

## Characteristics of Internal Carotid Artery Stenosis in Patients with Acute Ischemic Stroke

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**Background** : It has been known that Asians are more likely to develop atherosclerosis of the intracranial arteries while Caucasians have more extracranial arterial diseases. Angiographic distribution and frequency of the carotid artery stenosis have not been well known in Korean patients with acute ischemic stroke. **Methods** : From the Yonsei Stroke Registry, a total of 300 acute ischemic stroke patients, who were evaluated by a conventional cerebral angiography from July 1997 to September 2000, were enrolled for this study. Patients were divided into three groups: isolated intracranial internal carotid artery (ICA) stenosis (IICA group); isolated extracranial ICA stenosis (EICA group); and combined stenosis of intracranial and extracranial ICAs (combined group). The clinical and angiographical characteristics were investigated and compared among them. **Results** : A total of 107 patients had stenotic lesions in the ICA. They were 45 patients with lesions in the intracranial ICA (IICA group), 42 in the extracranial ICA (EICA group), and 20 patients in the both intracranial and extracranial ICAs (combined group). No significant differences were found among the three groups in terms of the degree of stenosis (50.2%, 49.6%, 56.8% each:  $p=0.34$ ), risk factors of ischemic stroke, and frequency of combined stenosis in the other intracranial arteries. **Conclusions** : ICA stenosis was common in patients with acute ischemic stroke. Significant differences of the frequency and risk factors between intracranial and extracranial ICA stenosis were not found. ICA stenosis at the extracranial portion as well as at the intracranial portion should be considered as a common cause of ischemic stroke occurring in the carotid artery system.

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**Key Words** : Carotid stenosis, Cerebral angiography, Stroke

cranial Doppler study) (transcranial Doppler study) (magnetic resonance angiography, MRA) (angioplasty, stent) .<sup>1-3</sup>

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<sup>4-10</sup>

(endarterectomy) 가

가

가 .<sup>11</sup>

2.

300

300

<sup>11-13</sup>

TOAST (Trial of Org 10172 in Acute Stroke Treatment) <sup>15</sup>

3.

(1)

Bouthillie<sup>6</sup> Gibo<sup>17</sup>

가

가

1.

Yonsei Stroke Registry

7

Gibo

(cervical portion, C1)

(petrous

bone portion, C2)

(cavernous sinus portion, C3)

(supraclinoid portion, C4)

C1

C2, C3, C4

1997 7 2000 9 Yonsei Stroke Registry

300

Yonsei Stroke Registry

가

(2)

0.2 mm

가

10

가

<sup>18</sup>

Percentage of stenosis (%) = [(1-diameter of the most severe stenosis / diameter of the proximal normal artery)] × 100

가

North American Symptomatic Carotid Endarterectomy Trials (NASCET)<sup>2</sup>

Percentage of stenosis (%) = [(1-diameter of the most severe stenosis / diameter of the distal normal artery)] × 100

가

(intracranial internal carotid stenosis group, IICA group), (extracranial internal carotid stenosis group, EICA group)

(combined intracranial and extracranial stenosis group, combined group)

가

NASCET



Logistic regression combined group, EICA, TIA, ESR, odds ratio, anterior circulation, intracranial posterior circulation, extracranial posterior circulation (Table 3). (3) IICA, EICA, combined group (Table 4).

**Table 1.** Distribution of internal carotid artery stenosis

Location	C1	C2	C3	C4
Left	25 (5)	11 (3)	18 (10)	5 (3)
Right	17 (15)	9 (1)	20 (12)	5 (4)
Bilateral	20 (2)	2 (1)	22 (3)	2 (1)
Total	62 (22)	22 (5)	60 (25)	12 (8)

Values are numbers of patients. Values in parenthesis are numbers of patients with internal carotid artery stenosis greater than 50%. European Carotid Stroke Trials criteria was applied for measurement of degree of stenosis at the extracranial portion of internal carotid artery, while Samuel's method was applied for that at intracranial portion of internal carotid artery. C1; cervical portion, C2; petrous portion, C3; cavernous sinus portion, C4; supraclinoid portion.

