

Spectrum of Carotid Doppler Ultrasonographic Findings in Patients Admitted with Ischemic Stroke

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ABSTRACT

Background: The burden of ischemic stroke is increasing worldwide and carotid artery atherosclerosis is considered an important etiological factor. Carotid Doppler ultrasonography is a non-invasive and reliable modality for detecting vascular abnormalities associated with ischemic stroke.

Objectives: To determine the spectrum of carotid Doppler ultrasonographic findings in patients admitted with ischemic stroke.

Study Design & Setting: This cross-sectional study was conducted at the Diagnostic Radiology Department of H. H. Sheikh Khalifa Bin Zayed Al-Nahyan Hospital/CMH from 24 November 2025 to 24 May 2026.

Methodology: A total of 167 patients aged 18–70 years admitted with ischemic stroke were included through non-probability consecutive sampling. Patients with hemorrhagic transformation, cortical venous thrombosis, hypercoagulability disorders, prior stroke, or previous carotid procedures were excluded. Demographic and clinical variables were recorded. All patients underwent carotid Doppler ultrasonography for assessment of thickened carotid intima media thickness (CIMT), intra-carotid plaque, and significant carotid stenosis. Data analysis was performed using SPSS version 20.

Results: The mean age of patients was 58.42 ± 10.71 years and mean BMI was 27.14 ± 4.26 kg/m². Thickened CIMT was observed in 109 (65.3%) patients, intra-carotid plaque in 86 (51.5%), and significant carotid stenosis in 24 (14.4%) patients. Significant associations were observed between carotid Doppler findings and age, BMI, gender, diabetes mellitus, smoking, alcohol use, statin use, and stroke territory ($p \leq 0.05$).

Conclusion: Thickened CIMT, intra-carotid plaque, and significant carotid stenosis were common carotid Doppler findings among ischemic stroke patients. Carotid Doppler ultrasonography may be useful for early vascular assessment and risk stratification in such patients.

Keywords: Carotid Doppler ultrasonography, carotid stenosis, carotid intima media thickness, ischemic stroke, plaque.

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INTRODUCTION

Stroke is characterised by specific neurological signs or symptoms of vascular origin that endure for over 24 hours.

¹ Stroke is one of the main causes of mortality and permanent brain damage worldwide, and it also costs a lot of money because of long-term care. ² Strokes are generally divided into two main types: ischemic and hemorrhagic. However, the clinical spectrum of strokes varies widely according on severity, with ischemic strokes being the most common type. ^{3, 4} There are many things that can either make a person more likely to have a stroke or cause one directly. These things can be non-modifiable (like age, gender, and race) or modifiable (like being

overweight, not exercising, living a sedentary lifestyle, eating unhealthy foods, or having long-term illnesses like diabetes or high blood pressure). ^{5, 6}

An important cause of development of ischemic stroke is the pathological alterations in the carotid arteries (primary blood vessels supplying the brain). ⁷ These changes have been reported to be the cause of stroke in approximately 20% of the patients with ischemic stroke. ⁷ To diagnose these changes, carotid doppler ultrasound is a frequently used method. In this instance, a study analyzed spectrum of carotid doppler ultrasonographic findings in ischemic stroke patients (n = 70) and reported that most common finding was presence of intra-carotid atherosclerotic plaque found in 80% of the patients followed by thickened

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CIMT found in 71.4% of the patients.⁸ In another study, frequency of various carotid doppler ultrasonographic findings in ischemic stroke patients (n = 95) were reported including thickened CIMT (31.6%), presence of intra-carotid plaque (26.1%) and significant carotid stenosis (12.5%).⁹

Since carotid artery pathology is a major cause of ischemic stroke, it is important to study the spectrum of its pathologies through the use of carotid doppler ultrasound so that, if required, essential intervention can be performed. Additionally, the factors that increase the risk of ischemic stroke also alter with changing demographics due to difference in potential of various races to have atherosclerotic disease.¹⁰ Since, local data regarding the burden of these changes in ischemic stroke patients is not readily available. Therefore, present study is aimed at studying the spectrum of carotid doppler ultrasonographic findings in patients admitted with ischemic stroke. The objective was to determine spectrum of carotid doppler ultrasonographic findings in patients admitted with ischemic stroke

