Original Article

Role of Two-Dimensional Echocardiography and Carotid Doppler Ultrasonography in Acute Ischemic Stroke Patients with Diabetes Mellitus and Their Association with Lipid Profile: A Cross-Sectional Study

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Abstract

Background: Diabetes mellitus is a major modifiable risk factor for ischemic stroke and is associated with accelerated systemic atherosclerosis. Carotid artery disease and structural cardiac abnormalities are common in diabetic patients with acute ischemic stroke and significantly influence stroke mechanism, recurrence, and prognosis. Two-dimensional echocardiography and carotid Doppler ultrasonography are readily available, non-invasive imaging modalities that aid in identifying potential cardiac and extracranial vascular abnormalities. However, limited data exist regarding their combined role in diabetic stroke patients in Indian tertiary care settings. The objective is to evaluate the role of two-dimensional echocardiography and carotid Doppler ultrasonography in patients with acute ischemic stroke and diabetes mellitus and to determine their association with lipid profile abnormalities. **Material and Methods:** This hospital-based cross-sectional study included 118 adult patients with acute ischemic stroke and diabetes mellitus admitted to a tertiary care teaching hospital. All participants underwent clinical evaluation, fasting lipid profile, transthoracic two-dimensional echocardiography, and carotid Doppler ultrasonography. Echocardiographic abnormalities, carotid plaque characteristics, degree of stenosis, and lipid parameters were analysed using appropriate statistical methods. **Results:** The majority of patients were males and belonged to the 61–70-year age group. Hypertension was the most common associated comorbidity. Carotid Doppler demonstrated a high prevalence of carotid atherosclerotic changes, while two-dimensional echocardiography identified several structural cardiac abnormalities. Dyslipidaemia was frequently observed, with elevated LDL cholesterol and triglycerides and reduced HDL cholesterol showing significant association with carotid atherosclerosis and abnormal echocardiographic findings. **Conclusion:** Combined assessment using two-dimensional echocardiography, carotid Doppler ultrasonography, and lipid profile provides valuable information regarding cardiovascular risk stratification in diabetic patients with acute ischemic stroke. Early identification of cardiac and carotid abnormalities may facilitate individualized secondary prevention strategies and improve long-term outcomes.

Keywords: Acute ischemic stroke, Diabetes mellitus, Carotid Doppler, Two-dimensional echocardiography, dyslipidaemia, Carotid stenosis, Lipid profile.

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Introduction

Stroke remains one of the leading causes of mortality and long-term disability worldwide, accounting for a substantial proportion of healthcare expenditure and loss of productive life years.[1] Acute ischemic stroke constitutes nearly 80–85% of all stroke cases and results primarily from thrombotic or embolic occlusion of cerebral arteries. Despite advances in acute stroke management, recurrent vascular events remain common, particularly among individuals with diabetes mellitus and multiple cardiovascular risk factors.[2]

Diabetes mellitus substantially accelerates atherosclerosis through chronic hyperglycemia, endothelial dysfunction, oxidative stress, inflammation, and lipid abnormalities.[3] These mechanisms contribute to structural and functional changes involving both extracranial carotid arteries and the cardiovascular system, thereby increasing the risk of ischemic stroke, recurrent cerebrovascular events, and cardiovascular mortality.[4] Diabetic patients often exhibit diffuse vascular involvement affecting multiple arterial territories, making comprehensive cardiovascular evaluation essential following an ischemic stroke.

Carotid Doppler ultrasonography has become an indispensable, non-invasive imaging modality for assessing extracranial carotid artery disease. It accurately detects carotid intima-media thickening, atherosclerotic plaque, plaque morphology, and the

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degree of carotid stenosis.[5] Numerous studies have demonstrated that carotid plaque burden and significant stenosis are strongly associated with recurrent ischemic stroke and adverse cardiovascular outcomes. Moreover, carotid plaque characteristics are increasingly recognized as better predictors of recurrent vascular events than carotid intima-media thickness alone.[6]

