Prevalence of Ischemic Stroke Subtype and Relationship Between Patient Factors and Each Subtype in Taksin Hospital

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ABSTRACT

Background: Ischemic stroke is a global health issue. Prevention strategies depend on its subtype, the standard criterion is a TOAST classification. Few studies in Thailand clarified stroke of undetermined etiology into incomplete evaluation subtype that reflecting care service quality.

Objectives: This study aims to establish local prevalence in hospital that cerebrovascular imaging not routinely done as reference for improving protocol of comprehensive evaluation and predictors for each subtype.

Materials and Methods: This retrospective cross-sectional study included acute ischemic stroke patients who admitted in stroke unit between October 1st, 2021 and September 30th, 2022. All patients were classified into 7 subtypes and then analysed relationship between patient factors and each subtype.

Results: A total of 382 patients are categorised as follow: Incomplete evaluation, 218 (57%); LAA, 55 (14%); SVO, 42 (11%); CE, 25 (7%); Negative evaluation, 19 (5%); Two or more causes identified, 12 (3%); and SOE, 11 (3%). Lack of cerebrovascular assessments is the cause of incomplete evaluation related with aged 45 years or older, beyond fast-track period, cortical NIHSS ratio <0.1, and lacunar infarction. Incomplete evaluation consists of lacunar infarction (38%), known specific cause (10%), poor prognosis (2%) and denial (1%) and unspecified reason (6%). To LAA, moderately high LDL-c and current smoking more likely relate with aOR 3.65 and 3.15 (p value=0.04) but lacunar infarction least likely relates with aOR 0.04 (p value <0.001).

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Conclusion: Stroke of undetermined etiology with incomplete evaluation is around a half in the setting of non-routine cerebrovascular assessment and mostly consists of the lacunar infarction. Local prevalence should be established for enhancing cerebrovascular accessibility, the implementation of vascular study protocol should apply for current smoking patient who has not in optimal range of LDL-c presenting with non-lacunar infarction.

Keyword: Ischemic stroke subtype prevalence, TOAST classification, Relationship between patient factors and stroke subtype, Incomplete evaluation with lacunar infarction, Cerebrovascular assessment

Introduction

Stroke is the global health issue, the second of mortality rate and the third of disability rate because the exposure of vascular risk factor such as aging, hypertension, diabetes mellitus, dyslipidemia, smoking or pollution for a period of time causes inadequate perfusion or occlusion of blood clot from local chronic inflammatory vasculature or upstream source[1,2]. Prevention by antiplatelets, anticoagulants or carotid intervention beside optimization of vascular risk factor needs identifying subtype of ischemic stroke that TOAST classification is a standard, simple, and high inter-rater reliable system[3].

In Thailand, the first study of stroke prevalence was published without ischemic stroke subtype distribution[4]. There were a few studies regarding to the prevalence of ischemic stroke subtype. These previous studies reported ischemic stroke preva-

lence according to TOAST classification with SUE ranges from 3.6% to 18% but They did not clarify SUE into 3 categories namely two or more causes identified, negative evaluation, and incomplete evaluation[5-7]. Incomplete evaluation was low about 1.7% in the high-rate cerebrovascular imaging center that both intra and extracranial magnetic resonance angiography was performed up to 98.7%[8]. Patient who is ignored for cerebrovascular assessment could be losing benefit of carotid intervention or high intensity antiplatelet regimens. The data of incomplete evaluation are important to promote cerebrovascular assessment protocol.

This study focuses on prevalence of incomplete evaluation subtype that is expected high because cerebrovascular assessment is not routinely performed in all ischemic stroke patients unlike the residency or fellowship training hospitals. Furthermore, the cause of incomplete evaluation and the predictors of other subtypes are also explored.

