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ORIGINAL RESEARCH

COMMON CAROTID ARTERY INTIMA-MEDIA THICKNESS, PLAQUE MORPHOLOGY AND CAROTID DISTENSIBILITY EVALUATION BY HIGH-RESOLUTION ULTRASOUND IN KNOWN CASES OF CORONARY ARTERY DISEASE – AN OBSERVATIONAL STUDY

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Abstract

Background: Common Carotid Artery Intima-Media Thickness (CCAIMT) is increasingly used as a surrogate marker of early atherosclerosis, and recently been shown that CCAIMT is a strong predictor of future vascular events such as stroke and myocardial infarction.

Aims and Objectives:

1. Correlation of common carotid artery bulb intima-media thickness and plaque analysis with coronary heart disease.
2. To evaluate the distensibility of carotid arteries in known cases of coronary artery disease.
3. To estimate the risk of cerebrovascular accidents in patients who are known cases of coronary artery disease.

Materials and Methods: This was a prospective, observational study conducted among one hundred known cases of coronary artery disease from June 2016 to January 2018 in Vikram Hospital private limited, Yadavagiri, Mysore, Karnataka. After obtaining approval from the ethical committee of the hospital, in the Department of Radiology.

Results: Morphological features of increased common carotid artery intima-media thickness, high plaque score and decreased carotid artery distensibility in the carotid Doppler study show a good correlation between carotid artery disease and coronary angiographic findings. The systolic and diastolic diameters of the CCA can be measured reliably by M mode sonography. However, even a small variance in these measurements will cause a considerable difference in arterial distensibility metrics.

Conclusion: Our study concluded that HRUS plays an important role in the evaluation of carotid arteries in known cases of coronary disease, which is a safe, reliable and moderately inexpensive modality.

Keywords: Common Carotid Artery Intima-Media Thickness (CCAIMT), Plaque Morphology, Carotid Distensibility, High-Resolution Ultrasound, Coronary Artery Disease

Introduction

Carotid artery disease is a common finding in patients with coronary artery disease (CAD) and its presence is associated with worse clinical outcomes. Common Carotid Artery Intima-Media Thickness (CCAIMT) is increasingly used as a surrogate marker of early atherosclerosis, and has recently been shown that it is a strong predictor of future vascular events such as stroke and myocardial infarction.[1]The atherosclerotic vascular disease usually begins in childhood and progresses over decades.[2] Clinically symptomatic cardiovascular disease (CVD) events generally do not occur until atherosclerosis progresses to flow-limiting disease that causes ischemia, or when a thrombus forms on an existing plaque as a result of rupture or erosion.[3]

Measurement of Carotid Intima-Media Thickness (CIMT) with B mode ultrasound is efficient, non-invasive, sensitive, relatively inexpensive, reliable, reproducible and did not cause radiation risks or risks of contrast media.[4]

Aims and Objectives

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Material and methods

This was a prospective, observational study conducted among one hundred known cases of coronary artery disease from June 2016 to January 2018 in Vikram Hospital private limited, Yadavagiri, Mysore, Karnataka. After obtaining approval from the ethical committee of the hospital, in the Department of Radiology.

Sample Size with Justification

The sample size was calculated using the formula.

Formula:

$$n = \frac{Z_{1-\alpha/2}\ \sigma^2}{\epsilon^2\ \mu^2}$$

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

σ: Standard Deviation

ε : Relative Precision

μ : Mean

$1 - \alpha/2$: Desired Confidence Level

Assuming the average CIMT as 0.69 with a standard deviation of 0.13, with a relative precision of 12% and an alpha level of 5%, a sample size of 90 had to be studied, which was rounded off to 100. A convenient sampling technique was used. Confirmed cases of coronary artery diseases by angiography were included in the study continuously based on availability. Written & informed consent was taken.

