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ORIGINAL ARTICLES

Stroke subtypes and risk factors of ischemic stroke in young Korean adults

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Abstract

Background and Objectives: This study aimed to describe the ischemic stroke subtypes and risk factors in young Korean adults, focusing mainly on traditional risk factors and management of ischemic stroke. *Methods:* The study patients were the first-ever acute cerebral ischemic infarction age 49 years or below admitted to the Kyung Hee University Medical Centre from September 2003 to June 2009, with ischaemic stroke patients ≥50 years as control. The stroke subtypes was categorized according to Trial of Org 10172 in Acute Stroke Treatment classification. The traditional risk factors of ischemic stroke were examined. For those known to have hypertension and diabetes prior to onset of stroke, their adherence to treatment of hypertension and diabetes was also assessed. *Results:* Close to half of the patients ≤49 years were due to premature atherosclerosis from small vessel occlusion and large artery atherosclerosis. The most common risk factor in declining order was hypertension, smoking, dyslipidemia and obesity. On logistic regression analysis, hypertension, dyslipidemia, and obesity were strongly associated with small vessel occlusion. In patients who were known to have hypertension and diabetes prior to the onset of stroke, the younger patients were less adherent to the treatment as primary prevention than the older stroke patients. *Conclusion:* This study suggests that premature atherosclerosis from small vessel occulusion is the most common cause of ischaemic stroke among young adults in Korea. Non-adherence to primary preventive treatment of hypertension and diabetes is common.

INTRODUCTION

Ischemic stroke in young adults is uncommon, accounting for 2-12% of all ischemic strokes.[1-4] Although the treatment and management of stroke has improved in recent years, only a small number of stroke patients can return to work.[5] Sequelae such as hemiplegia or dysphasia in young adult stroke survivors constitute serious problems, both for the survivors, and socio-economically for their community, because young adults are in their most active stage of social life.

In young adults, causes of ischemic stroke are more diverse than in the elderly stroke population. Nevertheless, studies have shown hypertension, diabetes, dyslipidemia, heart disease, obesity, and smoking are the major risk factors of ischemic stroke in young adults as well as in older populations.[2,6-15] It is important to identify stroke's etiologies and risk factors in young Korean adults, because racial/ethnic differences have a marked effect on stroke subtypes and risk factors in young adults.[11-13,16]

This study aimed to describe the subtypes of ischemic stroke in Korean young adults, focusing mainly on the traditional risk factors and the management of ischemic stroke. An understanding of these risk factors and the best management practices may help in developing a better-focused preventative strategies.

METHODS

Study populations

From September 2003 to June 2009, patients with first-ever acute cerebral ischemic stroke, whom the Department of Neurology admitted within 7 days of the onset of symptoms were enrolled in this study. We collected the data from a prospective clinical registry of patients with acute ischemic stroke. We performed this study at the Kyung Hee University Medical Center, located in the northeastern area of Seoul, Korea. We excluded patients with transient ischemic attack (TIA),

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cerebral venous thrombosis, stroke attributable to direct head trauma or strangulation, and ischemic lesion attributable to immediate complications originating from subarachnoid hemorrhage.

Participants were patients with first-ever acute cerebral ischemic infarction who were ≤ 49 years, and controls were patients ≥ 50 years. We subdivided the participants ≤ 49 years into 4 age groups (15-24, 25-34, 35-44, and 45-49), to estimate the trends of prevalence of risk factors and stroke subtype associated with aging in young adult.

This study was approved by the institutional review board at Kyung Hee University Medical Center (KMC IRB 1020-04).