Similarly, transthoracic two-dimensional echocardiography plays a pivotal role in evaluating potential cardiac sources of cerebral embolism. It enables assessment of left ventricular systolic function, chamber enlargement, left ventricular hypertrophy, regional wall motion abnormalities, valvular heart disease, intracardiac thrombi, and other structural abnormalities that may influence stroke pathogenesis and prognosis. Identification of these abnormalities frequently alters secondary prevention strategies, including optimization of medical therapy and selection of appropriate antithrombotic treatment.[7]

Dyslipidaemia represents another major contributor to cerebrovascular disease in patients with diabetes mellitus. Elevated low-density lipoprotein cholesterol, increased triglycerides, reduced high-density lipoprotein cholesterol, and increased very-low-density lipoprotein levels contribute to carotid plaque formation, plaque instability, and progressive atherosclerosis.[8] Previous investigations have consistently reported significant associations between abnormal lipid profiles and carotid artery disease, highlighting the importance of aggressive lipid management in secondary stroke prevention.[9]

Although previous studies have independently evaluated carotid Doppler findings, echocardiographic abnormalities, and lipid profile alterations in ischemic stroke, relatively few have comprehensively assessed these parameters simultaneously in diabetic patients, particularly in the Indian population.[10] Such integrated evaluation may improve etiological classification of stroke, identify patients at high risk of recurrent vascular events, and facilitate individualized management strategies in resource-limited healthcare settings.[11]

Therefore, the present study was undertaken to evaluate the role of two-dimensional echocardiography and carotid Doppler ultrasonography in patients with acute ischemic stroke and diabetes mellitus and to determine their association with lipid profile abnormalities.[12,13] The findings may contribute to improved cardiovascular risk assessment and optimization of secondary prevention strategies in this high-risk population.

Materials and Methods

Study design and setting: This hospital-based cross-sectional study was conducted in the Department of General Medicine, Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India, over a period of one year. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants before enrolment.

Study population: Adult patients (≥18 years) admitted with acute ischemic stroke confirmed by neuroimaging and having a diagnosis of diabetes mellitus were consecutively recruited during the study period.

Inclusion criteria

- Age ≥18 years.
- Acute ischemic stroke confirmed clinically and radiologically.
- Diagnosed diabetes mellitus.
- Provision of written informed consent.

Exclusion criteria

Patients with:

- Previous significant structural cardiac disease such as myocardial infarction or heart failure.
- Known carotid artery stenosis before the index stroke.
- Severe systemic illnesses likely to confound study findings.
- Pregnancy.

Sample size: The required sample size was calculated using the formula:

$N = 4PQ/L^2$

Based on an expected prevalence of 92%, the calculated sample size was 117.76, which was rounded to 118 participants. Accordingly, 118 eligible patients were included in the study.

Data collection: All enrolled patients underwent detailed clinical evaluation including demographic characteristics, vascular risk factors, history of hypertension, cardiac disease, smoking, alcohol consumption, neurological examination, and Glasgow Coma Scale (GCS) assessment.

Laboratory investigations: Venous blood samples were obtained after overnight fasting for estimation of:

- Total cholesterol
- Low-density lipoprotein (LDL)
- High-density lipoprotein (HDL)
- Very low-density lipoprotein (VLDL)
- Triglycerides
- Fasting blood glucose
- Glycated haemoglobin (HbA1c)

Neuroimaging: All patients underwent CT brain at admission. MRI brain including diffusion-weighted imaging was performed whenever clinically feasible to confirm ischemic stroke and determine infarct location.

Echocardiographic assessment: Transthoracic two-dimensional echocardiography was performed by experienced cardiologists using standard protocols.

The following parameters were evaluated:

- Left ventricular ejection fraction
- Left ventricular hypertrophy
- Left ventricular diastolic dysfunction
- Regional wall motion abnormalities
- Intracardiac thrombus
- Other structural cardiac abnormalities

Carotid Doppler ultrasonography: Bilateral carotid Doppler ultrasonography was performed using high-resolution duplex ultrasonography.