**Table 2.** Comparison of risk factors for acute ischemic stroke among intracranial, extracranial, and combined intracranial-extracranial internal carotid artery stenosis groups

Risk Factors	IICA group (n=45)	EICA group (n=42)	Combined group (n=20)	p-value*
Age (mean ± SD, years)	60.9 ± 9.7	61.5 ± 7.7	63.8 ± 8.2	0.45
Sex (male: female)	27:18	28:14	15:5	0.49
Hypertension (%)	80.0	61.9	80.0	0.12
Diabetes mellitus (%)	46.7	35.7	25.0	0.23
Smoking (%)	26.7	23.8	35.0	0.65
Previous TIA (%)	6.7	9.5	30.0	0.02
Previous stroke (%)	35.6	33.3	35.0	0.97
Coronary disease (%)	4.4	2.3	10.0	0.41
Hemoglobin (mg/dl)	13.9 ± 2.6	14.0 ± 1.3	14.6 ± 1.1	0.41
Hematocrit (%)	41.8 ± 4.0	41.4 ± 3.9	43.1 ± 3.9	0.28
PT (INR)	0.99 ± 0.2	0.99 ± 0.4	0.93 ± 0.1	0.77
PTT (sec)	30.5 ± 4.6	31.4 ± 6.1	31.1 ± 4.0	0.67
Hypercholesterolemia (%)	37.8 (n=17/45)	21.1 (n=8/38)	26.3 (n=5/19)	0.12
Hypertriglycemia (%)	44.2 (n=19/43)	34.2 (n=13/38)	35.0 (n=7/20)	0.61
Elevated CRP (%)	17.2 (n=5/29)	18.8 (n=6/32)	26.7 (n=4/15)	0.75
Elevated ESR (%)	50.0 (n=11/22)	29.2 (n=7/24)	25.0 (n=3/12)	0.23

IICA group; intracranial internal carotid artery stenosis group, EICA group; extracranial internal carotid artery stenosis group, Combined group; combined intracranial-extracranial internal carotid artery stenosis group, TIA; transient ischemic attack, PT; prothrombin time, INR; international normalized ratio, PTT; partial thromboplastin time, CRP; chronic reactive protein, ESR; erythrocyte sedimentation rate, \*For comparison among groups, chi-square test was used for sex, hypertension, diabetes mellitus, smoking, previous TIA, previous stroke, coronary disease, hypercholesterolemia, hypertriglycemia, elevated CRP, and elevated ESR, and ANOVA was used for Age, Hemoglobin, PT, PTT.



combined group  
 IICA, EICA, com-  
 combined group IICA  
 IICA, EICA, combined group  
 anterior circulation, intracranial  
 posterior circulation, extracranial posterior circula-  
 tion  
 anterior circu-  
 lation intracranial posterior circulation  
 IICA, EICA, combined group  
 (angioplasty and  
 MRA  
 (selection  
 TOAST  
 Lee  
 1000  
 Yonsei Stroke Registry<sup>14</sup>

large artery atherosclerosis  
 cardiac embolism undetermined cause  
 Lee undetermined etiology  
 40.6% undetermined etiolo-  
 gy  
 large artery atherosclerosis  
 undetermined etiology  
 cardiac embolism  
 large artery atherosclerosis  
 undetermined etiology  
 cardiac embolism

## REFERENCES

1. Choi NC, Lee KH, Lee BB. Clinical experiences of carotid endarterectomy at Samsung Medical Center. *J Korean Neurol Assoc* 1996;14:900-910.
2. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med* 1991;325:445-453.
3. European Carotid Surgery Trialists' Collaborative Group. MRC European Carotid Surgery Trial: interim results for symptomatic patients with severe (70-99%) or with mild (0-29%) carotid stenosis. *Lancet* 1991;337:1235-1243.
4. Sacco R, Kargman D, Gu Q, Zamanillo M. Race-ethnicity and determinants of intracranial atherosclerotic cerebral infarction: The northern Manhattan Stroke Study. *Stroke* 1995;26:14-20.
5. Nishimaru K, McHenry LC, Toole JF. Cerebral angiographic and clinical differences in carotid system transient ischemic attacks between American Caucasian and Japanese patients. *Stroke* 1984;15:56-59.
6. Caplan LR, Gorelick PB, Hier DB. Race, sex and occlusive cerebrovascular disease: a review. *Stroke* 1986;17: 648-665.
7. Fisher CM, Gore I, Okabe N, White PD. Atherosclerosis of the carotid and vertebral arteries-extracranial and intracranial. *J Neuropathol Exp Neurol* 1965;24:455-476.
8. Feldmann E, Daneault N, Kwan E, Ho KJ, Pessin MS, Langenberg P, et al. Chinese-white differences in the distribution of occlusive cerebrovascular disease. *Neurology*

