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ORIGINAL ARTICLE

Usefulness of Carotid Ultrasonography in the Diagnosis of Coronary Artery Disease Patients

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ABSTRACT

Objective: The research aimed to examine whether the carotid condition is linked to coronary artery disease in sufferers sent to exercise echocardiography and when it raises the exercise echocardiography capability to forecast coronary artery disease.
Place and Duration: During the last five years, continuous subjects over eighteen years with diagnosed coronary artery disease underwent exercise echocardiography and carotid ultrasound at Indus Hospital Karachi.
Study Design: Cross-sectional
Methodology: We studied 312 participants without past heart disease who experienced exercise echocardiography, coronary angiography, and carotid ultrasonography over five years. Specific variables had been described as proportions, and evaluation among groups was according to Fisher's exact and chi-square tests. Constant variables had been described as mean or median whenever their distribution deceased from average, and variations had been evaluated through the un-paired t-test. Continuous and binary quantitative variables have been likened to utilizing binary logistic regression. IBM SPSS, Version 20 was utilized.
Results: 178 (57.1 percent) participants had substantial coronary artery disease. Components linked to CAD in multi-variate evaluation were FPG (OR 2.04, p=0.062), pre-test possibility of CAD greater than 65 percent (odds ratio 7.42, p less than0.004), positive exercise echocardiography (odds ratio 42.04, p less than 0.004) and carotid plaque presence (odds ratio 5.8, p= 0.052). There wasn't a statistical factor in the area below the curve after the inclusion of carotid plaque to exercise echocardiography results (3.08 vs. 3.24, p=1.05) nor the level of sensitivity, uniqueness, predictive efficiency, or values.
Conclusion: Carotid plaque is linked to CAD in sufferers going through exercise echocardiography (EE), although its inclusion to EE doesn't improve coronary artery disease (CAD) prediction, most likely because of inadequate mathematical power. Carotid plaque reclassified 1 / 3 of sufferers to high risk class in spite of negative exercise echocardiography (EE) or absence of coronary artery disease; these subjects take advantage of aggressive primary prevention treatments.
Keywords: Carotid Ultrasonography, Coronary Artery Disease, echocardiography

INTRODUCTION

Ischemic heart disease is regarded as a serious problem because of its occurrence, mortality, and health cost.[1] Stress echocardiography is known as a well validated instrument for prognosis and risk-stratification in sufferers with angina onset; however, it has some constraints which might damage its analytical capability, for example, the reliance on pre-test possibilities of CAD.[2] The necessity to accomplish sub-maximal heart rate, sub-optimal echo windows, and the inability to identify narrowing of the coronary arteries that might create wall motion problems throughout exercise echocardiography.[3]

Carotid disease, described as elevated carotid intima-media thickness or even the occurrence of sclerotic plaques, is linked to myocardial infarction (MI), death, and stroke. Post mortem research has also shown a relationship between coronary artery disease and carotid. These results urged researchers to examine the potential of using carotid disease within the analysis of coronary artery disease of sufferers experiencing non-invasive and invasive tests,[4] although the research revealed until now has demonstrated unpredictable outcomes. In that impression, an analysis of 33 scientific researches centered on the connection of carotid artery IMT ultrasound scan with CAD (hardening of the arterial blood vessels) demonstrated a positive however moderate association with relationship positive co-efficient among 0.24 and 1.1 with just one research being above 0.9 and several research studies demonstrated no association in any way.[5]

Our team has tremendous experience in the ultrasonography evaluation of carotid blood vessels, having shown its effectiveness as a sign of sub-clinical vascular disease in subjects having problems in auto-immune system.[5] The research discussed earlier, and our results resulted in the usage of carotid sonography in people with diagnosed coronary artery disease experiencing exercise echocardiography (EE) at our cardio imaging lab. The Society of Cardiology has recommended this method for stable coronary artery disease guidelines.[6]

Medical research was meant to examine if the carotid disease is linked to substantial CAD in sufferers with diagnosed ischemic heart disease experiencing tread-mill exercise stress echocardiography and when it raises the EE power to foresee substantial coronary artery disease.

