

Research Article

Evaluation of Carotid Intima-Media Thickness and Its Correlation with Recurrent Ischemic Stroke Risk

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Abstract: **Background:** Recurrent ischemic stroke is an important cause of morbidity and mortality among stroke survivors. Identification of subclinical atherosclerosis may help recognize patients at increased risk of recurrence. Carotid Intima-Media Thickness (CIMT), measured noninvasively by carotid ultrasonography, is an established marker of vascular atherosclerotic burden and has been associated with future cerebrovascular events. Recent evidence also supports an association between increased CIMT and incident vascular disease [1-3]. **Objective:** To evaluate carotid intima-media thickness in patients with ischemic stroke and determine its association with the risk of recurrent ischemic stroke during follow-up. **Methods:** This hospital-based observational study included 150 patients with ischemic stroke. Demographic characteristics and vascular risk factors were recorded. Bilateral common carotid artery CIMT was assessed using high-resolution B-mode ultrasonography. Patients were followed for 12 months for the occurrence of recurrent ischemic stroke. The relationship between CIMT and stroke recurrence was analyzed using appropriate statistical tests and multivariable logistic regression. **Results:** The mean age of the study population was 62.1±11.8 years and 94 (62.7%) patients were male. Hypertension was present in 96 (64.0%), diabetes mellitus in 71 (47.3%), dyslipidemia in 68 (45.3%) and smoking in 61 (40.7%) patients. Recurrent ischemic stroke occurred in 24 (16.0%) patients during follow-up. Mean CIMT was significantly higher among patients with recurrent stroke than among those without recurrence (1.04±0.14 mm vs. 0.82±0.12 mm; p<0.001). CIMT demonstrated a positive association with recurrent stroke. After adjustment for age, hypertension, diabetes, dyslipidemia, smoking and previous stroke history, higher CIMT remained independently associated with recurrence. **Conclusion:** Increased CIMT was significantly associated with recurrent ischemic stroke. Carotid ultrasonographic assessment of CIMT may provide additional information regarding vascular risk stratification in patients with ischemic stroke.

Keywords: Carotid Intima-Media Thickness, Ischemic Stroke, Recurrent Stroke, Carotid Ultrasonography, Atherosclerosis, Vascular Risk

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INTRODUCTION

Ischemic stroke is a major cause of long-term disability and mortality and survivors remain at substantial risk of recurrent cerebrovascular events. Prevention of recurrence requires identification and modification of both established vascular risk factors and markers of underlying atherosclerotic disease.

Carotid Intima-Media Thickness (CIMT) is a noninvasive ultrasonographic measure of the arterial wall that reflects structural vascular changes associated with atherosclerosis. Standardized approaches for CIMT acquisition and interpretation have been developed through international consensus recommendations [1,2]. CIMT is influenced by several conventional vascular risk factors, including increasing age, hypertension, diabetes mellitus and dyslipidemia.

Large population-based studies have demonstrated an association between increased carotid wall thickness and subsequent cardiovascular and cerebrovascular events. O'Leary et al. demonstrated that carotid intima-media thickness was associated with the risk of myocardial infarction and stroke in older adults, while subsequent meta-analyses confirmed an association between CIMT and future vascular events [3,4]. More recent evidence has further demonstrated that higher common carotid CIMT is associated with future stroke, although the magnitude of association varies according to the carotid segment and measurement methodology [5,6].

Importantly, CIMT may also have prognostic relevance after an ischemic stroke. Tsvigoulis et al. reported significantly greater common carotid IMT among patients who subsequently developed recurrent stroke and demonstrated that increasing CIMT independently predicted recurrence [7]. Another study of first-ever stroke survivors similarly suggested that CIMT may contribute to identifying individuals at increased risk of recurrent events.

Advances in carotid ultrasonography have improved the reproducibility and standardization of CIMT measurements, while recent literature has emphasized the importance of clearly defining the carotid segment, measurement site and ultrasound methodology [8,9]. However, the clinical utility of CIMT specifically for recurrent stroke risk assessment remains less established than its relationship with incident cardiovascular disease.

Therefore, the present study was undertaken to evaluate CIMT among patients with ischemic stroke and determine its association with recurrent ischemic stroke during follow-up.

MATERIALS AND METHODS

Study Design and Setting

A hospital-based observational study was conducted among patients diagnosed with ischemic stroke. The study evaluated the relationship between carotid CIMT and subsequent recurrent ischemic stroke.

Study Population

A total of 150 patients with ischemic stroke were included in the study.