Methods

Study design

This study is a single center, retrospective cross-sectional study describing the prevalence of all ischemic stroke subtype according to TOAST classification in the hospital that cerebrovascular imaging is not routinely performed. Moreover, relationship between patient factors and each subtype is assessed for predictive factors of each subtype (Figure 1).
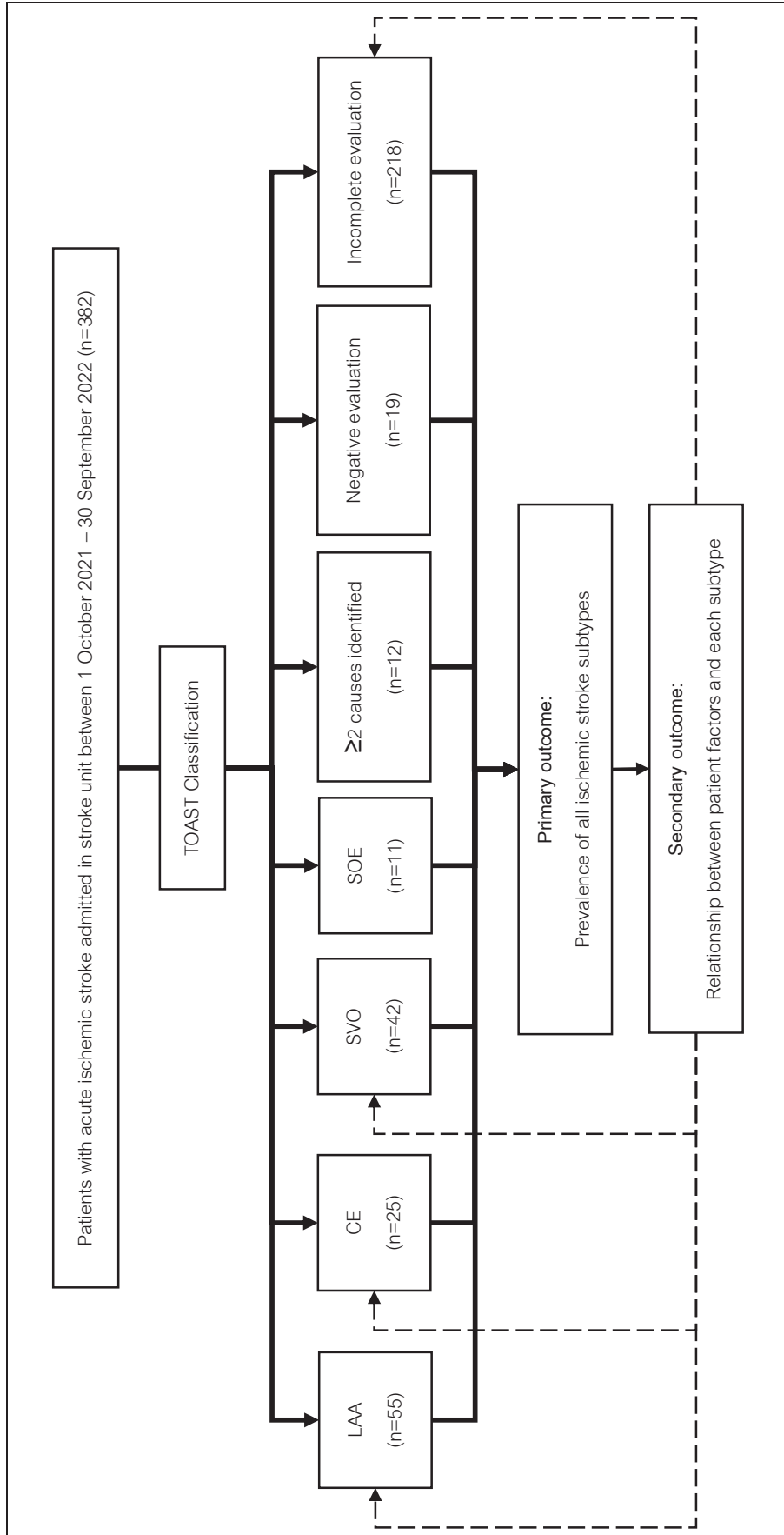
Figure 1 Patient flow chart

Study population

All patients were diagnosed acute ischemic stroke and admitted in stroke unit at Taksin hospital between October 1st, 2021, and September 30th, 2022. Patients presented with transient ischemic attack (TIA) and hemorrhagic stroke were excluded. The collected data were extracted from the patients' medical records and Thai Neurological Information Center stroke registry while neuroimaging studies were reviewed from PACS by neurologist. Demographic characteristics, vascular related medical history, clinical presentation, cardiac investigation (EKG and/or echocardiography), neuroimaging characteristics and laboratory values were collected. The recanalization procedures were also assessed in patients who presented within 6 hours or stroke fast track period.