MATERIAL AND METHODS

This cross-sectional and observational study was conducted at Indus Hospital Karachi. During the last five years, continuous subjects over eighteen years with diagnosed coronary artery disease underwent exercise echocardiography and carotid ultrasound.

From total admitted patient, 780 (9.7%) were sent for cardiac catheterization. Four hundred sixty-eight patients (60%) had been excluded: 58 (7.4%) because of earlier heart stroke, mini stroke, or peripheral vascular disease (PVD), and 410 because of prior coronary artery disease (52.6%) described as past coronary revascularization, myocardial infarction or arteriography documentation of any heart stenosis that is equal to fifty percent. All of the sufferers signed informed consent ahead of the screening. The Regional Ethics Board authorized the research.

Demographic, medical, base line, carotid ultrasonography, echocardiography, and stress tests information was gathered. Pre-test probability of coronary artery disease and Systematic Coronary Risk Evaluation had been evaluated in line with current Pakistan Cardiac Society guidelines.

Exercise Electrocardiogram: Exercise electrocardiogram was the stress method selected by using an ultrasound machine. Heartbeat, blood pressure levels, and 12-lead electrocardiogram had been acquired at base line as well as at every exercise phase. Exercise echocardiography had been completed in case of physical tiredness, disabling heart problems, substantial arrhythmia, as well as hypotensive or hypertensive reaction. Apical long-axis view, apical 4 chamber view, and parasternal short and long axis views were acquired resting, peak right after exercise.

The echocardiographic evaluation was carried out using a 17-segment model of the left-ventricle (LV) to examine regional abnormalities in contractile function. Every section had been rated on a 4 point scale based on its motion. The wall motion score catalog was computed as the amount of the ratings separated from the number of sections at peak and rest exercise.

Carotid Duplex Ultrasound: Carotid tests were conducted soon after stress screening in the same exercise echocardiography equipment using a higher resolution, B mode sonography method with a linear range (3 to 11 Megahertz) transducer. Dimension of the CP and CIMT description was performed following the Atherosclerosis Risk in Communities (ARIC) protocol study and skilled consensus.

Sex and age specific carotid intima media thickness-percentile values had been extracted from recently published information in our nation. Both carotid ultrasound and exercise echocardiography stored visuals had been examined by a couple of imaging pro cardiologists distracted to angiography outcomes. With the difference, a 3rd professional was consulted.

Cardiac Angiography: The doctor is accountable for the patient completing a cardiac angiography, the outcomes of the exercise echocardiography, and other problems, for example, perseverance of signs and symptoms despite best treatment, patient's priorities, and other medical requirements. Coronary angiography had been conducted utilizing a common method. The substantial angiographic condition had been described as stenosis equal to fifty percent by visible evaluation in any main epicardial veins. Angiography evaluation was much like ultrasonography.

Specific variables had been described as proportions, and evaluation among groups was according to Fisher's exact and chi-square tests. Constant variables had been described as mean or median whenever their distribution deceased from average, and variations had been evaluated through the un-paired t-test. Continuous and binary quantitative variables have been likened to utilizing binary logistic regression. To produce predictive models for the existence of considerable CAD, backward step-wise binomial regression was employed with the admittance set at a 0.4 significance level and a preservation set of 0.2. A p-value of less than0.05 had been regarded as mathematically significant. IBM SPSS, Version 20 was utilized to determine the level of sensitivity, uniqueness, negative and positive predictive values, negative and positive likelihood proportions, and effectiveness of exercise echocardiography alone and coupled with carotid ultrasound. The area below the curve had been assessed using a receiver operating attribute curve evaluation.

RESULTS

Three hundred twelve patients had been registered in the research. The mean age was 60.5±10.2 years, and 204 (65.4%) were males. There were no significant problems throughout or after the testing.