Inclusion Criteria

1. Patients who were confirmed as cases of coronary heart disease by coronary angiography which included a 50% stenosis of a single major epicardial vessel or more than a single vessel disease.
2. Patients in the age group of 30 to 70 years.

Exclusion Criteria

1. Patients who were comatose or critically ill.
2. Patients with technically unsatisfactory CT coronary angiography studies and carotid ultrasonography due to technical difficulty.
3. Patients who were already known cases of cerebrovascular accidents.

Study Procedure

Patients were examined in the supine position with the head slightly hyperextended and rotated 45° away from the side being examined. Carotid high-resolution ultrasound examinations were conducted using a commercially available linear array transducer (7 - 12 MHz linear probe, Acuson Antares 300, Siemens). Other machines used were Siemens Acuson NX3 and Philips Affiniti 70 G.

Statistical Methods

Data were entered into a Microsoft Excel data sheet and analysed using SPSS 22 version software. The demographic characteristics were represented using mean ± SD and percentages. Categorical data were represented in the form of frequencies and proportions. The chi-square test was used as a test of significance for qualitative data. Continuous data were represented as mean and SD. Independent t-test was used as a test of significance to identify the mean difference between two quantitative variables.

ANOVA (Analysis of Variance) was the test of significance to identify the mean difference between more than two groups for quantitative data. The logistic regression analysis has been used to predict cerebrovascular accidents using different independent variables such as CIMT, Plaque score and carotid artery distensibility. Pearson correlation was done to find the correlation between two quantitative variables and qualitative variables respectively. A p-value (Probability that the result is true) of <0.05 was considered statistically significant after assuming all the rules of statistical tests. MS Excel, SPSS version 22 (IBM SPSS Statistics,

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

Somers NY, USA) was used to analyse data. EPI Info (CDC Atlanta), OpenEpi, MedCalc and Medley's desktop were used to estimate sample size and reference management in the study.

Results

The majority of subjects with single vessel disease and double vessel disease were in the age group 51 to 60 years (45.3% and 44.4% respectively) and the majority of subjects with triple vessel disease were in the age group 61 to 70 years (85%). There was a significant difference in age distribution with respect to the type of CAD. The mean age was 55.61 years for females and 56.52 years for males.

Among those with single-vessel disease, 43.4% were females and 56.6% were males, for those with double vessel disease, 25.9% were females and 74.1% were males and for those with triple vessel disease, 30% were females and 70% were males. There was no significant difference in gender distribution between types of CAD. In total there were 64 males and 36 females.

Among single vessel disease subjects, 43.4% had hypertension, 47.2% had diabetes, 26.4% had dyslipidemia and 34% were smokers. Of those with double vessel disease, 96.3% had hypertension, 48.1% had diabetes, 59.3% had dyslipidemia and 70.4% were smokers. Of those with triple vessel disease, 100% had hypertension, 90% had diabetes, 85% had dyslipidemia and 80% were smokers. There was a significant difference in type of CAD with respect to hypertension, diabetes, dyslipidemia and smoking status. Among those with single-vessel disease, 49.1% were non-obese and 50.9% were obese, for those with double vessel disease, 40.7% were non-obese and 59.3% were obese and for those with triple vessel disease, 35% were non-obese and 65% were obese. There was no significant difference in BMI distribution between types of CAD.

Distribution of Types of Plaques

In our study population, Type 1 plaques (58) were the most common, followed by Type 2(53) and Type 3(47).Type 4 plaques (35) were the least among all**.** Type 1 and Type 2 plaques were considered echolucent plaques and Type 3 and 4 were considered echogenic plaques in our study. Among triple vessel disease, 9 echolucent plaques and 11 echogenic plaques were found. In double vessel disease, 15 echolucent plaques and 12 echogenic plaques were seen. Single-vessel disease patients had 29 echolucent plaques and 24 echogenic plaques.