Measurements

Subtypes of ischemic stroke using original TOAST criteria were identified by neurologist using clinical history, results of diagnostic tests including EKG, echocardiography, CT or MR brain, cerebrovascular imaging and compatible laboratory findings. Patients were classified into 7 categories as follows; LAA: upstream intra or extracranial stenosis ≥50%; CE: high risk sources such as atrial fibrillation, valvular heart disease and left-side thrombus; SVO: recent area of infarction ≤15mm with upstream intra or extracranial stenosis <50%; SOE: uncommon identified cause such as non-atherosclerotic vasculopathy, hypercoagulable state, hypoperfusion, or iatrogenic cause; Two or more causes identified of SUE; Negative evaluation of SUE: recent area of infarction >15mm without upstream intra or extracranial stenosis ≥50% or high risk cardioembolic source by EKG and/or echocardiography; and Incomplete evaluation of SUE.

Factors that might be associated in each category were defined as follows; age, sex, vascular risk factors including hypertension (patient's self-report, or use of antihypertensive medication), diabetes mellitus (patient's self-report, use of antihyperglycemic agent, or HbA1C >6.5%), and dyslipidemia (LDL-c >130mg/dL), history of end organ damage including old CVD (patient's self-report, or old vascular brain lesion in CT scan), IHD (patient's self-report and medical records), and CKD (eGFR <60mL/min/1.73m^2), atrial fibrillation (medical records, detection by screening EKG or 24-hour EKG monitor), smoking habit (current smoker within previous 6 months, yes or no), alcohol consumption behavior (> 1 drink per week, yes or no), activation of stroke fast track (yes or no), referral stroke (transferring from other hospital, yes or no), clinical characteristics including NIHSS (range from 0 to 42, with higher scores indicating more severe neurologic deficit) and cortical NIHSS (ratio ≥0.1 by summation of part 2-best gaze (score 0-2), part 3-visual field (score 0-3), part 9-best language (score 0-3) and part 11-extinction and inattention (score 0-2) divided by total NIHSS, yes or no), lacunar infarction (recent area of infarction ≤15mm, yes or no) and laboratory values including HbA1C, LDL-c and eGFR.

Ethical considerations

This study was approved by the Bangkok Metropolitan Administration Ethics Committee for Human Research (BMAEC-S017hc66_EXP). The data were collected and analysed in Taksin hospital computer without extracting to personal computer. Information was kept anonymous without name or hospital number when extracting outside stroke unit. The researcher collected every eligible patient even missing some data for avoiding selection bias.

Statistical analysis

Using n4Studies calculated sample size by the infinite population proportion method from a previous study including missing rate 10% resulting in 349 patients[7,9]. Categorical variables were presented as number and percentage, and continuous variables were presented as median and interquartile. Relationship was tested between patient factors and all subtypes by Chi-square and Kruskal-Wallis. Using Stata software, predictors for each subtype were analysed by logistic regression with p<0.05 considered statistically significant.

Results

A total of 382 patients with acute ischemic stroke admitted in stroke unit at Taksin hospital from October 2021 through September 2022 were included. The median age was 66 years (min=23 and max=96), and 57.6% were male. Around one-fourths were current smoking. Hypertension was the most common vascular risk factors by 61.5%, and history of previous stroke was the most common underlying end organ damage by 23.3%. Atrial fibrillation was found in 17.3% that around two-thirds were firstly detected in this admission. Most patients had moderate severity (Median NIHSS 5) with low cortical NIHSS ratio (72%). Almost all were performed CT scan and a half was lacunar infarction. Most of them were in a normal range of HbA1C 6.1%, LDL-c 112mg/dL and eGFR 81mL/min/1.73m^2 (Table 1).

Among 112 patients were activated stroke fast track. They had median of stroke duration as 155 minutes, ASPECTS as 9, and posterior ASPECTS as 8.5. Recanalized procedures were given in 65 patients (17%) consisted of intravenous alteplase in 62 patients (16%) and mechanical thrombectomy in 18 patients (5%). Seven patients had symptomatic intracerebral hemorrhage. All of them received IV alteplase that median ASPECTS as 3 (Table 2).