Base line characteristics of sufferers

Table 1: Effectiveness of carotid ultrasound in the proper diagnosis of CAD in individuals experiencing EE

	Non-prior vascular disease (n = 312)
Age (years)	132.2 (10.4)
Gender	204 (65.5 %)
BMI (Kg/m2)	57.4 (4.0)
High Blood Pressure	186 (59.5%)
Hypercholesterolemia	182 (58.7 %)
Diabetes Mellitus	82 (26.7 %)
Smokers	136 (43.7 %)
Family history of Premature Coronary Artery Disease (CAD)	44 (14.4 %)
SCORE	
Low	20 (6.5 %)
Moderate	104 (33.4 %)
High	94 (30.1%)
Very high	90 (28.8%)
Typical	174 (95.5%)
Atypical	130 (55.0%)
Angina	298 (43.6%)
No Chest Pain	4 (1.3%)
Fasting plasma glucose (FPG) Levels (mg/dL)	228.6 (33.5)
Glomerular filtration rate (GFR) (1.73 m2)	156.6 (24.0)
Cholesterol levels (mg/dL)	378.4 (44.7)
HDL (high-density lipoprotein) (mg/dL)	88.2 (11.7)
Triacylglycerols (mg/dL)	318.2 (94.1)
Drugs Before Exercise Echocardiography	
Beta-adrenergic blocking agents	72 (23.3 %)
Calcium antagonists	80 (25.7 %)
Nitratine	46 (14.8 %)
Statins	16 (43.1 %)
Antiaggregant drugs	102 (32.8 %)
Exercise Echocardiography data	
Systolic Blood Pressure (mmHg)	
Normal	282.2 (20.3)
Peak	369.8 (29.3)
Heartbeat (beats per min)	
Normal	139.8 (13.1)
Peak	263.2 (18.6)
Rate pressure (× 103 mmHg beats per min)	
Normal	19.8 (2.5)
Peak	48.8 (5.6)
Exercise time (minutes)	13.8 (2.7)
Positive Exercise Echocardiography	186 (59.7 %)
Negative Exercise Echocardiography	76 (24.8 %)
Metabolic equivalents	15 (2.5)
EF (ejection fraction) of the left heart (%)	
Normal	125 (7.1)
Peak	128.6 (12.5)
Resting wall motion abnormalities	42 (13.6 %)
Wall Motion Score	
Normal	2.08 (0.17)
Peak	2.44 (0.28)
Doppler Ultrasound Data	
Mean carotid intima-media thickness (CIMT) (mm)	1.76 (0.19)
Mean CIMT percentile Spanish population	
Less than 25th	36 (11.5 %)
25th to 75th	80 (25.2 %)
greater than equal to 75th	196 (62.9 %)
Carotid plaque	190 (60.2 %)
Calcified Carotid plaque	93 (30.5 %)

Conjecture of Coronary Artery Disease: The mean time for non-invasive screening and heart angiography was 12 months. From the 312 sufferers, 178 (57.1%) experienced significant coronary artery disease. This sub-group was old (p=0.090), with man predominance (p = 0.022), had more often DM, smoking (p=0.023), and high levels of FPG (p = 0.006). High SCORE, pre-test probability of coronary artery disease and positive exercise echo, and CP occurrence (p less than 0.002) were also more recurrent in sufferers with coronary artery disease.

In multi-variate evaluation, fasting plasma glucose (p = 0.062), pre-test probability greater than65% (p less than 0.002), positive exercise echocardiography (p less than0.004), and CP (p=0.026) were predictors of coronary artery disease. Evaluations of sub-groups without and with significant coronary artery disease and multivariate evaluation are symbolized in the tables below.

About the sub group of 42 (13.6 percent) subjects with rest wall motion irregularities 8 (19 percent) experienced left ventricular (LV) hypokinesia. From the 42 individuals 34 (81 percent) evolved worsening wall motion problems throughout exercise echocardiography and demonstrated significant coronary artery disease in the cardiac angiography, 4 (9.5%) had been described as negative exercise echocardiography and didn't have significant coronary artery disease and 4 (9.5 percent) couldn't accomplish sub-maximal expected heartrate, both without CAD in the cardiac angiography.

Sensitivity, predictive and specificity values, NLR, PLR and effectiveness: Area under the curve of exercise echocardiography alone was 1.54 (95 % CI 0.68 to 0.86), while AUC with CP results was 1.62 (95 percent confidence interval 0.70 to 0.92) (p=1.05).