For those with single vessel disease, 13.2% had CIMT <0.9 mm and 86.8% had CIMT >0.9 mm, among those with double vessel disease, 7.4% had CIMT <0.9 mm and 92.6% had CIMT >0.9 mm and among those with triple vessel disease, 100% had CIMT >0.9 mm. There was no significant difference in CIMT and type of CAD.

Among the single vessel disease patients, CIMT thickness was 0.93mm with a standard deviation of 0.07 mm and was seen in 53 patients, followed by a double vessel disease having 1.01 mm of CIMT thickness with a standard deviation of 0.11 mm in 27 patients. The triple vessel disease involved patients with a maximum mean CIMT thickness of 1.19 mm and a standard deviation of 0.6 mm in 20 patients.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

		Type of CAD					
		Single Vessel Disease		Double Vessel Disease		Triple Vessel Disease	
		Count	%	Count	%	Count	%
CIMT	<0.9	7	13.2%	2	7.4%	0	0.0%
	>0.9	46	86.8%	25	92.6%	20	100.0%
CIMT comparison among three types of CAD							
χ 2 = 3.207, df = 2, p = 0.201							
		Types of CAD					
		Single Vessel Disease		**Double Vessel Disease**		**Triple Vessel Disease**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Plaque Score (in mm)	<1.9	18	34.0%	0	0.0%	0	0.0%
	>1.9	35	66.0%	27	100.0%	20	100.0%
Plaque score comparison among three types of CAD.							
χ 2 = 19.46, df = 2, p <0.001*							
		Type of CAD					
		Single Vessel Disease		**Double Vessel Disease**		**Triple Vessel Disease**	
		Count	**%**	**Count**	**%**	**Count**	**%**
CAS	No Stenosis	41	77.4%	2	7.4%	0	0.0%
	Mild Stenosis	10	18.9%	16	59.3%	3	15.0%
	Moderate Stenosis	2	3.8%	8	29.6%	10	50.0%
	Severe Stenosis	0	0.0%	1	3.7%	7	35.0%
	Near or Total occlusion	0	0.0%	0	0.0%	0	0%
CAS comparison among three types of CAD							
χ 2 = 83.175, df = 6, p <0.001*							
		Types of CAD					
		Single Vessel Disease		**Double Vessel Disease**		**Triple Vessel Disease**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Carotid Artery Distensibility Coefficient (in 10^{-3} /kPa)	<24	22	41.5%	27	100.0%	20	100.0%
	>24	31	58.5%	0	0.0%	0	0.0%
Carotid Artery Distensibility Coefficient comparison among three types of CAD.							
χ 2 = 39.84, df = 2, p <0.001*							
Table/Figure1							

There was a statistically significant difference in the mean CIMT values among different categories of vessel involvement. ANOVA test has been used here. The post hoc Bonferroni test showed a significant difference between all three combinations as well. Of those with single vessel disease, 34% had plaque score <1.9 mm and 66% had plaque score >1.9 mm, among those with double vessel disease and triple vessel disease, 100% had plaque score >1.9 mm. There was a significant difference in plaque score and types of CAD. Among the single-vessel diseased patients, the mean plaque score was 2.06 mm with a standard deviation

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

of 0.48 mm and was seen in 53 patients, followed by a double vessel having mean plaque score of 4.36 mm with a standard deviation of 0.72 mm seen in 27 patients. The remaining had triple vessel disease with a mean plaque score of 5.80 mm with a standard deviation of 0.68 mm in 20 patients.

There was a statistically significant difference in the mean plaque score values among different coronary artery diseases. ANOVA test was used here. The post hoc Bonferroni test showed a significant difference between all three combinations as well. F value = 329.8, among subjects with single vessel disease, 77.4% had no stenosis, 18.9% had mild and 3.8% had moderate stenosis. For those with double vessel disease, 7.4% had no stenosis, 59.3% had mild, 29.6% had moderate stenosis and 3.7% had severe stenosis and among those with triple vessel disease, 15% had mild, 50% had moderate and 35% had severe stenosis. No subject had near or total occlusion. There was a significant difference in carotid artery stenosis with the type of CAD. For those with single vessel disease, 41.5% had carotid artery distensibility coefficient <24 $x10^{-3}$ /kPa and 58.5% had carotid artery distensibility coefficient >24 $x10^{-3}$ /kPa, among those with double vessel disease and triple vessel disease, 100% had carotid artery distensibility coefficient <24 $x10^{-3}$ /kPa. There was a significant difference in the carotid artery distensibility coefficient and types of CAD.