Table 1 Baseline characteristics

	Total N=382	LAA n=55	CE n=25	SVO n=42	SOE n=11	5.1 n=12	SUE* 5.2 n=19	5.3 n=218	p-value
General characteristics									
Age - y Median [IQR]	66 [57-74.5]	66 [54.5-72]	77 [57-83]	59.5 [50.25-66]	60 [57.5-73]	70.5 [63.75-78.5]	61 [51-69.5]	67 [59-75]	<0.001
Male sex - no. (%)	220 (57.6)	39 (70.9)	10 (40)	24 (57.1)	3 (27.3)	6 (50)	9 (47.4)	129 (59.2)	0.049
Vascular risk factors lifestyle									
Current smoking - no. (%) †	94 (24.6)	23 (46)	4 (18.2)	11 (30.6)	1 (16.7)	2 (18.2)	2 (11.8)	51 (25.5)	0.042
High and moderate alcohol consumption - no. (%) ‡	39 (10.2)	8 (16)	3 (13.6)	3 (8.3)	0	2 (18.2)	3 (17.6)	20 (10.1)	0.708
Medical history									
Vascular risk factors									
Hypertension - no. (%)	235 (61.5)	30 (54.5)	11 (44)	24 (57.1)	8 (72.7)	9 (75)	11 (57.9)	142 (65.1)	0.275
Diabetes mellitus - no. (%)	161 (42.1)	20 (36.4)	8 (32)	18 (42.9)	1 (9.1)	2 (16.7)	9 (47.4)	103 (47.2)	0.052
Dyslipidaemia - no. (%)	136 (35.6)	25 (45.5)	6 (24)	18 (42.9)	4 (36.4)	3 (25)	7 (36.8)	73 (33.5)	0.447
End organ damage									
Old cerebrovascular disease - no. (%)	89 (23.3)	10 (18.2)	10 (40)	9 (21.4)	4 (36.4)	6 (50)	1 (5.3)	49 (22.5)	0.021
Ischemic heart disease - no. (%)	36 (9.4)	4 (7.3)	4 (16)	2 (4.8)	1 (9.1)	1 (8.3)	1 (5.3)	23 (10.6)	0.762
Chronic kidney disease - no. (%)	53 (13.9)	4 (7.3)	5 (20)	3 (7.1)	2 (18.2)	3 (25)	2 (10.5)	34 (15.6)	0.051
Atrial fibrillation - no. (%)	66 (17.3)	0	21 (84)	0	0	11 (91.7)	0	34 (15.6)	-
Known - no.	25	0	6	0	0	4	0	15	
At admission - no.	41	0	15	0	0	7	0	19	
Presentation									
Within 6h/stroke fast track - no. (%)	112 (29.3)	21 (38.2)	19 (76)	18 (42.9)	3 (27.3)	4 (33.3)	12 (63.2)	35 (16.1)	<0.001
Median - minute [IQR]	155 [91.5-241.25]	128 [75-216]	110 [58.5-202.5]	139 [90-208.75]	195 [119-257.5]	304 [254.25-312.5]	152.5 [135.5-216.5]	219 [138.5-267.5]	-
Referral stroke - no. (%)	67 (17.5)	16 (29.1)	5 (20)	7 (16.7)	3 (27.3)	4 (33.3)	9 (47.4)	23 (10.6)	<0.001

Table1 Baseline characteristics (continue)

| | Total N=382 | TOAST Classification | | | | SUE* | | | p-value |
		LAA n=55	CE n=25	SVO n=42	SOE n=11	5.1 n=12	5.2 n=19	5.3 n=218	
Clinical characteristics									
NIHSS - Median [IQR] §	5 [3-10]	9 [5-17]	16 [6.75-23.75]	5 [2-7]	6 [3-16.5]	10 [6.5-20]	11 [6-21]	4 [3-7]	<0.001
Cortical NIHSS ratio ≥0.1 - no. (%) ¶	96 (25.1)	28 (50.9)	16 (64)	6 (14.3)	4 (36.4)	5 (41.7)	9 (47.4)	28 (12.8)	<0.001
Imaging characteristic									
Lacunar infarction - no. (%)	203 (53.1)	6 (10.9)	7 (28)	42 (100)	3 (27.3)	2 (16.7)	0	143 (65.6)	<0.001
Laboratory values ‖									
HbA1C - Median [IQR]	6.1 [5.6-7.1]	5.8 [5.5-7.1]	6.0 [5.7-6.6]	6.3 [5.6-7.5]	5.45 [5.3-5.825]	6.3 [5.8-6.5]	6.1 [5.8-7.8]	6.1 [5.6-7.2]	0.128
LDL-c - Median [IQR]	112 [84.75-140.25]	125 [101-143]	87 [77.5-119]	127 [99-142]	129 [80-153]	75 [69.5-112]	110 [95.25-132.25]	108 [84-140]	0.015
eGFR - Median [IQR]	81 [60.25-94]	83 [69-97]	81 [51.75-97.75]	85 [74-101]	78 [53.5-87.25]	79 [50.5-82]	84 [58.25-97.25]	78 [57.5-93]	0.13

* SUE denotes Stroke of undetermined etiology including 5.1 Two or more etiologies, 5.2 Negative evaluation and 5.3 Incomplete evaluation.