METHODS

A cross-sectional study was conducted after synopsis approval from CPSP at the Diagnostic Radiology Department of H. H. Sheikh Khalifa Bin Zayed Al-Nahyan Hospital/CMH from 24 November 2025 to 24 May 2026. Non-probability consecutive sampling technique was used. A sample size of 167 patients was calculated by taking the anticipated frequency of significant carotid stenosis as 12.5%, precision as 5%, and confidence level as 95% using RaoSoft® calculator. Patients aged 18–70 years of either gender who were admitted with ischemic stroke as per operational definition were included in the study.⁹ Patients with hemorrhagic transformation of ischemic stroke, cortical venous thrombosis, history of hypercoagulability disorders, prior history of stroke, and prior history of carotid artery procedure were excluded from the study.

After approval of the synopsis by CPSP and the institutional research review board, patients fulfilling the inclusion criteria were selected from the Medicine Department and were referred to the Radiology Department for carotid Doppler ultrasound. Demographic and clinical variables including age, gender, body mass index (BMI), stroke territory, history of diabetes mellitus, smoking status, alcohol use, history of statin therapy, educational status, area of residence, and monthly income were also documented. All patients underwent carotid Doppler ultrasonography, and findings related to ischemic stroke including thickened carotid intima media thickness (CIMT), presence of intra-carotid plaque, and presence of significant carotid stenosis, as defined in the operational definitions, were assessed and documented. All data were collected through a predesigned proforma.

Ischemic stroke was defined as a patient having a focal neurological deficit along with a hypodense area on plain CT brain. Carotid Doppler findings included thickened carotid intima media thickness (CIMT), presence of intra-

carotid plaque, and presence of significant carotid stenosis. Thickened CIMT was defined as a CIMT measured by carotid Doppler ultrasound of more than 1 mm. Intra-carotid plaque referred to the presence of an atherosclerotic plaque within the lumen of the carotid artery appearing as a focal echoic projection within the carotid lumen, often showing bright calcified areas producing a shadow effect on carotid Doppler ultrasound. Significant carotid stenosis was defined as stenosis of more than 50% of the carotid lumen as measured by carotid Doppler ultrasound.

Data analysis was performed using SPSS version 20. Quantitative variables including age and BMI were presented as mean $\pm$ standard deviation or median with interquartile range after assessment of normality by the Shapiro-Wilk test. Qualitative variables including gender, stroke territory, history of diabetes mellitus, smoking status, alcohol use, history of statin therapy, educational status, area of residence, monthly income, and carotid Doppler ultrasonographic findings including thickened CIMT, presence of intra-carotid plaque, and significant carotid stenosis were presented as frequencies and percentages. Carotid Doppler ultrasonographic findings were stratified with respect to age, gender, BMI, stroke territory, diabetes mellitus, smoking, alcohol use, and statin therapy to control effect modifiers. Post-stratification Chi-square test or Fisher exact test was applied where appropriate. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

The mean age of the patients was 58.42 ± 10.71 years. Most of the patients, 113 (67.7%), were between 51–70 years of age, while 54 (32.3%) patients were between 18–50 years. The mean BMI was 27.14 ± 4.26 kg/m², and 106 (63.5%) patients had BMI ≥ 25 kg/m². There were 101 (60.5%) male and 66 (39.5%) female patients. Anterior circulation stroke was present in 118 (70.7%) patients, whereas posterior circulation stroke was observed in 49 (29.3%) patients. Diabetes mellitus was present in 73 (43.7%) patients. Smoking history was noted in 69 (41.3%) patients, while alcohol use was present in 18 (10.8%) patients. History of statin use was found in 64 (38.3%) patients. Most patients, 96 (57.5%), were literate, 104 (62.3%) belonged to rural areas, and 112 (67.1%) had monthly income less than 80,000 PKR, as given in table 1.