Stroke subtypes

We investigated the etiologies of ischemic stroke, using the Trial of Org 10172 in Acute Stroke Treatment (TOAST) classification[17], and analyzed ischemic stroke risk factors and management data. We divided ischemic stroke into the following subtypes: large artery atherosclerosis (LAA), small vessel occlusion (SVO), cardioembolism (CE), stroke of other determined etiology (SOE), and stroke of undetermined etiology (SUE). SUE was further subdivided into 3 subtypes: negative (though evaluation was adequate, cause of stroke could not be found), 2 or more (2 or more possible cause of the stroke was found), and incomplete (if we could not fully complete the patient's evaluation). LAA was defined as a stroke patient who had a significant stenosis (>50%) or an occlusion of major brain artery or cortical branch of relevant vascular territory for 1 or more acute ischemic lesion and 1 or more acute brainstem/subcortical hemispheric lesion larger than 1.5cm on the brain imaging. SVO was defined as a stroke patient who had a classical lacunar syndrome and a brain stem, deep or subcortical hemispheric lesion, less than 1.5cm on the brain imaging. Patients of above two subtypes must have no potential cardioembolic risk factors. CE was defined as an acute ischemic stroke patient who had 1 or more defined cardioembolic sources without other possible etiology within brain and cerebrovascular imaging. SOE includes stroke caused by non-atherosclerotic vasculopathy such as a vasculitis and other connective tissue disorder, intra or extra-cranial vascular dissections, Moyamoya disease, hypercoagulable states, and hematologic disorders.

Vascular risk factors

We evaluated the patients' traditional ischemic stroke risk factors: gender, age, hypertension, diabetes, dyslipidemia, smoking, obesity, and heart disease. We defined hypertension as patient who had already been diagnosed hypertension on admission, or who had a systolic blood pressure (BP) ≥ 140 mmHg or diastolic BP ≥ 90 mmHg at discharge.[18] We defined diabetes mellitus as patients who are known to be diabetic on admission, or patients with a fasting glucose ≥ 7.0 mmol/L (126 mg/dl) or a two-hour postprandial serum glucose ≥ 11.1 mmol/L (200 mg/dl), as per the 1999 World Health Organization criteria.[19] Dyslipidemia was defined as either a prior diagnosis of hypercholesterolemia, a fasting serum low-density lipoprotein (LDL) cholesterol ≥ 4.1 mmol/L (160 mg/dl), or a total cholesterol ≥ 6.3 mmol/L (240 mg/dl). Obesity was defined as a body mass index (BMI) ≥ 25kg/m^2, per the Asia-Pacific criterion of obesity[20], and being overweight was defined as a BMI ≥ 23kg/m^2.

Among the patients who were previously diagnosed and knew that they had hypertension, diabetes and dyslipidemia on admission, we divided these patients into two groups according to whether or not each participant took appropriate steps to manage their illness or risk factors. We defined "regularly managed" as patient who met a physician at least 4 times per year and took a medication as prescribed. Patient who did not fulfill this was classified as "irregularly managed". With regard to smoking, we divided the participants into three groups: current smokers, smokers attempting to quit smoking ("past smoker"), and non-smokers (patients who never smoke a cigarette). We performed a young-stroke battery on all patients, which consisted of antinuclear antibodies, anti-neutrophilic cytoplasmic antibodies, lupus anticoagulant, anti-cardiolipin antibodies, anti-ds-DNA antibodies, anti-phospholipid antibodies, D-dimer, fibrinogen, antithrombin III, Protein C, S, and Factor V Leiden mutation. We performed transthoracic echocardiography (TTE) on all patients. Those patients suspected to have cardioembolic ischemic stroke, but failed to identify the cardioembolic source by TTE, had 24 hours Holter monitoring and transesophageal echocardiography (TEE) with air bubble test. As required by TOAST classification, we categorized patients' heart diseases into either high or moderate risk of cardioembolism.[17]

Statistical analysis

To perform statistical comparisons on risk factor prevalence, management of risk factors, and the stroke etiologies between study subjects (49 years or below) and control (50 years or above), we used the Pearson chi-square test and Fisher's exact test. We analyzed the trends along with aging in young adult group (49 years or below), via linear by linear association tests of the 4 participant-age subdivision groups. In all tests, a p value < 0.05 was considered significant. All statistical analyses were conducted using the SPSS 16.0 package for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

During the 6-year study period, we had 1,701 patients with first-ever acute ischemic stroke on our registry. Of these, 196 patient were ≤ 49 years (11.5%). They consisted of 129 men and 67 women, mean age of 42.9 ± 6.4 years. There were 1,505 patients of ≥ 50 years (Control). They consisted of 886 men and 619 women; mean age 67.0 ± 9.2 years. In the ≤ 49 years group, there were 93 patients (5.5%) with age 15 to 44 years (62 men and 31 women), and 103 patients (6.1%) with age 45 to 49 years (67 men and 36 women).