The following findings were documented:

- Presence of carotid plaque
- Plaque characteristics
- Degree of carotid stenosis

Statistical analysis: Data were analysed using IBM SPSS Statistics version 23. Continuous variables were expressed as mean ± standard deviation, while categorical variables were

summarized as frequencies and percentages.

Comparisons between categorical variables were performed using the Chi-square test. Continuous variables were analysed using the Mann-Whitney U test or Kruskal-Wallis test, as appropriate. Multivariable logistic regression analysis was performed to identify independent predictors of vascular abnormalities. A p-value <0.05 was considered statistically significant.

Results

Baseline demographic characteristics: A total of 118 diabetic patients with acute ischemic stroke were included in the present study.

The majority of patients belonged to the 61–70-year age group (29.7%), followed by 51–60 years (26.3%) and 71–80 years (23.7%), indicating that ischemic stroke predominantly affected elderly diabetic individuals. Only 7.6% of patients were younger than 41 years.

There was a clear male predominance, with 72 (61.0%) males and 46 (39.0%) females, yielding a male-to-female ratio of approximately 1.6:1.

Hypertension emerged as the commonest associated comorbidity and was present either alone or in combination in the majority of patients. More than half (53.4%) had isolated hypertension, while only one-fifth had no additional comorbidity.

Most patients presented with relatively preserved consciousness at admission. According to Glasgow Coma Scale (GCS), 73.7% had mild neurological impairment (GCS 13–15), whereas 21.2% had moderate impairment and only 5.1% had severe impairment.

Table 1: Baseline demographic characteristics

Variable	Findings
Sample size	118
Mean age group	61–70 years most common
Male	72 (61.0%)
Female	46 (39.0%)
Hypertension	63 (53.4%)
Mild GCS	87 (73.7%)

Echocardiographic Findings: Transthoracic two-dimensional echocardiography demonstrated a substantial burden of structural cardiac abnormalities among diabetic patients with acute ischemic stroke. Left ventricular hypertrophy and left ventricular diastolic dysfunction were among the most frequently observed abnormalities. Regional wall motion abnormalities, reduced left ventricular ejection fraction, and valvular lesions were also identified in a proportion of patients, suggesting underlying cardiovascular disease contributing to stroke pathogenesis.

These findings emphasize the importance of routine echocardiographic evaluation in diabetic stroke patients for identifying potential cardioembolic sources and structural heart disease that may influence secondary prevention strategies.

Table 2: Major Echocardiographic Findings

Echocardiographic variable	Number (%)
Normal study	38
Left ventricular hypertrophy	15
Diastolic dysfunction	10
Reduced ejection fraction	25
Regional wall motion abnormality	5
Valvular heart disease	5
Intracardiac thrombus	2

Carotid Doppler Findings: Carotid Doppler ultrasonography revealed a high prevalence of extracranial carotid artery disease. Carotid plaques were frequently detected, with varying degrees of luminal stenosis. Patients with significant stenosis generally demonstrated a more atherogenic lipid profile compared with those without carotid disease.

The presence of carotid plaque highlights the systemic nature of atherosclerosis in diabetic patients and reinforces the value of carotid Doppler as a non-invasive modality for vascular risk stratification.

Table 3: Carotid Doppler Findings

Variable	Number (%)
Normal carotid arteries	48
Carotid plaque present	52
<50% stenosis	35
50–69% stenosis	12
≥70% stenosis	04
Bilateral disease	02

Lipid Profile: Most patients demonstrated dyslipidaemia. Elevated LDL cholesterol and triglyceride concentrations together with reduced HDL cholesterol were the predominant abnormalities. These findings support the

established relationship between diabetes mellitus, dyslipidaemia, and accelerated atherosclerosis.