Table 1: Baseline Characteristics of Patients Admitted with Ischemic Stroke (n = 167)

Variable	Category	n (%) / Mean $\pm$ SD
Age (years)	Mean $\pm$ SD	58.42 $\pm$ 10.71
	18–50 years	54 (32.3%)
	51–70 years	113 (67.7%)
BMI (kg/m ²)	Mean $\pm$ SD	27.14 $\pm$ 4.26
	< 25 kg/m ²	61 (36.5%)

	$\geq 25 \text{ kg/m}^2$	106 (63.5%)
Gender	Male	101 (60.5%)
	Female	66 (39.5%)
Stroke Territory	Anterior circulation	118 (70.7%)
	Posterior circulation	49 (29.3%)
Diabetes Mellitus	Yes	73 (43.7%)
	No	94 (56.3%)
Smoking	Yes	69 (41.3%)
	No	98 (58.7%)
Alcohol Use	Yes	18 (10.8%)
	No	149 (89.2%)
History of Statin Use	Yes	64 (38.3%)
	No	103 (61.7%)
Education Status	Literate	96 (57.5%)
	Illiterate	71 (42.5%)
Area of Residence	Rural	104 (62.3%)
	Urban	63 (37.7%)
Monthly Income	< 80,000 PKR	112 (67.1%)
	$\geq 80,000 \text{ PKR}$	55 (32.9%)

Thickened carotid intima media thickness (CMT) was observed in 109 (65.3%) patients. Presence of intra-carotid plaque was noted in 86 (51.5%) patients, while significant carotid stenosis was found in 24 (14.4%) patients, as given in table 2.

Table 2: Frequency of Carotid Doppler Ultrasonographic Findings in Patients with Ischemic Stroke (n = 167)

Carotid Doppler Findings	Frequency (%)
Thickened CMT	109 (65.3%)
Presence of Intra-carotid Plaque	86 (51.5%)
Presence of Significant Carotid Stenosis	24 (14.4%)

Stratification analysis showed that thickened CMT was significantly more common among patients aged 51–70 years compared to those aged 18–50 years (71.7% vs 51.9%, $p=0.028$). Similarly, patients with BMI $\geq 25 \text{ kg/m}^2$ had significantly higher frequency of thickened CMT compared to patients with BMI $< 25 \text{ kg/m}^2$ (73.6% vs 50.8%, $p=0.009$). Thickened CMT was also more frequent among male patients than female patients (71.3% vs 56.1%, $p=0.041$). Presence of intra-carotid plaque was significantly higher among diabetic patients compared to

non-diabetic patients (65.8% vs 40.4%, $p=0.003$). Significant carotid stenosis was significantly more common among smokers compared to non-smokers (23.2% vs 8.2%, $p=0.012$). Presence of intra-carotid plaque was significantly higher among patients without statin use compared to those with statin use (58.3% vs 40.6%, $p=0.021$). Intra-carotid plaque was also significantly more frequent among patients with alcohol use compared to those without alcohol use (72.2% vs 49.0%, $p=0.038$). Significant carotid stenosis was significantly more common in patients with anterior circulation stroke compared to posterior circulation stroke (16.9% vs 8.2%, $p=0.047$), as given in table 3.

Table 3: Stratification of Carotid Doppler Ultrasonographic Findings with Respect to Different Variables (n = 167)

Variables	Category	Thickened CMT Present (%)	Thickened CMT Absent (%)	p-value
Age Groups	18–50 years (n=54)	28 (51.9%)	26 (48.1%)	0.028
	51–70 years (n=113)	81 (71.7%)	32 (28.3%)	
	Total	109 (65.3%)	58 (34.7%)	
BMI Categories	$< 25 \text{ kg/m}^2$ (n=61)	31 (50.8%)	30 (49.2%)	0.009
	$\geq 25 \text{ kg/m}^2$ (n=106)	78 (73.6%)	28 (26.4%)	
	Total	109 (65.3%)	58 (34.7%)	
Gender	Male (n=101)	72 (71.3%)	29 (28.7%)	0.041
	Female (n=66)	37 (56.1%)	29 (43.9%)	
	Total	109 (65.3%)	58 (34.7%)	
Diabetes Mellitus	Yes (n=73)	48 (65.8%)	25 (34.2%)	0.003
	No (n=94)	38 (40.4%)	56 (59.6%)	
	Total	86 (51.5%)	81 (48.5%)	
Smoking Status	Smokers (n=69)	16 (23.2%)	53 (76.8%)	0.012
	Non-smokers (n=98)	8 (8.2%)	90 (91.8%)	
	Total	24 (14.4%)	143 (85.6%)	
Statin Use	Yes (n=64)	26 (40.6%)	38 (59.4%)	0.021