† For the current smoking or smoking within previous 6 months, data were missing for 40 patients, 342 patients were included in the analysis.

‡ For more than moderate alcohol consumption or >1 drink per week, data were missing for 41 patients, 341 patients were included in the analysis.

§ Score on NIHSS range from 0 to 42, with higher scores indicating more severe neurologic deficits. For NIHSS, data were missing for 18 patients, 364 patients were included in the analysis.

¶ Summation of part 2-best gaze (score 0-2), part 3-visual field (score 0-3), part 9-best language (score 0-3) and part 11-extinction and inattention (score 0-2) divided by total NIHSS. For cortical NIHSS ratio, data were missing for 45 patients, 337 patients were included in the analysis.

‖ For laboratory value, data were missing for 12 patients in HbA1C, 14 patients in LDL-c, and 20 patients in eGFR. 370 patients for HbA1C, 368 patients for LDL-c, and 362 patients for eGFR were included in the analysis.

Table 2 Recanalized procedure in stroke fast track

	Total n=112	TOAST Classification						
		LAA n=21	CE n=19	SVO n=18	SOE n=3	5.1 n=4	SUE 5.2 n=12	5.3 n=35
Clinical characteristics								
NIHSS score - Median [IQR]	7 [4-17]	17 [9-24]	18 [11-26]	5 [3.25-7.75]	16.5 [15.25-17.75]	8 [5.5-16.5]	11 [6-19]	4.5 [2-6]
Imaging characteristics								
Within 6 hours/stroke fast track								
ASPECTS †† - Median [IQR]	9 [8-10]	7 [4-9]	9 [6.5-10]	10 [10-10]	10 [7.5-10]	8 [4.5-9]	6 [3-8.5]	10 [9-10]
Pc-ASPECTS †† - Median [IQR]	8.5 [8-9]	7.5 [7.25-7.75]	-	-	-	10 [10-10]	8.5 [8.25-8.75]	9 [9-9]
Recanalization procedure - no. (%)								
IV alteplase and/or thrombectomy	65	15	13	11	1	2	10	13
IV alteplase	62	15	11	11	1	1	10	13
Thrombectomy	18	6**	7	0	0	1	4**	0
Symptomatic intracerebral haemorrhage	7	2	2	0	0	0	3	0
After IV alteplase	7	2	2	0	0	0	3	0
After thrombectomy	4	1	2	0	0	0	1	0
Failure of thrombectomy	2	1	0	0	0	1	0	0

†† The Alberta Stroke Program Early Computed Tomography Score (ASPECTS) is an imaging measure of the extent of ischemic stroke. Scores ranges from 0 to 10 that higher scores indicating a smaller infarct core with 6 patients had pc-ASPECTS (details are available at www.aspectsinstroke.com).