- 1990;40:1541-1545.
9. Wityk R.J, Lehman D, Klag M, Coresh J, Ahn H, Litt B. Race and sex differences in the distribution of cerebral atherosclerosis. *Stroke* 1996;27:1974-1980.
  10. Gorelick PB, Caplan LR, Hier DB, Parker SL, Patel D. Racial differences in the distribution of anterior circulation occlusive disease. *Neurology* 1984;34:54-59.
  11. Lee SJ. Relation Between the Distribution of Cerebral Atherosclerosis and Stroke Risk Factors in Patients with Extracranial Carotid Disease. *J Korean Neurol Assoc* 2001;19:566~572.
  12. Craig DR, Meguro K, Watridge C, Robertson JT, Barnett HJ, Fox AJ. Intracranial internal carotid artery stenosis. *Stroke* 1982;13:825-828.
  13. Raju S, Fredericks RK. Carotid siphon stenosis. *J Cardiovasc Surg* 1987;28:671-677.
  14. Lee BI, Nam HS, Heo JH, Kim DI. Yonsei Stroke Registry. *Cerebrov Dis* 2001;12:145-151.
  15. Adams HP Jr, Bendixen BH, Kappelle LJ, Biller J, Love BB, Gordon DL, et al. Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of Org 10172 in Acute Stroke Treatment. *Stroke* 1993;24:35-41.
  16. Bouthillier A, van Loveren HR, Keller JT. Segments of the internal carotid artery: a new classification. *Neurosurgery* 1996;38:425-433.
  17. Gibo H, Lenkey C, Rhoton L. A. Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. *J Neurosurg* 1981;55:560-574.
  18. Samuel O, Dawson D, Joseph G. A new method for measuring intracranial arterial stenosis using conventional angiography. *Neurology* 1997;48:A157.
  19. Young GR, Humphrey PR, Nixon TE, Smith ET. Variability in measurement of extracranial internal carotid artery stenosis as displayed by both digital subtraction and magnetic resonance angiography. *Stroke* 1996;27:467-473.
  20. Nakamura M, Torii S, Yatsuki K, Kikuchi Y, Yamamoto H. Cerebral atherosclerosis in Japanese. 1. Lipids and glycosaminoglycans in cerebral arteries. *Atherosclerosis* 1971;13:185-197.
  21. Nakamura M, Imaizumi K, Kikuchi Y, Kanaide H. Cerebral atherosclerosis in Japanese. Part 4: relationship between lipid content and macroscopic severity of atherosclerosis. *Stroke* 1976;7:591-594.
  22. Baker A, Iannone A. Cerebrovascular disease. I. The large arteries of the circle of Willis. *Neurology* 1959;9:321-332.
  23. Heyman A, Fields WS, Keating RD. Joint study of extracranial arterial occlusion. VI. Racial differences in hospitalized patients with ischemic stroke. *JAMA* 1972; 222:285-289.
  24. Kieffer SA, Takeya Y, Resch JA, Amplatz K. Racial differences in cerebrovascular disease: angiographic evaluation of Japanese and American populations. *Am J Roentgenol Radium Ther Necl Med* 1967;101:94-9933.
  25. Nagao T, Sadoshima S, Ibayashi S, Takeya Yo, Fujishima M. Increase in extracranial atherosclerotic carotid lesions in patients with brain ischemia in Japan: an angiographic study. *Stroke* 1994;25:766-770.
  26. Tomita T, Mihara H. Cerebral angiographic study on C.V.D. in Japan. *Angiology* 1972;23:228-239.
  27. Hass WK, Fields WS, North RR, Kircheff II, Chase NE, Bauer RB. Joint study of extracranial arterial occlusion. II. Arteriography, techniques, sites, and complications. *JAMA* 1968;203:961-968.
  28. Rouleau PA, Huston J, Gilbertson J, Brown RD, Meyer FB, Brown TC. Carotid artery tandem lesions: frequency of angiographic detection and consequences for endarterectomy. *AJNR* 1992;20:621-625.
  29. Wechsler LR, Kistler JP, Davis KR, Kaminski MJ. The prognosis of carotid siphon stenosis. *Stroke* 1986;17:714-718.
  30. Borozan PG, Schuler JJ, LaRossa MP, Ware MS, Flanigan DP. The natural history of isolated carotid siphon stenosis. *J Vasc Surg* 1984;1:744-749.
  31. Inzitari D, Hachinski VC, Taylor DW, Barnett HJ. Racial differences in the anterior circulation in cerebrovascular disease. How much can be explained by risk factors? *Arch Neurol* 1990;47:1080-1084.
  32. Yadav JS, Roubin GS, Iyer S, Vitek J, King P, Jordan WD, et al. Elective stenting of the extracranial carotid arteries. *Circulation* 1997;95:376-381.