Level of sensitivity, uniqueness, predictive values, and probability ratios for Coronary Artery Disease diagnosis

Table 2: Medical, exercise, carotid sonography, demographic data in the sub-group of individuals without and with Coronary Artery Disease (CAD)

	Coronary Artery Disease greater than equal to 50 % (n = 178)	Coronary Artery Disease less than 50 % (n = 134)	p-value
Age (years)	135.2 (9.2)	128.2 (11.6)	0.09
Gender	132 (74.2%)	144 (53.7 %)	0.022
BMI (Kg/m2)	58.2 (4.2)	56.2 (3.8)	0.268
High Blood Pressure	110 (61.8 %)	76 (56.5 %)	0.621
Hypercholesterolemia	112 (62.9 %)	70 (52.3 %)	0.193
Diabetes Mellitus	62 (34.8 %)	20 (14.9 %)	0.012
Smokers	92 (51.7 %)	36 (32.9 %)	0.046
Family history of Premature Coronary Artery Disease (CAD)	28 (15.7 %)	16 (11.8 %)	1.286
FPG Levels (mg/dL)	241.4 (38.7)	211.4 (22.4)	0.06
Glomerular filtration rate (GFR) (1.73 m2)	384.0 (47.5)	371 (40.8)	0.758
Cholesterol levels (mg/dL)	117.2 (40.7)	221.4 (36.1)	0.0.616
HDL (high-density lipoprotein) (mg/dL)	86.0 (11.3)	91.8 (12.2)	0.336
Triacylglycerols (mg/dL)	321.2 (91.1)	314.4 (98.7)	1.648
Glomerular filtration rate (GFR)	151.2 (23.2)	162.2 (24.8)	0.21
SCORE			< 0.002
Low	2 (1.1 %)	18 (13.6 %)	
Moderate	48 (27.3 %)	56 (42.4 %)	
High	56 (31.8 %)	38 (28.8 %)	
Peak	70 (39.8 %)	20 (15.3 %)	
PTP of Coronary Artery Disease			< 0.002
Less than 15 Percent	0 (0 %)	6 (4.5 %)	
15 to 65 Percent	62 (34.8%)	84 (62.7 %)	
65 to 85 Percent	110 (61.8%)	44 (32.8 %)	
Greater than 85 Percent	6 (3.4%)	0 (0%)	
Positive EE	146 (82.0%)	40 (29.9%)	< 0.002
Mean Constraint-induced movement therapy (CIMT) (mm)	1.76 (0.21)	1.78 (0.18)	1.852
Constraint-induced movement therapy greater than 0.9 mm	76 (42.7%)	62 (46.3%)	1.49
Constraint-induced movement therapy greater than 75th percentile	104 (58.4%)	92 (68.7%)	0.484
Carotid plaque	132 (74.2%)	58 (43.3%)	< 0.002
Calcified Carotid plaque	64 (36.0%)	30 (22.4%)	0.158

Multivariate Coronary Artery Disease (CAD) evaluation

Table 3: Effectiveness of carotid sonography in the medical diagnosis of CAD in individuals going through EE

Variables	B	P-value	OR	95 % Confidence Interval (CI)	
				Low	High
Constant	−9.66	< 0.002	0.02		
Smokers	1.68	0.0114	4.62	1.96	10.92
Fasting plasma glucose	0.4	0.62	2.04	2.00	2.08
PTP of Coro nary Artery Disease > 65%	2.62	0.006	7.42	3.14	17.58
Positive Exercise echocardiography	4.7	< 0.002	21.02	8.72	50.4
Carotid plaque	2.16	0.026	5.9	2.5	13.8

Table 4: Effectiveness of carotid ultrasound in the proper diagnosis of CAD in individuals experiencing EE

Conclusive Exercise echocardiography (N = 262)								
	Sensitivity (95% Confidence Interval (CI))	Specificity (95% Confidence Interval (CI))	PPV (95% Confidence Interval (CI))	NPV (95% Confidence Interval (CI))	Efficiency (95% Confidence Interval (CI))	AUC (95% Confidence Interval (CI))	Positive likelihood ratio	Negative likelihood ratio
Exercise echocardiography	94.2% (168.8–193)	61.5% (96.0–147)	78.5% (138.2–171.2)	84.2% (139.2–185.2)	80.3% (145–172.2)	0.78 (1.36–1.72)	4.8	0.24
Exercise echocardiography + CP	98.1% (180.2–199.4)	63.3% (91–156.2)	82.5% (142.8–180.0)	95.0% (152.4–198.2)	86.1% (152.8–183)	0.82 (1.4–1.84)	5.36	0.06

Level of sensitivity, uniqueness, predictive values, NLR, PLR and effectiveness with exercise echocardiography and exercise echocardiography along with CP are described in the Table below.