** Only 1 patient from LAA and 5.2 were perfomed thrombectomy beyond 6 hours.

Among 382 patients, all had screening EKG or 24-h EKG monitor but only 160 patients (42%) had CT or MR angiography. The distribution of subtype was as followed: Incomplete evaluation, 218 (57%); LAA, 55 (14%); SVO, 42 (11%); CE, 25 (7%); Negative evaluation, 19 (5%); Two or more causes identified 19 (5%); and SOE, 11 (3%). Incomplete evaluation was the most common subtype, and no one had cerebrovascular assessment in both extra and intracranial artery. This group consisted of lacunar infarction (38%), known specific cause (10%) mainly AF (the others: valvular heart disease, 2; apical aneurysm, 1; acute anemia, 1; and polycythemia vera, 1), poor prognosis (2%) (previous bed ridden status, 5; large infarction, 3; and active hepatocellular carcinoma, 1, denial of further investigation (1%) (lack of caregiver, 2; and lack of health coverage scheme, 2), and unspecified reason (6%) (Figure 2).
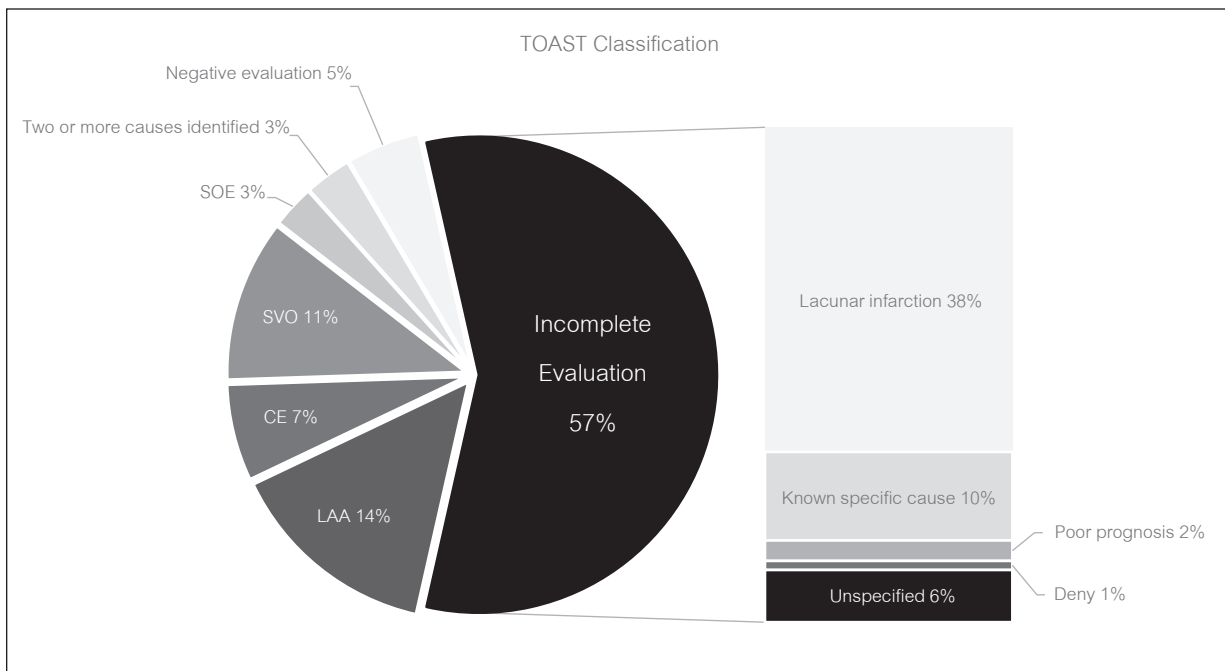

Figure 2 Prevalence of ischemic stroke subtype

The second most common was LAA including carotid stenosis in 7 patients [13%] and the rest of intracranial LAA as followed; MCA, 32 [58%]; ICA, 7 [13%]; VA, 4 [7%]; BA, 3 [6%]; ACA, 1 [2%]; and PCA, 1 [2%] respectively. Third was lacunar infarction without upstream significant stenosis and high risk cardioembolic source identified, the other lacunar infarction in 161 patients were also found in other subtypes as followed: Incomplete evaluation, 143; CE, 7; LAA, 6; SOE, 3; and two or more causes identified, 2. Almost high risk cardioembolic sources were AF in 21 patients [84%] followed by cardiomyopathy in 3 patients [12%] and acute myocardial infarction in 1 patient. For two or more causes identified, almost all were combination of LAA and CE but the only one was combination of LAA and SOE with acute anemia. The least was SOE or stroke of uncommon cause consisted of septicaemia, 3;

vascular malformation, 2; and cryptococcal meningitis, 1; advanced stage hepatocellular carcinoma, 1; acute anemia, 1; polycythemia vera, 1; essential thrombocytosis, 1; and vaccination, 1.

Median age in SVO (59.5 years) had lower than CE, two or more causes identified, incomplete evaluation and LAA (77, 70.5, 67, and 66 years respectively). Male and current smoking had more proportion in LAA (70.9% and 46%). Medical history of old cerebrovascular disease had more proportion in two or more causes identified, CE and SOE (50%, 40% and 36.4% respectively). Not only non-stroke fast track and non-referral stroke had the most (84% and 89.4%) but also median NIHSS and high cortical NIHSS ratio had the least (4 point and 12.8%) in incomplete evaluation. For lacunar infarction excluding SVO and negative evaluation by definition, incomplete evaluation had the most (65.6%) and LAA had the least (10.9%). Lastly median LDL-c level in SVO and LAA (127mg/dL and 125mg/dL) had higher than incomplete evaluation, CE and two or more causes identified (108, 87 and 75mg/dL respectively) (Table 1).

To LAA, current smoking and LDL-c level of 130-159mg/dL relate but lacunar infarction does not. To CE, stroke fast track and high cortical NIHSS ratio relate but age 45-64 years and LDL-c level of 130-159mg/dL do not. To SVO, stroke fast track and LDL-c level of 100-159mg/dL relate. Finally, age 45 years or older and lacunar infarction relate but stroke fast track and high cortical NIHSS ratio do not relate to incomplete evaluation (Table 3).

