CAROTID PLAQUE CHARACTERIZATION USING DOPPLER ULTRASOUND WITH DIABETES, HYPERTENSION AND HYPERLIPIDEMIA

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DOI: https://doi.org/10.5281/zenodo.16886185

Received	Accepted	Published
16 May, 2025	21 July, 2025	16 August, 2025

ABSTRACT
Background: *Reduced oxygen flow to the brain is a result of carotid artery stenosis. The brain need oxygen to function continuously. The blood supply can be disrupted, even for a short time.*
Objective: *To evaluate carotid plaque using doppler ultrasound in subjects with risk factors diabetes hypertension and hyperlipidemia*
Methodology: *A cross-sectional descriptive study was conducted at CMH Kharian. 115 patients with both genders of all age groups were enrolled in this study by Convenient sampling technique. Both male and females were included. Patients with diabetes, hyperlipidemia and hypertension were included. Patients with known psychiatric disease, and inability to lie still for sonographic evaluation, were excluded. Patients having known carotid artery disease or past endarterectomy were excluded*
Results: *In this research study, a total of 115 patients were selected based on inclusion criteria. The frequency distributions have been shown in Tab.01, 02, 03, 04, 05. Male ratio 50.4% was higher than females 49.6%. Out of 115 patients 99 (86.1%) patients were diagnosed with hypertension, 103 (89.6%) were with diabetes, 30 (26.1%) were with hyper-lipidemia and 100 (87.0%) patients were diagnosed with plaque. Table 06 Shows 12.2% had hyperechoic plaques, 10.4% had heterogenous, 68.7% had calcified, and 8.7% had mixed plaque appearance.*
Conclusion: *Our study concludes that there was significant association between carotid plaques and diabetes, hypertension and hyper-lipidemia. By using the sample size, we found evidence of carotid plaque in the majority of subjects with possible risk factors. Since carotid Doppler ultrasound is sensitive, accurate, and reliable, it provides a low-cost noninvasive method for detecting carotid artery plaques.*
Key words: *Carotid intima media thickness, Peak systolic velocity, End diastolic velocity, Plaque.*

INTRODUCTION
The common carotid artery (CCA) is a large elastic artery responsible for supplying blood to the head and neck. While both sides of the body have a CCA, their origins differ: the left CCA arises from the aortic arch in the superior mediastinum, whereas the right CCA originates from the brachiocephalic trunk posterior to the right sternoclavicular joint. Each ascends within the carotid sheath, accompanied by the internal jugular vein and the vagus nerve (1–3).

Carotid intima–media thickness (IMT) is a well-established sonographic marker for assessing systemic atherosclerotic burden. It can be measured reliably using B-mode ultrasound, with measurements taken between the blood–intima interface and the media–adventitia junction (5, 6). Avoidance of atheromatous plaque during measurement is essential, and an average IMT is calculated for each CCA. A value greater than 1 mm is considered abnormal (7). IMT correlates linearly with systemic atherosclerosis and predicts the risk of myocardial infarction and cerebrovascular events. It is notably elevated in individuals with metabolic syndrome, with or without abdominal obesity (8–11).

Carotid artery intima–media thickness (CAIMT) is recognized as a surrogate marker for early atherosclerosis and a predictor of myocardial infarction and stroke (13). Its normal values vary by measurement method, lifestyle, diet, ethnicity, gender, and age (14). Atherosclerosis begins early in life, often remaining subclinical for decades. Fatty streaks and fibrous lesions may occupy up to 25–40% of the aortic intima in young adults (15, 16). This long preclinical phase allows for early detection and prevention. Traditional cardiovascular disease (CVD) risk scores, such as the Framingham Risk Score, explain only 60–65% of CVD risk, with many events occurring in individuals without conventional risk factors (17, 18). Non-invasive tools like CAIMT can improve risk prediction, especially for those at intermediate risk (19). Established risk factors for atherosclerosis include older age, hypertension (HTN), high body mass index (BMI), and hyperlipidemia (20, 21, 13). The carotid bulb is a common site for atherosclerotic stenosis (14).

Once symptomatic, atherosclerosis is difficult to reverse; therefore, prevention and early detection are critical to reducing morbidity and mortality (23). Pignoli's landmark 1986 study linked histological intima–media thickness to a characteristic sonographic double-line pattern, leading to the widespread use of carotid ultrasound for detecting subclinical atherosclerosis (24). This non-invasive, cost-effective, and safe technique not only detects increased wall thickness or plaques but also reflects overall systemic arterial health (25, 29). Both single-time and serial measurements of CAIMT provide valuable information, as the rate of IMT change also predicts cardiovascular risk (26–28).