DISCUSSION

The research study correlates coronary artery disease and carotid disease within the real-life cohort of affected individuals without earlier cardio vascular disease going through exercise echocardiography. Although, its inclusion in stress tests does not improve coronary artery disease forecast by cardiac angiography. It's important to check the reality that about 1 / 3 individuals with negative exercise echocardiography and without coronary artery disease are re-classified to the high risk group in accordance with carotid sonography results.[7]

Akosah et al.,[8] identified a connection among carotid (maximal Constraint-induced movement therapy or CP =1 millimeter) and coronary artery disease in 236 sufferers known for elective heart angiography with a higher negative predictive value with both negative testing. Although only 165 (68.6 per cent) subjects had stress-test conducted (the type wasn't explained within their research), the low positive predictive value (36 per cent), as well as 95 % confidence interval, weren't described. Kanwar et al.,[9] described research on fifty symptomatic individuals without coronary artery disease who experienced angiography after stress-testing.[10] CP, particularly those having heterogeneous structure, abnormal surface area or calcification, was a forecaster of coronary artery disease displaying a NPV of a hundred per cent in affected individuals with equivocal stress test and carotid plaque deficiency.[11] Coskun et al.,[12] recognized high blood pressure and carotid intima media thickness =1 millimeter as predictors of coronary artery disease in individuals without past stroke or CAD, planned for angiography after a positive-stress test. Much like Akosah et al.,[8] the stress test's positive predictive value was low compared to our final results (60 per cent). Ultimately, Ahmadvazir et al.,[13] determined pre-test possibilities, positive-stress-test and the existence of carotid plaque as predictors of coronary artery disease in 592 affected individuals with diagnosed coronary artery disease experiencing stress echo. As in past research studies, the negative predictive value merging stress test and carotid ultrasound was higher (80 per cent) and, in agreement with the results, almost 1 / 3 of the sufferers had been re-classified for risk score based on carotid plaque outcomes.[8] Although just thirty-five per cent of the individuals were exercised as stress strategy was just utilized in sixty-two per cent and just eighty-three (14 per cent) experienced heart angiography and, like the other studies, confidence interval or evaluation between areas under the curve weren't reported. Compared with past studies, Sachpekidis didn't find any mathematical relationship among CAD and carotid (described as a positive dobut-amine stress test) in one hundred thirty sufferers, forty-three per cent of whom had prior coronary artery disease. Although the research population was small, with just 37.5 per cent producing good results, earlier coronary artery disease might have affected its results, and there wasn't any comparability with angiography.

Vascular disease is a systemic problem; most likely that individuals with the carotid disease have coronary artery disease. This reality, as earlier mentioned, was shown in post-mortem research as well as in meta-analysis. The high variation of the relationship, with the relationship ranging from -0.08 to 1.1 in the previously mentioned meta-analysis, might result from methodological variations in carotid sonography evaluation and variation in vascular disease advancement amongst the vascular areas. Based on guidelines about the management of stable coronary artery disease, pre-test probability of coronary artery disease should be set up along with a non-invasive test that needs to be conducted for prognostic or diagnostic reasons concerning the degree of pretest possibilities.[12] Both acknowledge that the background of peripheral or cerebrovascular artery disease boosts the probability of coronary artery disease.