Table 3 Logistic regression for patient factors and each subtype

Variable	LAA		CE		SVO		Incomplete evaluation	
	p-value	Adjusted odds ratio (95% CI)	Adjusted odds ratio (95% CI)	p-value	Adjusted odds ratio (95% CI)	p-value	p-value	Adjusted odds ratio (95% CI)
Age 18 - 44	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Age 45 - 64	0.65	1.49 (0.27 - 8.21)	0.01 (0.00 - 0.43)	0.02	0.31 (0.07 - 1.38)	0.12	<0.01	5.06 (1.68 - 15.24)
Age 65 - 74	0.18	3.36 (0.58 - 19.66)	0.26 (0.02 - 2.72)	0.26	0.25 (0.05 - 1.34)	0.11	0.01	4.46 (1.41 - 14.14)
Age ≥75	0.5	0.45 (0.05 - 4.46)	6.63 (0.42 - 105.84)	0.18	0.13 (0.01 - 1.40)	0.09	<0.01	9.11 (2.30 - 36.08)
Male sex	0.09	2.71 (0.87 - 8.39)	3.58 (0.52 - 24.73)	0.2	0.68 (0.21 - 2.19)	0.52	0.49	0.78 (0.39 - 1.58)
Current smoking	0.04	3.15 (1.05 - 9.43)	0.40 (0.03 - 5.85)	0.5	1.04 (0.31 - 3.49)	0.95	0.85	1.08 (0.50 - 2.34)
Old cerebrovascular disease	0.46	0.64 (0.20 - 2.08)	1.00 (0.15 - 6.50)	1.0	2.62 (0.66 - 10.38)	0.17	0.44	0.74 (0.35 - 1.58)
Stroke fast track	0.61	1.29 (0.49 - 3.41)	121.45 (8.89 - 1658.55)	<0.01	3.53 (1.15 - 10.83)	0.03	<0.01	0.20 (0.10 - 0.40)
Referral stroke	0.24	1.94 (0.65 - 5.84)	1.99 (0.28 - 13.95)	0.49	3.44 (0.55 - 21.29)	0.19	0.18	0.54 (0.22 - 1.33)
NIHSS 0-4	Ref	Ref	Ref	Ref	0.42 (0.02 - 10.59)	0.6	0.32	1.96 (0.52 - 7.35)
NIHSS 5-15	0.86	0.91 (0.32 - 2.62)	0.32 (0.03 - 3.39)	0.35	1.27 (0.05 - 29.87)	0.88	0.7	1.28 (0.37 - 4.43)
NIHSS 16-20	0.12	4.57 (0.68 - 30.64)	0.23 (0.01 - 5.91)	0.38	0.21 (0.00 - 19.31)	0.5	0.43	0.47 (0.07 - 3.07)
NIHSS 21-42	0.55	0.60 (0.11 - 3.24)	0.81 (0.05 - 14.29)	0.89	Ref	Ref	Ref	Ref
Cortical NIHSS ratio ≥10%	0.18	2.16 (0.70 - 6.62)	25.86 (1.37 - 489.7)	0.03	2.50 (0.54 - 11.59)	0.24	<0.01	0.29 (0.12 - 0.69)
Lacunar infarction	<0.01	0.04 (0.01 - 0.14)	0.98 (0.14 - 6.85)	0.99	-	-	<0.01	2.34 (1.24 - 4.43)
LDL-c <100	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
LDL-c 100-129	0.23	2.10 (0.63 - 6.99)	0.11 (0.01 - 1.26)	0.08	4.84 (1.21 - 19.35)	0.03	0.22	0.61 (0.28 - 1.34)
LDL-c 130-159	0.04	3.69 (1.10 - 12.43)	0.01 (0.00 - 0.36)	0.01	8.05 (1.68 - 38.58)	0.01	0.32	0.64 (0.26 - 1.55)
LDL ≥160	0.23	2.34 (0.58 - 9.42)	1.11 (0.13 - 9.09)	0.92	1.12 (0.23 - 5.35)	0.89	0.67	0.82 (0.33 - 2.05)