Table 1 shows the distribution of the stroke etiology. The stroke etiologies differed significantly between the ≤ 49 years and ≥ 50 years groups. The most common etiologies in patients ≤ 49 years were SVO (35.2%), SOE (16.8%), and SUE-negative (14.3%). In patients ≥ 50 years, the most common etiologies were LAA (33.1%), SVO (31.9%), and CE (10.8%). Overall, premature atherosclerosis (SVO + LAA) accounted for 49.9 of ischaemic stroke in those ≤ 49 years. Among younger patients with SOE, 10 (30.3%) had primary anti-phospholipid antibody syndrome, 6 patients (18.2%) had arterial dissection, 4 (12.1%) had Moyamoya disease, 3 (9.1%) had systemic lupus erythematosus (SLE)-related ischemic stroke, and 2 (6.1%) had fibromuscular dysplasia. The proportion of SVO patients increased with advancing age, 15-24 years (0%), 25-34 years (12.5%), 35-44 years (36.1%), and 45-49 years (39.8%); p = 0.017 (Table 1). In contrast, the number of SOE patients decreased with advancing age, 15-24 years (80.0%), 25-34 years (50.0%), 35-44 years (15.3%), and 45-49 years (9.7%); p < 0.001 (Table 1)

The most common traditional risk factor in patients ≤ 49 years was hypertension (51.5%), followed by smoking (48.5%), dyslipidemia (39.8%), and obesity (39.3%). (Table 1) We found smoking occurred at significantly higher rates in patients ≤ 49 years than in those ≥ 50 years (48.0% versus 39.6%, p = 0.02). Hypertension, diabetes, and cardioembolic risks were more frequent in those ≥ 50 years. There was no difference in the distribution of dyslipidemia between the 2 groups. Obesity was more common in patients ≤ 49 years than in those ≥ 50 years, though the difference was not statistically significant (39.3% vs. 32.7%, p = 0.076). Overweight subjects (BMI > 23) were also more common in those ≤ 49 years than those ≥ 50 years. Among patients ≤ 49 years, prevalence of hypertension, smoking, and dyslipidemia increased with advancing age (p = 0.006, p = 0.041, and p = 0.005, respectively, Table 1).

We performed a binary logistic regression analysis to clarify the association between traditional risk factors and SVO proportion of young stroke patients (Table 2). There was significant association between traditional risk factors (except cardioembolic risk factor) and SVO proportion in unadjusted model. Even after other traditional risk factors were adjusted, hypertension, dyslipidemia and obesity remained statistically significant, with Odd ratio of 3.353, 3.102, and 2.483 respectively (Table 2).

Table 3 shows the adherence to treatment of the known risk factors. Of the 101 patients with hypertension (51.5% of 196 young adult stroke patients), 78 patients were previously diagnosed and were aware that they had hypertension. Among the 78 patients, 41 (52.6%) patients regularly visited a physician and took antihypertensive medication. In the control patients of ≥ 50 years, 1,027 patients had hypertension, of whom 858 patients had a diagnosis of hypertension before their stroke. Among them, 706 (82.3%) patients regularly visited a physician and took antihypertensive medication. Thus, the younger patients were significantly less adherent than older patients in treatment of hypertension as primary prevention (52.6% vs. 82.3%, p < 0.001, Table 3). The younger patients were also significantly less adherent to treatment of diabetes mellitus when compared to the older patients (57.1% vs. 86.7%, p = 0.001, Table 3). However, there was no significant difference in the adherence to the dyslipidemia treatment between younger and older patients. With regard to smoking, there was significantly more current smokers among the younger as compared to the older patients (44.9% vs. 30.6%, p < 0.001, Table 3). Only 3.6% of the young adult stroke patients were non-smokers,