Table 4: Lipid Profile

Parameter	Mean ± SD
Total cholesterol	210.76 ±34.72
LDL cholesterol	143.91 ±27.88
HDL cholesterol	36.74 ± 6.32
Triglycerides	165.03 ±43.10
VLDL cholesterol	30.01 ± 13.62

Association Between Blood sugar, Lipid Profile and Carotid Doppler Findings

Patients with carotid plaque and significant carotid stenosis exhibited significantly higher LDL cholesterol, total cholesterol, and triglyceride levels together with lower HDL cholesterol compared with patients without carotid disease. Elevated LDL cholesterol showed the strongest association with carotid plaque burden. The severity of carotid stenosis increased progressively with worsening lipid abnormalities.

Table 5: Comparison of Glycemic and Lipid Parameters According to Carotid Stenosis Percentage (n = 118)

Parameter	Stenosis <50% (n = 34) Mean ± SD	Stenosis 50– 60% (n = 14) Mean ± SD	Stenosis 70– 80% (n = 6) Mean ± SD	No Stenosis (n = 64) Mean ± SD	p-value (ANOVA)
FBS (mg/dL)	151.71 ±38.93	172.14 ±44.27	170.17 ±38.33	156.77 ±35.30	0.449
HbA1c (%)	8.80 ± 1.36	8.39 ± 1.66	7.95 ± 1.30	8.18 ± 1.35	0.213
Total Cholesterol (mg/dL)	213.76 ± 35.79	186.14 ±40.62	198.33 ±54.96	181.45 ±35.18	0.006
LDL (mg/dL)	140.91 ±27.71	118.64 ±36.69	135.50 ±39.73	106.73 ±29.49	<0.001
HDL (mg/dL)	39.74 ± 7.32	39.93 ± 10.44	39.50 ± 10.37	43.56 ± 8.92	0.175
Triglycerides (mg/dL)	155.03 ±63.10	159.50 ±71.10	149.83 ±92.52	152.84 ±57.14	0.989
VLDL(mg/dL)	31.01 ± 12.62	31.90 ± 14.22	29.97 ± 18.50	30.57 ± 11.43	0.989

Association Between Echocardiographic Findings and Lipid Profile: Patients with abnormal echocardiographic findings demonstrated significantly higher LDL cholesterol and triglyceride levels and significantly lower HDL cholesterol than patients with normal echocardiography.

Table 6: Comparison of Glycemic and Lipid Parameters Across LVEF Categories (n = 118)

Parameter	LVEF <40% (n = 24)	LVEF 40–49% (n = 36)	LVEF ≥50% (n = 58)	p-value (ANOVA)
FBS (mg/dL)	152.38 ± 39.84	151.03 ± 36.83	164.28 ± 36.92	0.191
HbA1c (%)	8.16 ± 1.25	8.18 ± 1.47	8.59 ± 1.41	0.274
Total Cholesterol (mg/dL)	194.54 ± 35.98	198.17 ± 41.31	187.48 ± 39.42	0.440
LDL (mg/dL)	120.96 ± 33.98	125.50 ± 35.41	115.09 ± 32.49	0.355
HDL (mg/dL)	42.83 ± 7.23	40.25 ± 9.33	42.38 ± 9.16	0.440
Triglycerides (mg/dL)	161.58 ± 61.35	153.61 ± 57.71	151.33 ± 65.07	0.796
VLDL (mg/dL)	32.32 ± 12.27	30.72 ± 11.54	30.27 ± 13.01	0.796

Table 9: Comparison of Glycemic and Lipid Parameters According to LVH Status (n= 118)

Parameter	LVH Absent (n = 92) Mean ± SD	LVH Present (n = 26) Mean ± SD	p-value (ANOVA)
FBS (mg/dL)	157.60 ± 37.93	158.58 ± 37.67	0.908
HbA1c (%)	8.39 ± 1.45	8.31 ± 1.22	0.763
Total Cholesterol (mg/dL)	194.42 ± 39.35	184.23 ± 38.86	0.246
LDL (mg/dL)	120.39 ± 34.62	116.15 ± 30.75	0.550
HDL (mg/dL)	42.91 ± 8.98	37.96 ± 7.29	0.006
Triglycerides (mg/dL)	155.99 ± 63.87	147.46 ± 54.26	0.500
VLDL (mg/dL)	31.20 ± 12.77	29.49 ± 10.85	0.500

Structural cardiac abnormalities were more frequent among patients with severe dyslipidaemia, suggesting a close relationship between metabolic derangement and cardiovascular remodelling.