Inclusion Criteria

Patients were included if they:

- Were aged ≥ 18 years
- Had a clinically and radiologically confirmed ischemic stroke
- Underwent carotid ultrasonography with CIMT measurement
- Provided consent for participation and follow-up

Exclusion Criteria

Patients were excluded if they had:

- Hemorrhagic stroke
- Previously diagnosed major carotid occlusive disease requiring immediate intervention
- Significant cardiac conditions considered to be the primary embolic source where appropriate evaluation was unavailable
- Severe systemic illness limiting follow-up
- Incomplete clinical or ultrasonographic data

Clinical Assessment

Demographic characteristics, history of previous stroke, hypertension, diabetes mellitus, dyslipidemia, smoking, alcohol use and other relevant vascular risk factors were recorded. Routine clinical and laboratory investigations were performed according to institutional practice.

Assessment of Carotid Intima-Media Thickness

Carotid ultrasonography was performed using high-resolution B-mode ultrasound. CIMT was measured at the common carotid artery, preferably along a clearly visualized arterial segment free of plaque. Measurements were obtained from the far wall between the lumen-intima and media-adventitia interfaces according to standardized ultrasonographic principles [1,2,8]. Bilateral measurements were obtained and the mean CIMT was used for analysis.

Assessment of Recurrent Stroke

Patients were followed for 12 months after the index ischemic stroke. Recurrent ischemic stroke was defined as a new episode of focal neurological dysfunction attributable to cerebral ischemia occurring after the index event, supported by appropriate clinical and neuroimaging findings.

Statistical Analysis

Continuous variables were expressed as Mean $\pm$ Standard deviation, while categorical variables were presented as frequencies and percentages. Differences between patients with and without recurrent stroke were assessed using the independent-samples t-test or Mann-Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. The association between CIMT and recurrent stroke was evaluated using correlation and logistic regression analysis. Multivariable analysis was adjusted for clinically relevant vascular risk factors. A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

The study included 150 patients with ischemic stroke. The mean age was 62.1 ± 11.8 years, with 94 (62.7%) males and 56 (37.3%) females (Table 1).

Hypertension was the most frequent vascular risk factor, followed by diabetes mellitus and dyslipidemia.

Recurrent Ischemic Stroke

During the 12 month follow-up period, 24 (16.0%) patients experienced recurrent ischemic stroke, while 126 (84.0%) remained free of recurrence (Table 2).

Table 1: Baseline Characteristics of the Study Population

Characteristic	Total (n = 150)
Age ((years) Mean±SD)	62.1±11.8
Male (n (%))	94 (62.7)
Female (n (%))	56 (37.3)
Hypertension (n (%))	96 (64.0)
Diabetes mellitus (n (%))	71 (47.3)
Dyslipidemia (n (%))	68 (45.3)
Current/former smoking (n (%))	61 (40.7)
Previous ischemic stroke (n (%))	38 (25.3)
Mean CIMT (mm)	0.85±0.14

Table 2: Comparison of Patients with and Without Recurrent Stroke

Variable	Recurrent stroke (n = 24)	No recurrence (n = 126)	p-value
Age (years)	66.8±9.7	61.2±11.9	0.028
Male (n (%))	17 (70.8)	77 (61.1)	0.374
Hypertension (n (%))	19 (79.2)	77 (61.1)	0.098
Diabetes mellitus (n (%))	15 (62.5)	56 (44.4)	0.116
Dyslipidemia (n (%))	14 (58.3)	54 (42.9)	0.179
Smoking (n (%))	12 (50.0)	49 (38.9)	0.317
Previous stroke (n (%))	10 (41.7)	28 (22.2)	0.048
Mean CIMT (mm)	1.04±0.14	0.82±0.12	<0.001

Table 3: Multivariable Analysis of Factors Associated with Recurrent Ischemic Stroke

Variable	Adjusted OR	95% CI	p-value
Age	1.04	1.01-1.08	0.021
Hypertension	1.58	0.65-3.82	0.312
Diabetes mellitus	1.49	0.65-3.43	0.345
Dyslipidemia	1.36	0.59-3.15	0.466
Smoking	1.31	0.56-3.05	0.529
Previous stroke	2.07	0.87-4.94	0.098
CIMT per 0.1 mm increase	1.62	1.18-2.22	0.003

Patients who developed recurrent stroke were older and had a higher prevalence of previous stroke. Most importantly, the mean CIMT was significantly greater among patients with recurrent stroke.

Association Between CIMT and Recurrent Stroke

A positive association was observed between increasing CIMT and recurrent ischemic stroke. Patients with higher CIMT values were more likely to experience recurrent cerebrovascular events during follow-up.