In our research, most of the affected individuals (96.5 per cent) had advanced pretest probability, and, most of all, none experienced vascular or coronary artery disease earlier. Predictors positively linked to coronary artery disease were positive exercise echocardiography (odds ratio=42.04), pretest possibilities greater thn65 per cent (odds ratio=42.84), CP (odds ratio=11.8) and fasting plasma glucose levels (odds ratio=4.09). It's interesting to note that some other essential risks linked to coronary artery disease, for example, high blood pressure, levels of cholesterol, hypercholesterolemia or smoking, weren't considerably linked to coronary artery disease in our research; this fact might be described because of inadequate mathematical power and because of treatment impact, for instance, 84 patients (47.2%) with coronary artery disease had to have statins during the time of exercise echocardiography performance. However, just 52 (38.8 per cent) of subjects without coronary artery disease were taking them; also, 112 (62.9 per cent) subjects with coronary artery disease were on anti-hypertensive medications when compared to just 70 (52.2 per cent) of affected individuals without coronary artery disease. Fasting plasma glucose, not diabetes mellitus, was linked to coronary artery disease; the main reason might be because the advancement of macro-vascular disease takes place with insulin resistance before diabetes diagnosis; higher risk SCORE wasn't also linked to coronary artery disease, most likely as it's not developed to calculate it, only the risk of a deadly atherosclerotic accident. Although carotid plaque is the 3rd in order in-multivariable evaluation after positive exercise echocardiography and pre-test probability of coronary artery disease greater than 65 per cent, it boosts by almost three the probability of having significant coronary artery disease, so carotid sonography might be beneficial in case of advanced pretest possibilities, where medical diagnosis must be verified, or even in equivocal exercise echocardiography.[14]

Furthermore, Ahmadvazir et al.,[13] carotid plaque presence re-classified around 1 / 3 of affected individuals to a higher risk classification in spite of negative exercise echocardiography or a normal heart angiography.[15] It is an outstanding finding as these subjects take advantage of aggressive primary precautionary solutions and, though coronary disease avoidance in the medical practice, set up atherosclerotic plaque recognition by carotid artery checking in cardio risk evaluation as an II b class level of evidence recommendation, thinking about earlier mentioned research it may be altered to II a suggestion. Ultimately, although carotid plaque is linked to substantial coronary artery disease, its inclusion to exercise echocardiography didn't enhance the area under the curve (p=1.05), predictive values, effectiveness and probability ratios because of confidence interval overlap.[16] These details might be described by inadequate mathematical power; although it's essential to uncover the substantially, however mathematically, non-significant rise in both negative predictive value, particularly within the high and moderate pre-test probability of coronary artery disease groups as in the negative likelihood ratio. These results, however non-significant, are constant in Kanwar et al.,[9] and Ahmadvazir et al.,[13] research, where the confidence interval wasn't described. In this sense, we regarded the research only as hypothesis increasing and generating a sample that might corroborate it.[17] While there's research dealing with the usage of carotid ultrasound for choosing affected individuals who don't need coronary angiography before coronary heart valve surgical treatment, within our research, 25.8 per cent of affected individuals with significant coronary artery disease didn't have carotid plaque, and 43.3 per cent of affected individuals without substantial coronary artery disease have carotid plaque within the carotid ultrasound.[18]

CONCLUSIONS

To conclude, our research demonstrates that carotid disease, particularly the existence of carotid plaque, is linked to substantial coronary artery disease in affected individuals sent to exercise echocardiography. Its inclusion to exercise echocardiography doesn't boost the level of sensitivity, uniqueness, predictive values, probability ratios, effectiveness and area under the curve for significant coronary artery disease medical diagnosis, most likely because of inadequate statistical power. Although carotid plaque re-classified 1 / 3 of patients to higher risk SCORE classification in spite of negative exercise echocardiography or coronary artery disease absence and these subjects take advantage of aggressive primary prevention treatments.

Recommendation: Carotid ultrasound is advised if a person have medical conditions that can alleviate the risk of stroke and other coronary artery related issues.

Ethics approval and consent to participate:

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Authors' contributions: Dr. Tahir Hussain provided the idea of the study and contributed in topic selection and manuscript write up. Dr. Rafeah Khan, Dr. Muhammad Saqib Qamar Ishaqi designed the methodology. Dr. Syed M Shahnawaz Hyder, Dr. Manoj Kumar, Dr. Sheema Ihtisham analyzed the data and performed manuscript write up and proofreading.

