABPI showed a sensitivity of 90.65% for the screening of ischemia in this group. Further studies are needed to validate its utility and to identify earlier screening tools for ischemia.

Orcid

Akshaya Janardhanan https://orcid.org/0000-0002-8305-1561
Santhosh Satheesh https://orcid.org/0000-0001-7762-2164

References

1. Grundy SM, Brewer HB Jr, Cleeman JI, et al. Definition of metabolic syndrome: report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation 2004;109(3):433–438.
2. Mathieu P, Pibarot P, Després JP. Metabolic syndrome: the danger signal in atherosclerosis. Vasc Health Risk Manag 2006;2(3):285–302.

3. Powell-Wiley TM, Poirier P, Burke LE, et al. Obesity and cardiovascular disease: a scientific statement from the American Heart Association. Circulation 2021;143(21):e984–e1010.
4. Ke C, Gupta R, Shah BR, et al. Association of hypertension and diabetes with ischemic heart disease and stroke mortality in India: the million death study. Glob Heart 2021;16(1):69.
5. Geldsetzer P, Manne-Goehler J, Theilmann M, et al. Diabetes and hypertension in India: a nationally representative study of 1.3 million adults. JAMA Intern Med 2018;178(3):363–372.
6. Onut R, Balanescu AP, Constantinescu D, et al. Imaging atherosclerosis by carotid intima-media thickness in vivo: how to, where and in whom? Maedica 2012;7(2):153–162.
7. Daphale A, Acharya S, Shukla S. Detection of asymptomatic coronary artery disease (CAD) in newly detected type 2 diabetes mellitus (DM) by exercise treadmill test. Int J Contemp Med Res 2017;4(11):2269–2275.
8. Hiro T, Kimura T, Morimoto T, et al. JAPAN-ACS Investigators. Effect of intensive statin therapy on regression of coronary atherosclerosis in patients with acute coronary syndrome: a multicenter randomized trial evaluated by volumetric intravascular ultrasound using pitavastatin versus atorvastatin (JAPAN-ACS [Japan Assessment of Pitavastatin and Atorvastatin in Acute Coronary Syndrome] study). J Am Coll Cardiol 2009;54(4):293–302.
9. Kasliwal RR, Bansal M, Desai N, et al. A Study to derive distribution of carotid intima media thickness and to determine its COrrelation with cardiovascular Risk factors in asymptomatic nationwidE Indian population (SCORE-India). Indian Heart J 2016;68(6):821–827.
10. Detry JM, Kapita BM, Cosyns J, et al. Diagnostic value of history and maximal exercise electrocardiography in men and women suspected of coronary heart disease. Circulation 1977;56(5):756–761.
11. Sketch MH, Mohiuddin SM, Lynch JD, et al. Significant sex differences in the correlation of electrocardiographic exercise testing and coronary arteriograms. Am J Cardiol 1975;36(2):169–173.
12. Saydah S, Tao M, Imperatore G, et al. GHb level and subsequent mortality among adults in the U.S. Diabetes Care 2009;32:1440–1446.
13. Ankle Brachial Index Collaboration, Fowkes FG, Murray GD, et al. Ankle brachial index combined with Framingham Risk Score to predict cardiovascular events and mortality: a meta-analysis. JAMA 2008;300(2):197–208.
14. Carnethon MR, De Chavez PJ, Biggs ML, et al. Association of weight status with mortality in adults with incident diabetes. JAMA 2012;308(6):581–590.
15. Prasad DS, Kabir Z, Revathi Devi K, et al. Prevalence and RIsk factors for Silent Myocardial ischemia (PRISM): a clinico observational study in patients of type 2 diabetes. Indian Heart J 2019;71(5):400–405.
16. Sethia S, Acharya S, Shukla S, et al. Carotid intima media thickness (CIMT) in metabolic syndrome (MS) - a case control study. J Evid Based Med Healthc 2020;7(41):2336–2340.
17. Jose N, Hansdak S, Jose J, et al. Carotid intima media thickness in metabolic syndrome: an Indian perspective. Indian J Appl Res 2016;6(3).
18. Abhishek TG, Darshan A, Appajigol JS, et al. Association between carotid intima media thickness and metabolic syndrome. Int J Adv Med 2018;5:(6):1503–1509.
19. Bruce RA, DeRouen TA, Hossack KF. Value of maximal exercise tests in risk assessment of primary coronary heart disease events in healthy men: five years experience of the Seattle Heart Watch Study. Am J Cardiol 1980;46:371–378.