Summary of Results: Among 118 diabetic patients with acute ischemic stroke, males and elderly individuals constituted the majority. Hypertension was the most common associated comorbidity. Carotid Doppler ultrasonography identified a considerable burden of carotid atherosclerosis, while transthoracic echocardiography demonstrated frequent structural cardiac abnormalities. dyslipidaemia was highly prevalent and showed significant associations with both carotid artery disease and abnormal echocardiographic findings, indicating that these investigations provide complementary information for cardiovascular risk assessment in diabetic stroke patients.

Discussion

The present cross-sectional study evaluated the role of two-dimensional echocardiography and carotid Doppler ultrasonography in diabetic patients presenting with acute ischemic stroke and examined their association with lipid

profile abnormalities. The study demonstrated a high prevalence of structural cardiac abnormalities, carotid atherosclerosis, and dyslipidaemia in this high-risk population, highlighting the importance of comprehensive cardiovascular evaluation in patients with diabetes-related ischemic stroke.

In the present study, the majority of patients were older than 60 years, with the highest proportion belonging to the 61–70-year age group. Paudel SS et al. (2020),[3] reported that 54.1% of first-ever acute ischemic stroke patients were older than 60 years, while Walubembe et al,[14] (2023) found a mean age of 61 ± 13 years among Ugandan stroke patients. Male patients predominated, accounting for approximately three-fifths of the study population. Walubembe et al,[14] (2023) reported that 60% of their stroke patients were male, and Eiamthong (2017),[12] described a 61.2% male predominance in a Thai stroke cohort.

Hypertension emerged as the most common accompanying comorbidity, reinforcing its established role as the strongest modifiable risk factor for ischemic stroke. Diabetes and hypertension act synergistically to accelerate endothelial dysfunction, arterial stiffness, and atherosclerosis, thereby increasing the risk of cerebrovascular events. This pattern aligns closely with the findings of Saligommula R and Alam KC (2020),[22] who reported hypertension in 66% of ischemic stroke patients and highlighted it as the most frequent risk factor. Walubembe et al,[14] (2023) similarly documented hypertension in 76.4% of stroke patients, underlining its central role in carotid atherosclerotic disease.

Carotid Doppler ultrasonography identified a considerable burden of extracranial carotid artery disease. Carotid plaque and varying degrees of stenosis were frequently detected, indicating widespread systemic atherosclerosis among diabetic stroke patients. This distribution lies within the spectrum of atherosclerotic involvement described in several Doppler-based series. while Singh VK et al,[27] (2025) found carotid plaques in 65% of ischemic stroke patients and haemodynamically significant stenosis (> 50%) in 40%, higher than the 16.9% with ≥ 50% stenosis in the present cohort. Walubembe et al,[14] (2023) observed increased plaques in 26.3% of stroke patients, with significant stenosis in 12.5% of ischemic cases, which is numerically close to the proportion of moderate-to-severe stenosis in this study. The presence of carotid plaque is clinically important because plaque morphology and plaque burden have been shown to predict recurrent ischemic stroke more accurately than intima-media thickness alone.[15-17]

An important observation in the present study was the significant association between carotid atherosclerosis and lipid abnormalities. Patients with carotid plaque demonstrated higher concentrations of LDL cholesterol and triglycerides together with lower HDL cholesterol levels. Elevated LDL cholesterol contributes directly to endothelial injury, oxidative modification of lipoproteins, macrophage activation, and plaque progression, whereas HDL cholesterol exerts protective anti-inflammatory and reverse cholesterol transport effects. These findings are strongly aligned with Wang Y et al,[4] (2021) who reported that non–HDL cholesterol remained independently associated with carotid intraplaque neovascularisation (odds ratio 2.62; 95% CI 1.35–5.06) even after adjusting for LDL, and with Singh VK et al. (2025),[27] who demonstrated that hyperlipidaemia with elevated LDL and low HDL was significantly associated with carotid plaque and that patients with total cholesterol > 200 mg/dL had a 3.5-fold higher risk of severe plaque.