Among the single vessel diseased patients, the carotid artery distensibility coefficient was 25.51 $x10^{-3}$ /kPa with a standard deviation of 6.65 $x10^{-3}$ /kPa and was seen in 53 patients, followed by a double vessel having 13.26 $x10^{-3}$ with standard deviation 3.80 $x10^{-3}$ /kPa seen in 27 patients. 20 patients had triple vessels having a mean carotid artery distensibility coefficient of 8.45 $x10^{-3}$ /kPa with a standard deviation of $2.85x10^{-3}$/kPa.

	Type of CAD									**P-Value**
	Single Vessel Disease			**Double Vessel Disease**			**Triple Vessel Disease**			
CIMT	0.94	0.08	0.90	1.10	0.12	1.10	1.19	0.06	1.20	<0.001*
PLQ Score	2.06	0.48	2.00	4.36	0.72	4.40	5.80	0.68	5.85	<0.001*
Carotid Artery Distensibility Coefficient	25.51	6.65	26.00	13.26	3.81	13.00	8.45	2.86	8.00	<0.001*

Table/Figure 2: CIMT, Plaque score and Carotid Artery Distensibility Coefficient comparison among three types of CAD

P-Value	**Single vs. Double Vessel**	**Single vs. Triple Vessel**	**Double vs. Triple Vessel**
CIMT	<0.001*	<0.001*	0.001*
PLQ Score	<0.001*	<0.001*	<0.001*
Carotid Artery Distensibility Coefficient	<0.001*	<0.001*	0.01*

Table/Figure 3: Comparison of CIMT, Plaque score and Carotid Artery Distensibility Coefficient among three types of CAD

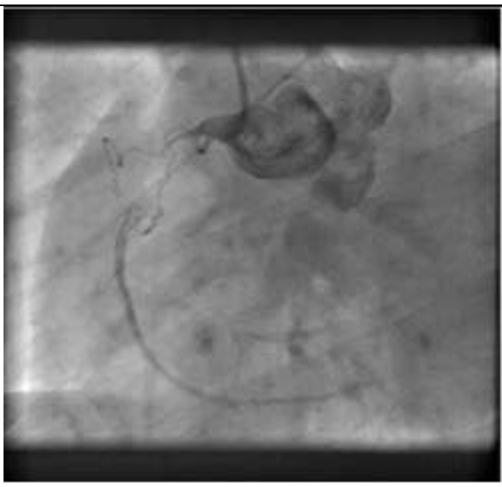
ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

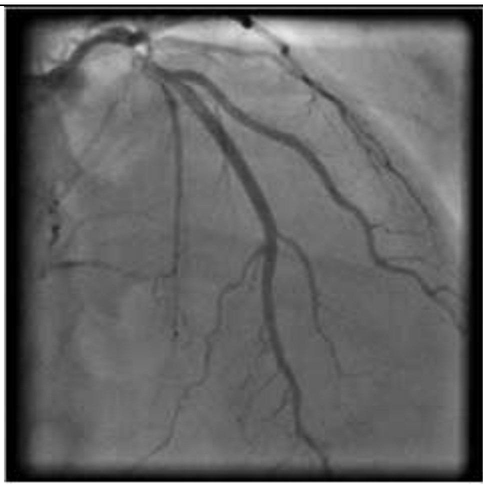
	CIMT	P-Value
Hypertensives	1.07± 0.13	<0.001*
Non-hypertensives	0.93 ± 0.06	
Diabetics	1.05± 0.13	0.032
Non-diabetics	0.99 ± 0.13	
Dyslipidemics	1.08± 0.13	<0.001*
Non-dyslipidemics	0.98 ± 0.12	
Smokers	1.10 ± 0.11	0.015
Non-smokers	0.94 ± 0.10	
Obese	1.04± 0.14	0.161
Non-obese	1.00 ± 0.13	