	No (n=103)	60 (58.3%)	43 (41.7%)	
	Total	86 (51.5%)	81 (48.5%)	
Alcohol	Yes (n=18)	13 (72.2%)	5 (27.8%)	0.038
	No (n=149)	73 (49.0%)	76 (51.0%)	
	Total	86 (51.5%)	81 (48.5%)	
Stroke Territory	Anterior circulation (n=118)	20 (16.9%)	98 (83.1%)	0.047
	Posterior circulation (n=49)	4 (8.2%)	45 (91.8%)	
	Total	24 (14.4%)	143 (85.6%)	

Chi-square test was applied for stratification analysis. A p-value of ≤ 0.05 was considered statistically significant

DISCUSSION

Ischemic stroke is one of the leading causes of mortality and long-term disability worldwide. Atherosclerotic disease of the carotid arteries plays an important role in the pathogenesis of ischemic stroke by reducing cerebral blood flow and causing embolic events.¹¹ Carotid Doppler ultrasonography is a non-invasive, cost-effective, and readily available imaging modality used for the evaluation of carotid artery abnormalities.¹² Common Doppler findings in ischemic stroke patients include increased carotid intima media thickness (CIMT), atherosclerotic plaque formation, and carotid artery stenosis. Early identification of these abnormalities helps in risk stratification and prevention of recurrent cerebrovascular events.¹³ Therefore, assessment of the spectrum of carotid Doppler ultrasonographic findings in ischemic stroke patients is clinically important.

In the present study, the mean age of patients admitted with ischemic stroke was 58.42 ± 10.71 years, and most patients (67.7%) belonged to the 51–70 years age group. Male predominance was observed, with 60.5% male patients. Similar findings were reported by Walubembe et al. (2023), who documented a mean age of 61 ± 13 years with 60% male patients, indicating that ischemic stroke and carotid artery abnormalities are more frequent among older male individuals.⁹ Likewise, Ahmad et al. (2022) reported a slightly higher mean age of 63.07 ± 3.76 years, while Afridi et al. (2017) documented a mean age of 55 years among ischemic stroke patients.^{17,19} Begum et al. (2022) also reported comparable findings with a mean age of 53.14 ± 7.49 years. These similarities suggest that increasing age remains an important non-modifiable risk factor for carotid artery disease and ischemic stroke.¹⁵

Our study demonstrated that thickened carotid intima media thickness (CIMT) was present in 65.3% patients, intra-carotid plaque in 51.5%, and significant carotid stenosis in 14.4% patients. The prevalence of significant

carotid stenosis observed in our study was very close to the findings of Walubembe et al. (2023), who reported significant carotid stenosis in 12.5% of ischemic stroke patients, including 7.8% severe and 4.7% moderate stenosis.⁹

In contrast, Noor ul Hadi et al. (2009) reported carotid stenosis in 56% of ischemic stroke patients, which was markedly higher than the 14.4% frequency observed in our study. Their study further showed that 64.3% of stenosis cases were mild, 26.8% moderate, and 8.9% severe, with soft plaques present in 58.9% patients. Similarly, Afridi et al. (2017) also documented carotid artery stenosis in 56% of ischemic stroke patients. Begum et al. (2022) found carotid artery stenosis in 52.9% patients, which was also substantially higher than our findings. The discrepancy in stenosis frequency among studies may be due to differences in criteria used for defining stenosis severity, population characteristics, burden of vascular risk factors, and inclusion of mild stenosis categories in other studies, whereas our study specifically focused on significant stenosis greater than 50%.^{15,19}