Table 1: Demographic data, risk factors, and etiology, by age group

	All N=1701 (%)	Age ≤49 years N=196 (%)	Age ≥50 years N=1505 (%)	*P**	Age 15 to 24 years N =5 (%)	Age 25 to 34 years N =16 (%)	Age 35 to 44 years N =72 (%)	Age 45 to 49 years N =103 (%)	*P***
Risk factors									
Gender	1015/686	129/67	886/619	0.064	2/3	10/6	50/22	67/36	0.840
(Male / Female)	(59.7/40.3)	(65.8/34.2)	(58.9/41.1)		(40.0/60.0)	(62.5/37.5)	(69.4/30.6)	(65.0/35.0)	
Age	64.2±11.7	42.9±6.4	67.0±9.2		19.8±2.8	30.8±2.6	41.1±2.6	47.2±1.4	
Hypertension	1128 (66.3)	101 (51.5)	1027 (68.2)	<0.001	0 (0)	6 (37.5)	35 (48.6)	60 (58.3)	0.006
Diabetes mellitus	544 (32.0)	33 (16.8)	511 (34.0)	<0.001	0 (0)	0 (0)	16 (22.2)	17 (16.5)	0.302
Smoking	691 (40.6)	95 (48.5)	596 (39.6)	0.020	0 (0)	5 (31.2)	37 (51.4)	53 (51.5)	0.041
Dyslipidemia	583 (34.3)	78 (39.8)	505 (33.6)	0.093	0 (0)	4 (25.0)	25 (34.7)	49 (47.6)	0.005
Cardioembolic risk	314 (18.5)	23 (11.7)	291 (19.3)	0.008	0 (0)	1 (6.2)	8 (11.1)	14 (13.6)	0.239
Moderate	80 (4.7)	12 (6.1)	68 (4.5)	0.367	0 (0)	1 (6.2)	6 (8.3)	5 (4.9)	0.776
High	233 (13.7)	11 (5.6)	222 (14.8)	<0.001	0 (0)	0 (0)	2 (2.8)	9 (8.7)	0.052
Obesity	569 (33.5)	77 (39.3)	492 (32.7)	0.076	1 (20.0)	5 (31.2)	29 (40.3)	42 (40.8)	0.352
Etiology by TOAST classification									
LAA	525 (30.9)	27 (13.8)	498 (33.1)	<0.001	0 (0)	0 (0)	12 (16.7)	15 (14.6)	0.223
CE	180 (10.6)	18 (9.2)	162 (10.8)	0.621	0 (0)	1 (6.2)	4 (5.6)	13 (12.6)	0.413
SVO	549 (32.3)	69 (35.2)	480 (31.9)	0.372	0 (0)	2 (12.5)	26 (36.1)	41 (39.8)	0.017
SOE	54 (3.2)	33 (16.8)	21 (1.4)	<0.001	4 (80.4)	8 (50.0)	11 (15.3)	10 (9.7)	<0.001
SUE	393 (23.1)	49 (25.0)	344 (22.9)	0.528	1 (20.0)	5 (31.2)	19 (26.4)	24 (23.3)	0.619
2 or more	153 (9.0.)	5 (2.6)	148 (9.8)	<0.001	0 (0)	0 (0)	3 (4.2)	2 (1.9)	0.868
Negative	96 (5.6)	28 (14.3)	68 (4.5)	<0.001	1 (20.0)	3 (18.8)	9 (12.5)	15 (14.6)	0.913
Incomplete	144 (8.5)	16 (8.2)	128 (8.5)	0.635	0 (0)	2 (12.5)	7 (9.7)	7 (6.8)	0.823

Data are expressed as mean ± SD or n (%). Abbreviations: TOAST, Trial of Org 10172 in Acute Stroke Treatment; LAA, Large artery Atherosclerosis; CE, Cardioembolism; SVO, Small vessel occlusion; SOE, Other determined etiology; SUE, Undetermined etiology; 2 or more, Multiple possible etiologies; negative, Undetermined etiology despite extensive evaluation; and Incomplete, Undetermined etiology due to incomplete evaluation.
*analyzed by Fisher's exact test **analyzed by Linear by linear association

Table 2: Logistic regression models showing odds of small vessel occlusion (SVO) proportion of young stroke patients by traditional risk factors.