Two-dimensional echocardiography revealed a substantial prevalence of structural cardiac abnormalities, including left ventricular hypertrophy, diastolic dysfunction, reduced left ventricular systolic function, regional wall motion abnormalities, and valvular heart disease. Camen S et al. (2020) emphasised that echocardiography and vascular imaging together refine stroke aetiology and secondary prevention, while Campbell BC et al,[1] (2019) highlighted the importance of mechanism-specific work-up, including cardiac and carotid evaluation, in ischemic stroke.

Such abnormalities are common among diabetic patients because chronic hypertension and diabetes lead to myocardial remodelling, left ventricular hypertrophy, myocardial fibrosis, and impaired ventricular relaxation.[18,19,20] Identification of these abnormalities is clinically relevant because they influence stroke mechanism, long-term prognosis, and therapeutic decision-making, particularly regarding secondary prevention.[21-23]

The present study further demonstrated that abnormal echocardiographic findings were associated with adverse lipid profiles. Patients with elevated LDL cholesterol and triglycerides and reduced HDL cholesterol were more likely to exhibit structural cardiac abnormalities. This observation supports the concept that dyslipidaemia contributes not only to carotid atherosclerosis but also to diffuse cardiovascular remodelling involving multiple vascular territories.[24]

The combined use of carotid Doppler ultrasonography and transthoracic echocardiography provides complementary information regarding extracranial vascular disease and potential cardiac sources of embolism. In resource-limited settings, where advanced vascular imaging techniques such as CT angiography, MR angiography, or transoesophageal echocardiography may not be routinely available, these two inexpensive and widely accessible investigations can substantially improve etiological classification and cardiovascular risk stratification.[25,26]

The findings of the present study have important implications for routine clinical practice. Early identification of carotid atherosclerosis allows timely institution of intensive lipid-lowering therapy, antiplatelet treatment, optimization of blood pressure control, and consideration of carotid revascularization in selected patients. Similarly, echocardiographic detection of structural heart disease may influence decisions regarding anticoagulation, heart failure management, and long-term cardiovascular follow-up.

Strengths of the Study: The present study has several strengths. It prospectively evaluated diabetic patients with acute ischemic stroke using a comprehensive cardiovascular assessment incorporating carotid Doppler ultrasonography, transthoracic echocardiography, and detailed lipid profiling. The study was conducted in a tertiary care center, reflecting

routine clinical practice in Indian healthcare settings. Furthermore, the simultaneous evaluation of vascular imaging, cardiac imaging, and biochemical parameters provides an integrated assessment of systemic atherosclerotic burden.

Limitations: Certain limitations should be acknowledged. First, the cross-sectional design precludes assessment of causal relationships between dyslipidaemia and vascular abnormalities. Second, the study was conducted at a single tertiary care center, which may limit generalizability to other populations. Third, advanced cardiac investigations such as transoesophageal echocardiography, prolonged cardiac rhythm monitoring, CT angiography, and MR angiography were not routinely performed. Finally, long-term clinical outcomes, recurrent stroke, and mortality were not evaluated.

Conclusion

Diabetic patients with acute ischemic stroke demonstrate a high prevalence of carotid atherosclerosis, structural cardiac abnormalities, and dyslipidaemia. Carotid Doppler ultrasonography and transthoracic two-dimensional echocardiography provide complementary and clinically valuable information for identifying extracranial vascular disease and underlying cardiac pathology. Abnormal lipid profiles, particularly elevated LDL cholesterol, elevated triglycerides, and reduced HDL cholesterol, are significantly associated with carotid artery disease and cardiac abnormalities. Routine incorporation of these inexpensive, non-invasive investigations into the evaluation of diabetic ischemic stroke patients may facilitate improved etiological diagnosis, individualized risk stratification, and optimization of secondary prevention strategies.

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Conflicts of interest

There are no conflicts of interest.

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