Table/Figure 4: Relationship of the Mean carotid artery intima-media thickness with Hypertension, Diabetes mellitus, Dyslipidemics, Smokers and Obesity

A:M mode Doppler ultrasound showing normal carotid distensibility

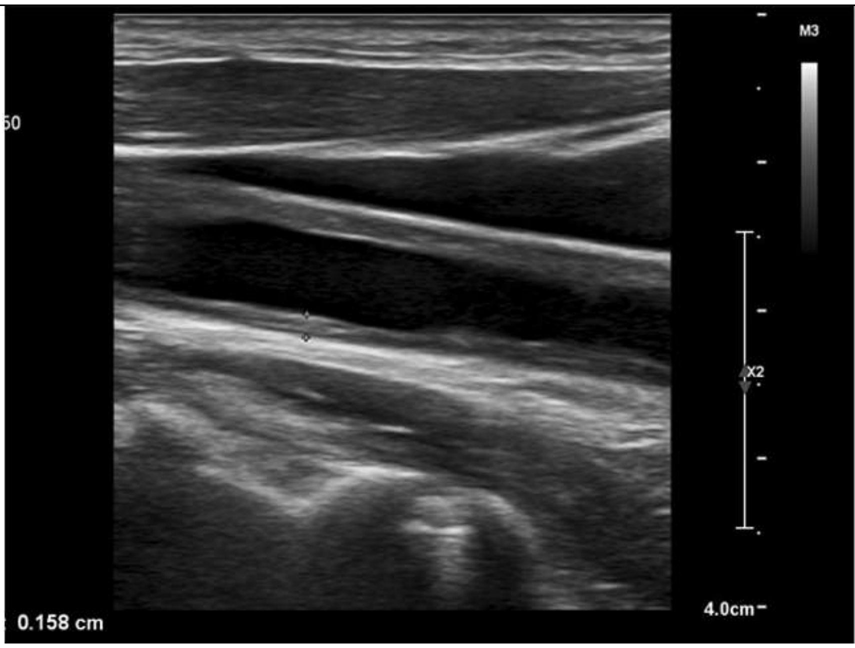
ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022



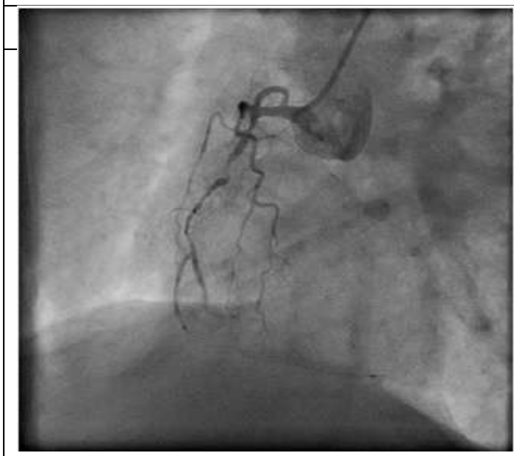


B and C: Coronary angiogram images showing single vessel disease

Table/Figure 5: A 46-year-old dyslipidemic female with single vessel disease



A: B mode grey scale ultrasound longitudinal section showing diffuse intimal thickening with plaques in the right common carotid artery



ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

B and C: Coronary angiogram images showing triple vessel disease
Table/Figure 6: A 56-year-old male patient with triple vessel disease

In the study, mean CIMT and plaque scores were significantly high in subjects with triple vessel disease compared to single and double vessel disease. Carotid artery distensibility was significantly low in subjects with triple vessel disease compared to single and double vessel disease.