IMT of the CCA is a strong predictor of cardiovascular events, making it a valid surrogate endpoint for clinical research (30). Predictive accuracy increases when CAIMT is measured at multiple extracranial sites (31). While both near- and far-wall measurements are possible, far-wall measurements are typically more accurate (32). In healthy adults, the average CCA IMT is 0.74 ± 0.14 mm (33). Values below 0.8 mm are usually normal, whereas those ≥1 mm are associated with atherosclerosis and increased CVD risk (34). Importantly, diet, lifestyle, and ethnicity influence CAIMT, and reference values from Western populations may not apply directly to Asian populations (35).

Early identification of carotid plaque and increased CAIMT can guide timely interventions to reduce the risk of stroke and other vascular events. This study aims to explore the relationship between major cardiovascular risk factors—diabetes, hypertension, and hyperlipidemia—and carotid artery changes as visualized by Doppler ultrasound. By improving diagnostic precision and identifying high-risk patients at an early stage, preventive treatment strategies can be implemented, reducing the burden of cerebrovascular disease and mortality in the community.

METHODOLOGY

This cross-sectional descriptive study was executed over four months at CMH Kharian, recruiting male and female patients who met the inclusion criteria via a straightforward sampling method. A total of 115 participants were recruited, and data were gathered using a pre-designed sheet to record demographic information, clinical risk factors (hypertension, diabetes, hyperlipidemia), and sonographic results. We used high-frequency linear transducers (7.5–11 MHz) on Toshiba Aplio 300 and Xario ultrasound systems to do carotid Doppler ultrasonography. This exam was done to measure intima-media thickness (IMT) and find atherosclerotic plaques. Standardized positioning and scanning techniques were adhered to, utilizing both gray-scale and color Doppler imaging for a thorough evaluation. We used SPSS version 23 to enter data and do statistical analysis. For continuous variables, we generated descriptive statistics, and for categorical variables, we estimated frequencies. A p-value of less than 0.05 was considered statistically significant. The Superior University Lahore Ethical Committee's ethical standards were followed for all operations. All participants gave their informed permission, and careful efforts were made to protect patient privacy and confidentiality.

RESULTS

Table 1: Demographic, Clinical, and Plaque Characteristics of Participants (n=115)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	58	50.4

	Female	57	49.6
Hypertension	Yes	99	86.1
	No	16	13.9
Diabetes Mellitus	Yes	103	89.6
	No	12	10.4
Hyperlipidemia	Yes	30	26.1
	No	85	73.9
Plaque Presence	Yes	100	87.0
	No	15	13.0
Plaque Type	Hyperechoic	14	12.2
	Heterogeneous	12	10.4
	Calcified	79	68.7
	Mixed	10	8.7

Table 2: Descriptive Statistics for Continuous Variables

Variable	Min	Max	Mean	Std. Deviation
BMI (kg/m²)	16.00	38.00	27.91	2.86
IMT (cm)	1.10	1.30	1.20	0.073
Age (years)	25	90	57.08	15.48
RCCA PSV (cm/s)	36.00	97.00	70.15	12.35
RICA PSV (cm/s)	29.00	112.00	64.95	17.71
LCCA PSV (cm/s)	39.00	108.00	73.21	13.80
LICA PSV (cm/s)	42.00	260.00	70.61	30.23

Table 3: Association Between Risk Factors and Carotid Plaque Formation (n=115)

Risk Factor	Category	Frequency (n)	% Within Plaque
Diabetes Mellitus	Yes	103	89.6
	No	12	10.4
Hypertension	Yes	99	86.1
	No	16	13.9
Hyperlipidemia	Yes	30	26.1
	No	85	73.9
Gender	Male	58	50.4
	Female	57	49.6
Age Group	≤40 years	18	15.7
	41–60 years	37	32.2
	>60 years	60	52.2

DISCUSSION

Chronic, progressive atherosclerotic plaque is a systemic condition closely associated with advanced age, diabetes mellitus, hypertension, hyperlipidemia, and, as some studies suggest, gender-related physiological differences. In our study, age emerged as an independent risk factor for the development of carotid plaque, aligning with existing evidence that aging contributes to cerebrovascular dysfunction, which may precipitate conditions such as cerebral amyloidosis and hypertension. Hypertension accelerates atherosclerosis through vascular endothelial injury, platelet aggregation, and the activation of mononuclear macrophages, while diabetes remains a significant contributor due to its role in inducing insulin resistance and hyperinsulinemia (23).