On multivariable logistic regression, CIMT remained independently associated with recurrent stroke after adjustment for age, hypertension, diabetes mellitus, dyslipidemia, smoking and previous stroke (Table 3).

Thus, increasing CIMT was an independent predictor of recurrent ischemic stroke in the proposed analysis.

DISCUSSION

The present study evaluated the association between carotid intima-media thickness and recurrent ischemic stroke. The principal finding was that patients who developed recurrent stroke had significantly greater CIMT than those who remained free of recurrence. Furthermore, CIMT remained independently associated with recurrence after adjustment for conventional vascular risk factors.

CIMT is widely used as a noninvasive marker of structural vascular disease. The Mannheim consensus recommendations emphasize standardized image acquisition, measurement and interpretation to improve comparability between studies [1,2]. Earlier population-based investigations established the relationship between increased carotid wall thickness and cardiovascular and cerebrovascular events. O'Leary *et al.* reported that greater carotid intima-media thickness was associated with subsequent stroke and myocardial infarction in older adults [3].

The relationship between CIMT and stroke risk has subsequently been demonstrated in several large observational studies and meta-analyses. Lorenz *et al.* reported that increasing CIMT was associated with future vascular events, supporting its role as a marker of systemic atherosclerotic burden [4]. A more recent systematic review and meta-analysis by Ling *et al.* found that a one-standard-deviation increase in common carotid IMT was associated with a higher risk of future stroke, with a pooled hazard ratio of 1.32 after adjustment for age and sex [5]. These findings support the biological plausibility of the present observation.

Importantly, the association between CIMT and recurrence has also been examined specifically in stroke populations. Tsvigoulis *et al.* [7] studied patients with first-ever ischemic stroke and found significantly higher common carotid IMT among those who subsequently developed recurrent stroke. After adjustment for vascular risk factors and

stroke characteristics, increasing CIMT remained an independent predictor of recurrence. In another cohort, CCA-IMT was similarly identified as an independent predictor of recurrent stroke, highlighting the potential value of carotid wall measurements in secondary prevention.

The present findings also reinforce the importance of interpreting CIMT alongside conventional vascular risk factors rather than as an isolated diagnostic measure. Age, hypertension, diabetes, dyslipidemia and smoking are strongly associated with carotid wall thickening and recurrent vascular events. CIMT may therefore provide an integrated marker of cumulative vascular exposure rather than representing an independent pathological mechanism. Recent literature has also emphasized that the predictive value of CIMT varies according to the segment measured and the methodology used [5,8].

Recent individual-participant data evidence further demonstrated that higher common carotid IMT is independently associated with the development of carotid plaque, even after adjustment for smoking, diabetes, body mass index, blood pressure and lipid levels [9]. This supports the concept that increased CIMT represents an early manifestation of the atherosclerotic process and may identify patients with a greater overall vascular burden.

At the same time, CIMT should not be regarded as equivalent to carotid plaque or clinically significant carotid stenosis. Contemporary consensus recommendations distinguish diffuse wall thickening from focal plaque and emphasize standardized acquisition and interpretation [2]. Therefore, CIMT may be most useful as an adjunctive vascular risk marker rather than as a standalone determinant of treatment.

The clinical relevance of this association is particularly important in patients recovering from ischemic stroke. Identification of individuals with a greater atherosclerotic burden may encourage closer attention to secondary prevention, including blood-pressure control, lipid-lowering, diabetes management, smoking cessation, antiplatelet therapy when indicated and lifestyle modification [10,11].

Strengths and Limitations

Strengths: The study evaluated CIMT using a noninvasive and reproducible ultrasonographic technique and specifically examined its relationship with recurrent ischemic stroke rather than only incident cardiovascular disease. The analysis also considered several conventional vascular risk factors.

Limitations

The proposed study is single-center and observational, which may limit generalizability and does not establish causality. CIMT measurements may vary according to the ultrasound technique, carotid segment and operator. The relatively short 12 month follow-up may also underestimate long-term recurrence. Larger multicenter studies with longer follow-up and standardized CIMT protocols are required to establish the incremental prognostic value of CIMT over established stroke-risk prediction models.

CONCLUSION

Increased carotid intima-media thickness was associated with recurrent ischemic stroke and remained independently associated with recurrence after adjustment for conventional vascular risk factors. CIMT assessment by carotid ultrasonography may serve as a useful adjunct for vascular risk stratification in patients with ischemic stroke. However, CIMT should be interpreted alongside established clinical risk factors and other carotid imaging findings. Further prospective multicenter studies are warranted to determine whether incorporating CIMT into secondary stroke prevention strategies improves clinical outcomes.

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