The post hoc Bonferroni test showed that there was a significant difference in mean CIMT, plaque score and carotid artery distensibility b/w single vs. double vessel disease, single vs. triple vessel disease and double vs. triple vessel disease.

Among the study population of 100, there was a highly statistically significant difference between the CIMT values of hypertensives and non-hypertensives, dyslipidemics and non-dyslipidemics. The mean CIMT values for the smokers, diabetics and obese patients were higher compared to their normal counterparts but the difference was not statistically significant though.

In our study out of 100 patients, 69 were hypertensives and 31 were non-hypertensives. Carotid artery distensibility coefficient among the hypertensives was $14.09 \pm 6.02 \times 10^{-3}$ /kPa and non-hypertensives was $29.26 \pm 5.16 \times 10^{-3}$ /kPa.

There was a highly statistically significant difference between the carotid artery distensibility values of hypertensive and non-hypertensive subjects. The carotid artery distensibility coefficient values for the hypertensives were found to be lower.

There was no statistically significant difference between the carotid artery distensibility coefficient values of diabetics and non-diabetics. The carotid artery distensibility values for diabetics were found to be comparatively lower than non-diabetics. In our study, single vessel involvement was the most common and was seen in 53 patients. Among them, 31 patients had normal carotid artery distensibility and 22 had abnormal carotid artery distensibility, followed by double vessel involvement in 27 patients and all 27 patients had abnormal carotid artery distensibility. Rest was triple vessel involvement in 20 patients and all of them had abnormal carotid artery distensibility.

The mean carotid artery distensibility coefficient of those 5 patients who had a cerebrovascular accident was $8.50 \pm 3.27 \times 10^{-3}$ /kPa and among the rest of the 95 patients it was $19.45 \pm 8.9 \times 10^{-3}$ /kPa. There was a statistically significant difference noted between the carotid artery distensibility of the patients having cerebrovascular events and among those without cerebrovascular events.

P value	**Single vs Double vessel**	**Single vs Triple Vessel**	**Double vs Triple Vessel**
CIMT	<0.001*	<0.001*	0.001*
PLQ Score	<0.001*	<0.001*	<0.001*
Carotid Artery Distensibility Coefficient	<0.001*	<0.001*	0.01*

Table/Figure 7: Comparison of CIMT, Plaque score and Carotid Artery Distensibility Coefficient among three types of CAD.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

Correlations				
		CIMT	**Plaque Score**	**Coronary Artery Distensibility**
CIMT	Pearson Correlation	1	0.332	0.197
	Sig. (2-tailed)		0.153	0.406
	N	20	20	20
Plaque Score	Pearson Correlation	0.332	1	-0.441
	P value	0.153		0.052
	N	20	20	20
Coronary Artery Distensibility Coefficient	Pearson Correlation	0.197	-0.441	1
	P value	0.406	0.052	
	N	20	20	20
a. Type of CAD = Triple Vessel Disease				

Table/Figure 8: Correlation among CIMT, Plaque Score and Coronary Artery Distensibility Coefficient among Triple vessel disease subjects

Among the subjects with triple vessel disease, there was a positive correlation between CIMT and plaque score i.e. with an increase in CIMT there was an increase in plaque score.

A negative correlation was observed between plaque score and coronary artery distensibility i.e. with an increase in plaque score there was a decrease in coronary artery distensibility and vice versa.

A positive correlation was observed between CIMT and coronary artery distensibility i.e. with an increase in CIMT there was an increase in coronary artery distensibility and vice versa.

However, none of the correlations was statistically significant. Risk estimation of cerebrovascular accidents in known cases of coronary artery disease was done by carotid artery intima-media thickness, plaque score and carotid artery distensibility.

Among 100 patients in our study, only 5 patients had cerebrovascular accidents during the follow-up of three months.