REFERENCES

1. Li, W., Wang, Y., Chen, S., Zhao, J., Fan, Y., Wu, S., ... & Hong, J. (2022). Evaluation of carotid artery atherosclerosis and arterial stiffness in cardiovascular disease risk: An ongoing prospective study from the Kailuan cohort. Frontiers in Cardiovascular Medicine, 858.
2. Thygesen, K., Alpert, J. S., Jaffe, A. S., Chaitman, B. R., Bax, J. J., Morrow, D. A., ... & Executive Group on behalf of the Joint European Society of Cardiology (ESC)/American College of Cardiology (ACC)/American Heart Association (AHA)/World Heart Federation (WHF) Task Force for the Universal Definition of Myocardial Infarction. (2018). Fourth universal definition of myocardial infarction (2018). Journal of the American College of Cardiology, 72(18), 2231-2264.
3. Alpert, J. S., Jaffe, A. S., White, H. D., & Thygesen, K. A. (2022). Type 1, Type 2 myocardial infarction and non-ischemic myocardial injury—opinion from the front lines. The American journal of medicine.
4. Tsirimiagkou, C., Karatzi, K., Argyris, A., Chalkidou, F., Tzelefa, V., Sfikakis, P. P., ... & Protogerou, A. D. (2021). Levels of dietary sodium intake: Diverging associations with arterial stiffness and atheromatosis. Hellenic Journal of Cardiology, 62(6), 439-446.
5. Campbell, N. R., He, F. J., Cappuccio, F. P., MacGregor, G. A., & McLean, R. M. (2021). Levels of dietary sodium intake: diverging associations with arterial stiffness and Atheromatosis. Concerns about the evidence review and methods. Hellenic J Cardiol.
6. Carey, R. M., & Whelton, P. K. (2018). The 2017 American College of Cardiology/American Heart Association hypertension guideline: a resource for practicing clinicians. Annals of Internal Medicine, 168(5), 359-360.
7. D'Elia, L. and Strazzullo, P., 2019. Sodium and Potassium. Manual of Hypertension of the European Society of Hypertension, pp.75-79.
8. Otsuka, K., Nakanishi, K., Shimada, K., Nakamura, H., Inanami, H., Nishioka, H., ... & Yoshiyama, M. (2019). Ankle-brachial index, arterial stiffness, and biomarkers in the prediction of mortality and outcomes in patients with end-stage kidney disease. Clinical Cardiology, 42(7), 656-662.
9. Jennings, A., Berendsen, A. M., De Groot, L. C., Feskens, E. J., Brzozowska, A., Sicinska, E., ... & Cassidy, A. (2019). Mediterranean-style diet improves systolic blood pressure and arterial stiffness in older adults: results of a 1-year European multi-center trial. Hypertension, 73(3), 578-586.
10. Tomiyama, H., Ohkuma, T., Ninomiya, T., Mastumoto, C., Kario, K., Hoshide, S., ... & Collaborative Group for J-BAVELs (Japan Brachial-Ankle Pulse Wave Velocity Individual Participant Data Meta-Analysis of Prospective Studies). (2019). Steno-stiffness approach for cardiovascular disease risk assessment in primary prevention. Hypertension, 73(3), 508-513.
11. Wu, S., An, S., Li, W., Lichtenstein, A. H., Gao, J., Kris-Etherton, P. M., ... & Gao, X. (2019). Association of trajectory of cardiovascular health score and incident cardiovascular disease. JAMA network open, 2(5), e194758-e194758.
12. Asada, M., Oishi, E., Sakata, S., Hata, J., Yoshida, D., Honda, T., ... & Ninomiya, T. (2019). Serum lipopolysaccharide-binding protein levels and the incidence of cardiovascular disease in a general Japanese population: the hisayama study. Journal of the American Heart Association, 8(21), e013628.
13. Saiki, A., Ohira, M., Yamaguchi, T., Nagayama, D., Shimizu, N., Shirai, K., & Tatsuno, I. (2020). New horizons of arterial stiffness developed using cardio-ankle vascular index (CAVI). Journal of Atherosclerosis and Thrombosis, 27(8), 732-748.
14. Chen, C., Yan, J. T., Zhou, N., Zhao, J. P., & Wang, D. W. (2020). Analysis of myocardial injury in patients with COVID-19 and association between concomitant cardiovascular diseases and severity of COVID-19. Zhonghua xin xue guan bing za zhi, 567-571.
15. Carey, R. M., & Whelton, P. K. (2018). The 2017 American College of Cardiology/American Heart Association hypertension guideline: a resource for practicing clinicians. Annals of Internal Medicine, 168(5), 359-360..