	Age ≤49 years (N=196)				Age ≧50 years (N=1505)			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	P value	OR (95% C.I.)	P value	OR (95%C.I.)	P value	OR (95%C.I.)	P value	OR (95% C.I.)
Age	0.020	1.069 (1.011 – 1.131)	0.404	1.030 (0.961 - 1.105)	<0.001	0.967 (0.955 - 0.979)	<0.001	0.971 (0.958 - 0.985)
Sex	0.018	2.223 (1.146 - 4.310)	0.485	1.399 (0.545 - 3.589)	0.460	0.920 (0.739 - 1.147)	0.404	0.880 (0.661 - 1.171)
Hypertension	<0.001	4.869 (2.532 - 9.363)	0.002	3.353 (1.583 - 7.103)	0.863	1.021 (0.808 - 1.289)	0.625	0.948 (0.737 - 1.219)
Diabetes	0.013	2.635 (1.231 - 5.641)	0.091	2.178 (0.883 - 5.371)	0.349	1.115 (0.888 - 1.400)	0.662	0.948 (0.745 - 1.207)
Dyslipidemia	<0.001	4.814 (2.567 - 9.027)	0.002	3.102 (1.519 - 6.333)	0.245	1.145 (0.912 - 1.438)	0.821	0.960 (0.751 - 1.227)
Cardioembolism	0.066	0.350 (0.114 - 1.073)	0.100	0.342 (0.095 - 1.227)	<0.001	0.075 (0.042 - 0.132)	<0.001	0.078 (0.044 - 0.137)
Smoking	<0.001	3.184 (1.721 - 5.888)	0.135	1.916 (0.817 - 4.492)	0.491	0.925 (0.740 - 1.155)	0.147	0.789 (0.593 - 1.049)
Obesity	0.003	2.515 (1.376 - 4.598)	0.013	2.483 (1.216 - 5.069)	0.033	1.281 (1.020 - 1.610)	0.150	1.175 (0.920 - 1.501)

Abbreviations: OR, odd ratio; C.I., confidence interval

which was significantly less than the older patients (3.6% vs. 9.0%, p = 0.009, Table 3).

DISCUSSION

In our study on young Korean adults with stroke, we found that the most common etiology in patients ≤ 49 years was SVO, and the number of SVO patients increased significantly with advancing age. As for risk factors, the most common traditional risk factor in our young adult patients was hypertension, smoking, dyslipidemia, and obesity. Among patients ≤ 49 years, advancing age was associated with more hypertension, smoking, and dyslipidemia. Also, our younger patients were significantly less adherent to treatment of hypertension and diabetes as primary prevention of stroke than the older patients. In addition, there were significantly more current smokers among the young as compared to the older stroke patients, and abstainers from smoking were rare among our young adult patients with stroke.

Of strokes occurring in young Korean adult, SVO and LAA from premature atherosclerosis accounted for close to half of the patients. Moreover, SVO (35.2%) was most frequent in our series, which is similar to the results of studies in most of Asian studies.[10-12] Stroke subtypes vary considerably across different racial/ethnic populations, such that CE, LAA and SOE make up a larger proportion of strokes in the white population[6,7,12,21,22], while SVO is more common in Asian and black populations.[2,8,10-15,23] (Table 4)

As compared to the older patients with stroke, there have been fewer studies of the risk factors among the young adults. The racial/ethnic stroke subtype differences in young adults mentioned above may be due to differences in vascular risk factors.[12,13,16,24] With regards to risk factor prevalence and distribution of stroke subtype, Asian and Black population showed quite distinct characteristics as compared to other populations.[2,6-12,14,21-23] Previous studies among the Asians and Black population showed high prevalence of hypertension and high proportion of SVO and LAA, similar to the results in this study, except in reports from India and Thailand.[2,6-12,14,21-23] Lipska *et al*. from India showed risk factor prevalence similar to that of other Asians but stroke subtype distribution was similar to that of the Western countries.[15] Luijckx *et al*. from Thailand showed high proportion of CE but has small sample size and high prevalence of rheumatic heart disease.[13] (Table 4) We have also demonstrated the significant association of hypertension, dyslipidemia and obesity with SVO using logistic regression analysis among our patients (Table 2).