Discussion

1. Age Group Distribution of Study Subjects

The findings of our study in this regard correlate with the study of Schwitter et al[5] who found that the pathogenesis of MI was a lifestyle-related disease and the risk of disease increases with ageing. In their prospective study of 48 patients with suspected CAD, the mean age of the patients was 50 years.

2. Sex Distribution of Study Subjects

Findings of our study in this regard correlate with the study of Schwitter et al that showed male preponderance in the case of MI. In their study, it was noted that 38 patients were males and 10 patients were females. Also, several literatures agree with the male preponderance attributing to many factors like increased stress, lack of exercise and sedentary lifestyle.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

3. Risk Factors

In the study conducted by Schwitter et al,the risk factors identified were systemic hypertension (23 patients), hypercholesterolemia (27), diabetes mellitus (7 patients) smoking / history of smoking (20patients) and positive family history (12 patients). In another study by Guillem Pons Lladó et al,[6] the prevalence of cardiovascular risk factors was as follows: Hypertension 53%, smoking 72%, hypercholesterolemia 53%, and diabetes 31%. Our study results showed an agreement with both of these studies.

4. Coronary Angiography

Findings of our study in this regard correlate with the study of J Schwitter et al, single vessel involvement was seen in 16 patients (43%), double vessel involvement was seen in 14 (38%) patients and triple vessel involvement was seen in 7 (19%), making it the most common subgroup.

5. Carotid Artery Intima-Media Thickness

The findings of our study in this regard disagreed with the findings of the study ofLee EJ et al,[7] Poredos P et al[8] and agreed with George JM et al.[9]When 0.9 mm was used as the cut-off value (p-value =0.201), the difference was not seen, which was probably because our study population included only diseased patients.

6. Plaque Analysis

Morito N et al[10]studied 116 patients to see the correlation between plaque score and coronary artery disease. The coronary angiographic data was obtained in the same period as carotid ultrasonography was performed which showed that patients with single-vessel disease having plaque score of 3.8 mm and double vessel disease having 4.8 mm and the triple vessel with 7.9 mm showing the linear correlation of plaque score with the coronary artery disease. When compared with our study the mean plaque score for single vessel disease was 2.06 mm and for double vessel disease 4.36 mm and for triple vessel disease it was 5.80 mm, thus showing a similar linear correlation and strong agreement with this study. The cut-off value of 1.9 mm taken from this study proved highly significant in our study too.

7. Types of Plaques

In our study population, Type 1 plaques (58) were the most common, followed by Type 2(53) and Type 3(47).Type 4 plaques (35) were the least among all. Type 1 and 2 were echolucent plaques and type 3 and 4 were echogenic plaques.

Among triple vessel disease, 9 echolucent plaques and 11 echogenic plaques were found. In double vessel disease, 15 echolucent plaques and 12 echogenic plaques were seen.Single vessel disease patients had 29 echolucent plaques and 24 echogenic plaques.

Ellisiv. B. Mathiesen et al[11] assessed whether plaque morphology was associated with the risk of ischemic stroke and other cerebrovascular events in subjects with carotid stenosis and found that echolucent atherosclerotic plaques had an increased risk of ischemic cerebrovascular events independent of the degree of stenosis and cardiovascular risk factors.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

In our study, Type 4 had been taken as the reference category (as it had the lowest risk) and the most echolucent plaques (Type 1) posed a risk of 3.20 times when compared with most echogenic plaques (Type 4), though statistically insignificant. (OR=3.20, P value=0.501).