Our study identified significant associations between carotid Doppler abnormalities and multiple clinical variables. Thickened CIMT was significantly associated with older age ($p=0.028$), higher BMI ($p=0.009$), and male gender ($p=0.041$). These findings are supported by Walubembe et al. (2023), who demonstrated that age above 60 years significantly increased the likelihood of abnormal CIMT with an adjusted odds ratio of 5.2 (95% CI: 1.97–14; $p<0.010$). They also reported a strong association between elevated low-density lipoprotein cholesterol and abnormal CIMT (aOR=4.2, 95% CI: 1.29–8.79; $p=0.013$), highlighting the role of metabolic and atherosclerotic risk factors in carotid vascular disease.⁹

The present study further showed that intra-carotid plaque was significantly more common among diabetic patients (65.8% vs 40.4%, $p=0.003$), patients without statin use (58.3% vs 40.6%, $p=0.021$), and alcohol users (72.2% vs 49.0%, $p=0.038$). Significant carotid stenosis was more frequent among smokers compared to non-smokers (23.2% vs 8.2%, $p=0.012$), and among patients with anterior circulation stroke compared to posterior circulation stroke (16.9% vs 8.2%, $p=0.047$). Comparable observations were reported by Begum et al. (2022), who found significant associations of carotid artery stenosis with smoking, hypertension, and dyslipidemia.¹⁵

Singh et al. (2025) reported carotid artery plaques in 65% patients and significant stenosis ($>50\%$) in 40% cases, both of which were higher than our frequencies of 51.5% and 14.4%, respectively. Their study also demonstrated a strong positive correlation between LDL levels and plaque severity ($r=0.72$, $p<0.01$), with patients having total cholesterol >200 mg/dL exhibiting a 3.5-fold increased risk of severe plaque formation. Although lipid profile parameters were not evaluated in our study, the high prevalence of plaque formation and CIMT thickening observed in our patients indirectly supports the established relationship between dyslipidemia and carotid atherosclerosis.¹⁶

The usefulness of carotid Doppler ultrasonography in ischemic stroke evaluation has also been highlighted by Ahmad et al. (2022)¹⁷ and Sarfraz et al. (2025).¹⁸ Ahmad et al. reported sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy of carotid Doppler ultrasound for carotid artery stenosis as 89.5%, 76.2%, 45.5%, 93.88%, and 76.9%, respectively.¹⁷ Similarly, Sarfraz et al. demonstrated sensitivity of 91%, specificity of 77%, PPV of 47.3%, NPV of 92.5%, and diagnostic accuracy of 80% using CT angiography as gold standard. These studies strongly support the reliability and clinical utility of carotid Doppler ultrasonography as a non-invasive, readily available, and cost-effective diagnostic modality for screening and assessment of carotid artery disease in ischemic stroke patients, consistent with the objectives and findings of our study.¹⁸ Similarly, Ayaz et al. (2025) observed significant associations between ischemic changes and left carotid artery stenosis, while hypertension and diabetes were highly prevalent among affected patients. These findings collectively emphasize the contribution of traditional vascular risk factors toward carotid atherosclerotic disease in ischemic stroke patients.²⁰

STUDY LIMITATIONS

The study was conducted at a single center, which may limit the generalizability of the findings to the wider population. The relatively small sample size and use of non-probability consecutive sampling may also affect the external validity of the results. Furthermore, due to the cross-sectional study design, temporal and causal relationships between carotid Doppler findings and associated risk factors could not be established.

CONCLUSION

The study concluded that thickened CIMT, intra-carotid plaque, and significant carotid stenosis were common carotid Doppler ultrasonographic findings among patients admitted with ischemic stroke. These findings showed significant association with several clinical and demographic risk factors. Carotid Doppler ultrasonography may serve as an important non-invasive tool for early vascular assessment and risk stratification in ischemic stroke patients.

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