Cigarette smoking is said to independently increases the relative risk of stroke about three-fold.[25] The relative risk of stroke is maximal in middle age, declining with advancing years.[25] In this study, smoking was the 2nd most common risk factor (48%) in those ≤ 49 years old. The prevalence of smoking among young adult with ischaemic stroke in the recent Western studies is 44-47%[1,7], which is similar to our study and those from the other East Asian countries, but higher than South West Asian, Indian, and Malaysian studies.[2,8,10-15]

Prevalence of Diabetes in young Asian and Black stroke patients is generally higher than white population. In our study, 16.8% of young stroke patients had diabetes, a rate similar to Saudi Arabian and Indian studies.[10,15] Prevalence of diabetes was highest in the Malaysian study, up to 52.2%.[12] With regards to dyslipidemia, this was seen in 39.8% of our young stroke patients, a rate similar to Malaysian[12] and Qatari[14] studies, but slightly higher than other Asian studies[10,15], and slightly lower than Taiwan[11] and Western studies.[1,6]

The Korean national health and nutrition survey (KNHANES IV-1) conducted in 2008, revealed prevalence of hypertension, diabetes, dyslipidemia, and smoking of 39 to 49 year old population to be 15.15%, 4.78%, 7.16% and 30.12%, respectively. In our study, these risk factor prevalence were much higher at 51.5%, 16.8%, 39.8%, and 48.5% respectively among our young stroke patients, supporting their etiologic role in the development of stroke.

It is worrisome that despite the high prevalence of traditional vascular risk factors demonstrated in the KNHANES IV-I survey, our young Korean stroke patients showed less adherence to their treatment as primary prevention. This was true for hypertension and diabetes. Similarly, there were significantly more current smokers and less past smoker among those ≤ 49 years than those in older age group (Table 3). This may be reflective of the less concerned attitude of the young adult Korean to these risk factors.

The strong points of this study are, firstly, we belief our data on stroke etiologies and risk factor profiles are relatively reliable, as we created this series based on a stroke registry, the data acquired by two stroke physicians whose diagnostic workup was in accordance with a standardized protocol. Secondly, other than the traditional risk factors,

Table 3: Management of traditional risk factors for primary prevention

	All N=1701 (%)	Age ≤49 years N=196 (%)	Age ≥50 years N=1505 (%)	*P**	Age 15 to 24 years N =5 (%)	Age 25 to 34 years N =16 (%)	Age 35 to 44 years N =72 (%)	Age 45 to 49 years N =103 (%)	*P***
Hypertension	747/936 (79.8)	41/78 (52.6)	706/858 (82.3)	<0.001	0/0 (0)	1/6 (16.7)	13/30 (43.3)	27/42 (64.3)	0.012
Diabetes mellitus	370/434 (85.3)	12/21 (57.1)	358/413 (86.7)	0.001	0/0 (0)	0/0 (0)	6/11 (54.5)	6/10 (60.0)	0.806
Dyslipidemia	45/91 (49.5)	5/10 (50.0)	40/81 (49.4)	1.000	0/0 (0)	0/0 (0)	2/5 (40.0)	3/5 (60.0)	0.549
Smoking									
Current smoker	549 (32.3)	88 (44.9)	461 (30.6)	<0.001	0 (0)	5 (31.2)	36 (50.0)	47 (45.6)	0.153
Past smoker	142 (8.3)	7 (3.6)	135 (9.0)	0.009	0 (0)	0 (0)	1 (1.4)	6 (5.8)	0.094
Non-smoker	1010 (59.4)	101 (51.5)	909 (60.4)	0.020	5 (100.0)	11 (68.8)	35 (48.6)	50 (48.5)	0.041

Number of patients who had been being regularly managed a risk factor / Number of patients who diagnosed those risk factors before admission. Data are expressed as n (%). *analyzed by Fisher's exact test **analyzed by Linear by linear association test