8. Carotid Artery Stenosis

Ioannis Kallikazaros et al[12] studied whether carotid artery disease detected by ultrasonography can be a clinically useful marker for the presence of severe coronary artery disease (CAD) in patients evaluated for chest pain. Duplex ultrasonography and quantitative coronary angiography were used to assess carotid and coronary artery atherosclerosis in 225 consecutive patients (mean age, 58-69 years) with chest pain referred for cardiac catheterization. CAD was present in 197 patients (88%). Fifty-seven patients (25%) had single vessel disease, 52 (23%) had double vessel disease, 53 (24%) had triple vessel disease, and 35 (16%) had left main stem CAD (LMS-CAD). The incidence of severe CAD (triple vessel disease or LMS-CAD) was 24% and 63% in the normal and impaired ejection fraction (EF) subgroups, respectively (P<0.005). Carotid disease (lumen diameter stenosis of >50%) was present in 5.3%, 13.5%, 24.5%, and 40% of patients with single, double, triple vessel disease and LMS-CAD, respectively. Our results too showed similar significant linear correlation between the severity of vessel involvement and carotid artery stenosis, i.e.; (SVD (0%), DVD (3.7%) and TVD (35%).

9. Relationship of the Carotid Artery Distensibility with Hypertension

Our study partly agreed with the study of Stephane Laurent et al.[13]It showed a highly significant reduction in carotid artery distensibility (P<0.001) in hypertensives but we did not match for mean arterial pressure thus explaining its significance in causing the decrease in distensibility.

10. Relationship of the Carotid Artery Distensibility with Diabetes Mellitus

Carotid artery distensibility coefficient among the diabetics (n=56) was $17.62 \pm 9.6 \times 10^{-3}$ /kPa and non-diabetics (n =44) was $20.27 \pm 8.20 \times 10^{-3}$ /kPa which was lower among the diabetics. There was no statistical significance though (p-value is 0.149) J Charvat et al[14]evaluated carotid artery parameters in normotensive patients with type 2 diabetes compared with non-diabetic control subjects. Using a high-resolution M mode ultrasound scanner in 82 patients with type 2 diabetes and 41 controls, the distensibility of the common carotid artery was calculated using the Reneman equation. Distensibility was significantly decreased in the diabetes group having 21.2×10^{-3} /kPa. In our study, diabetics had $17.62 \pm 9.6 \times 10^{-3}$ /kPa, suggesting that they had decreased elasticity of the vessel as said by decreased distensibility. Our study shows partial agreement with the J Charvat et al study but statistically insignificant (p-value is 0.149), attributable to our small study sample size.

Limitations

1. We studied a group of patients who were referred for carotid ultrasonography after coronary angiography and were confirmed cases of ischemic heart disease. This selection bias meant that our findings regarding the relationship of carotid artery disease with CAD might be relevant only to this special group of patients and might not apply to the general

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

population.
2. Classification of the extent of CAD based on the number of diseased vessels might not be as precise as other specific indexes for assessing the severity of the atherosclerotic disease.
3. Our study did not account for the effect of the potential development of new risk factors on vascular risk during follow-up.
4. The sample size of our study was small so the results of the study require further confirmation by a large group of study.

Conclusion

Our study concluded that HRUS plays an important role in the evaluation of carotid arteries in known cases of coronary disease, which is a safe, reliable and moderately inexpensive modality.

Morphological features of increased common carotid artery intima-media thickness, high plaque score and decreased carotid artery distensibility in the carotid Doppler study show a good correlation between carotid artery disease and coronary angiographic findings.

Carotid artery stenosis grading could be used to assess percentage diameter stenosis and identify moderate and severe stenosis which warrants early intervention like carotid endarterectomy/carotid artery stenting. The triple vessel coronary artery disease patients had an increased prevalence of severe stenosis in the carotid arteries.

Increased carotid artery distensibility had a protective effect from stroke and hypertension was the most important risk factor causing a decrease in distensibility.

The systolic and diastolic diameters of the CCA can be measured reliably by M mode sonography. However, even a small variance in these measurements will cause a considerable difference in arterial distensibility metrics.

All the cardiovascular risk factors except obesity (hypertension, diabetes, dyslipidemia and smoking) showed a strong relationship with coronary angiogram findings.

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ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

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