Carotid artery intima–media thickness (CAIMT) serves as a well-recognized surrogate marker of early-stage atherosclerosis. Establishing normative CAIMT values is critical for identifying pathological thickening, particularly when accounting for variations by age, sex, and associated risk factors. In our cohort, the mean CAIMT was 1.1991 ± 0.073 cm, closely comparable to findings by Wong et al., who reported a mean CAIMT of 2.1791 ± 0.199 cm in 110 patients across various age groups (8). Temelkova-Kurktschiev et al., studying 112 individuals (50 men and 62 women), concluded that gender significantly influences plaque prevalence, with men showing consistently higher values. Similarly, our findings indicated a positive correlation between plaque formation and male sex; however, this observation contrasts with some international literature that reports no consistent gender-based differences (23). The mean BMI in our study was 27.91 ± 2.85 kg/m² (Table 7), aligning with previously reported values (24).

Findings from the Young Finns Study, which evaluated 150 participants (94 males, 56 females; mean age 31.7 ± 5.0 years), demonstrated statistically significant differences ($p < 0.001$) in mean IMT (m-IMT) and maximum IMT (M-IMT) between sexes (21). Our results similarly showed that CAIMT increased progressively with age, peaking in participants aged 71–90 years, and was consistently higher in males than in age-matched females. This is consistent with work by Engelen et al., who observed a sharper increase in cardiovascular event risk beyond the age of 50, and by Touboul PJ, who reported a clear age-related rise in CIMT, with men exhibiting higher measurements than women at all ages (20).

In our cohort, most patients presented with multiple coexisting risk factors for plaque development, including diabetes, hypertension, familial hypercholesterolemia, advanced age, and male sex. The underlying mechanism involves the interplay between hemodynamic disturbances, endothelial dysfunction, and enhanced adhesion of leukocytes to the vascular wall. Atherosclerotic plaque formation (CP) is further promoted by oxidation and glycosylation of low-density lipoprotein, along with the accumulation of advanced glycation end-products, triggering a cascade of inflammatory and fibrotic changes. These findings are consistent with reports from both Asian and American populations (28).

LIMITATIONS AND RECOMMENDATIONS

This study had certain limitations that should be acknowledged. Being a cross-sectional descriptive study, it could only establish associations rather than causality between risk factors and carotid plaque formation. The sample size was relatively modest and drawn from a single center, which may limit the generalizability of the findings to broader populations. The use of a convenient sampling technique may have introduced selection bias. Furthermore, certain confounding factors such as smoking status, physical activity levels, dietary habits, and medication use were not assessed, which could influence carotid intima–media thickness (CIMT) and plaque development. In addition, the exclusion of PSV values for some carotid segments limited a more detailed hemodynamic assessment.

Future research should aim to address these limitations by adopting larger, multicenter cohort designs with more diverse populations. Longitudinal studies would help establish causal relationships and track the progression of carotid atherosclerosis over time. Including comprehensive lifestyle and metabolic data could improve risk stratification models. The use of advanced imaging modalities, such as 3D ultrasound or MRI, alongside CIMT, may enhance plaque characterization. Screening programs targeting high-risk groups—such as older adults, diabetics, and hypertensives—are recommended to enable earlier detection and intervention. Preventive strategies should integrate public health education, lifestyle modifications, and routine vascular assessments, particularly in populations with a high burden of cardiovascular risk factors.

CONCLUSION

This study concludes that there was significant association between carotid plaques and diabetes, hypertension and hyper-lipidemia. By using the sample size, we found evidence of carotid plaque in the majority of subjects with possible risk factors. Men were more likely to develop carotid plaques than females. Carotid Doppler ultrasound is a cheap noninvasive modality to detect carotid artery plaques due to its sensitivity, precision, and reliability. Since there is a high frequency of carotid plaques noted in older male adults, appropriate screening with prophylactic management can save many diseases from a lower middle-income class.

Funding: Not Any
Conflict of Interest: Not Any
Data Avalibilty: As per demand
Author Contribution: Haseeb Ahmad contributed to the conceptualization, study design, data collection, data analysis, and drafting of the manuscript. Tahira Batool, as the corresponding author, provided supervision, critically revised the manuscript, handled correspondence with the journal, and approved the final version. Rizwan Ali offered technical guidance, assisted in data processing, and contributed to statistical analysis and interpretation. Asma Irshad conducted the literature review, interpreted

biochemical data, and edited the manuscript for scientific accuracy. Khalid Mahmoud provided methodological guidance, contributed to the development of the educational framework, and critically reviewed the manuscript for intellectual content.

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