Table 4: Distributions of ischemic stroke subtypes and risk factors in different countries

	Country	Age criteria (years)	No. of patients	Subtype (%)					Risk factors (%)			
				LAA	SVO	CE	SOE	SUE	HTN	DM	DL	SM
Europe												
Carolei *et al.*[6]	Italy	18-44	333	33.1		23.7	8.1	35.1	18.9	2.7	53.7	35.1
Putaala *et al.*[7]	Finland	15-49	1008	7.5	13.8	19.6	26.0	43.0	39.1	10.4	59.5	44.2
Luijckx *et al.*[13]	Netherland	<50	55	38		16	31	15	16.3	7.3	9.1	16.3
North America												
Williams *et al.*[22]	US	18-44	116	16	3	14	44	23		NA		
Chan *et al.*[21]	Canada	15-45	356	6	8	14	28	44		NA		
Qureshi *et al.*[8]	US, black	15-44	112	9	21	20	24	26	55.3	11.6	NA	43.7
Central and South America												
Barinagarrementeria *et al.*[9]	Mexico	<40	300	3		24	40	32	10/5*	NA	10/2*	36/14*
Siqueira Neto *et al.*[23]	Brazil	15-40	106	8.5	12.5	28.3	34.9	16.0		NA		
Australia												
Tan *et al.*[12]	Australia	18-49	61	9.8	14.8	21.3	22.9	31.0	22.5	13.1	26.2	44.2
South West Asia												
Awada *et al.*[10]	Saudi	15-45	70	12.9	24.3	17.1	30.0	15.7	32	16	NA	26
Khan *et al.*[14]	Qatar	15-45	40	NA	42.5	NA	NA	NA	40.0	32.5	27.5	27.5
South Asia												
Lipska *et al.*[15]	India	15-45	214	12.6	7.5	25.2	11.2	43.5	36.0	14.0	29	37.0
South East Asia												
Tan *et al.*[12]	Malaysia	18-49	67	28.3	32.8	12.6	5.0	26.4	65.7	52.2	37.3	22.4
East Asia												
Lee *et al.*[11]	Taiwan	15-45	241	7.9	22.4	19.5	24.5	25.7	45.8	NA	53.1	49.8
Luijckx *et al.*[13]	Thailand	<50	56	23		28	15	32	17.9	7.1	8.9	14.3
Kwon *et al.*[2]	Korea	15-44	149	20.8	17.4	18.1	26.8	16.8	38.3	10.1	8.1	51.0
Present study	Korea	15-49	196	13.8	35.2	9.2	16.8	25.0	51.5	16.8	39.8	48.5

Abbreviations: HTN, hypertension; DM, Diabetes mellitus; DL, Dyslipidemia; SM, Smoking; LAA, Large artery Atherosclerosis; SVO, Small vessel disease; SOE, Other determined etiology; SUE, Undetermined etiology; and NA, None applicable *Male/Female

we also studied that risk factor management of the young adult patients prior to their stroke.

Our study has limitation of a single center study with a small sample size. In our series, the proportion of adults ≤ 49 years was 11.5 % of all ischemic strokes patients, and those under 44 years was 5.5%, which is lower than some other Asian series.[2,11] The low proportion of age under 44 years adult stroke patients in this series could be due to less referral bias. In some young adult stroke, the upper age cut-off has been 44 years or less. We used age 49 as the upper cut-off for a "young adult." We believe it is reasonable to have a higher upper age cut-off, due to aging trend worldwide.[7]

This study shows that SVO is the most common ischemic stroke subtype in Korean young adult, and close to half of the young stroke patients were due to premature atherosclerosis from SVO and LAA. Hypertension, dyslipidemia, and obesity were strongly associated with SVO. These risk factors often precede or accompany young adults with stroke, with many of them ignoring the need to manage these risk factors. Therefore, greater attention to primary prevention of ischemic stroke, with better control of traditional vascular risk factors among the young Korean adult is of high priority.

DISCLOSURE

Conflict of interest: None

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