Discussion

The result shows very high prevalence of incomplete evaluation because the case performed further CTA/MRA brain and neck is selected by uncommon presentation or LAA-like characteristics such as stroke in the young, moderate or severe stroke severity, cortical lobe sign presentation, recurrent episode of previous symptom, asymmetrical or territorial infarction appearance. This is emphasized by the result of relationship that age 45 years or older (not be stroke in the young), non-stroke fast track, low cortical NIHSS ratio, and lacunar infarction more likely do not go on cerebrovascular assessment. The large amount of incomplete evaluation is still expected in the hospital that cerebrovascular accessibility is limited whether it is insufficient radiologist, technician, or facility. By the way, this limitation could be improving if the data are illustrated. The main reason for no further vascular study is lacunar infarction. Some patients with lacunar infarction could uncommonly have coexisted LAA as same as some patients with known specific disease especially AF. They might lose benefit of carotid intervention.

Prevalence of other subtypes is similar to a previous Korean study in order of frequency as follows: LAA (37.3%) had more common than SVO, CE, negative evaluation, two or more causes identified and SOE (22.9, 20.6, 11.1, 3.4 and 2.9% respectively). However, they had no study of relationship despite they could performed cerebrovascular imaging in almost all patients with the least prevalence of incomplete evaluation[8].

This study demonstrates relationship corresponding to the previous studies. Unlike CE in younger than 65 years corresponds to the association between atrial fibrillation and the elder who are 75 years or older[7]. In addition, current smoking and LAA is consistent with Kim et al that shown regular cigarette smoking within the last 5 years associated with significant stenosis of intracranial atherosclerosis[10].

Moreover, Patients present during stroke fast track period or with high cortical NIHSS ratio are more likely CE. This may be because the ischemia from CE occurs without time to prepare for collaterals causing more severe stroke (median NIHSS 18) and more cortical involvement (64%). Stroke fast track also relates to SVO that could be impairment of collateral recruitment[11]. Lastly, relationship between LDL-c and each subtype shows moderately high LDL-c level related to atherosclerotic vasculopathy in contrast to CE (Table 3).

For application, cerebrovascular assessment should be assessed for current smoking patient who has not in optimal range of LDL-c presents with non-lacunar infarction. There's no need to be moderately high LDL-c because of cross-related SVO. However, vascular study should perform for all later when resources are ready.

Limitation of this study; First, although there is the risk of misclassification, the data are double corrected by medical record and stroke registry, the raw picture of cerebrovascular assessment need to present in PACS, and the degree of stenosis is reviewed strictly on standard criteria. Second, the proportion of incomplete evaluation is too high for generalizing proper dominant ischemic stroke subtypes in this area but in terms of care service, the prevalence of incomplete evaluation should be reported in individual hospital for improving protocol even further. Third, there are quite small proportion in LAA, CE, SVO and SOE subtypes for analyzing the relationship but these is comparable to a previous study in the number of patients[6].

This is the first study demonstrating complete TOAST classification subtypes and analyzing relationship between multiple categorized factors and each subtype. Basic information of stroke unit was established as a baseline profile that could be a reference and encouraged cerebrovascular accessibility in the future such as carotid and transcranial ultrasound for reducing proportion of incomplete evaluation and improving stroke prevention protocol. The next study should re-analyzes relationship with a few proportions of incomplete evaluation, however even optimized protocol, there is still an incomplete evaluation around 3% owing to poor prognosis and denial for further investigation but the prevalence should be reported in individual hospital for improving the stroke prevention service even further.

Conclusion

Stroke of undetermined etiology with incomplete evaluation is around a half in the setting of non-routine cerebrovascular assessment and mostly consists of the lacunar infarction. Local prevalence should be established for enhancing cerebrovascular accessibility, the implementation of vascular study protocol should apply for current smoking patient who has not in optimal range of LDL-c presenting with non-lacunar infarction.

Abbreviations

TOAST: Trial of Org 10,172 in Acute Stroke Treatment; LAA: Large artery atherosclerosis; CE: Cardioembolism; SVO: Small vessel occlusion; SOE: Stroke of other determined etiology; SUE: Stroke of undetermined etiology; CT: computer tomography; MRI: Magnetic resonance imaging;

PACS: Picture archiving and communication system; EKG: Electrocardiogram; old CVD: old Cerebrovascular disease; IHD: Ischemic heart disease; CKD: Chronic kidney disease; NIHSS: National Institute of Health Stroke Scale; ASPECTS: Alberta Stroke Program Early Computed Tomography Score; HbA1c: Hemoglobin A1c; LDL-c: Low-density lipoprotein cholesterol; eGFR: Estimated glomerular filtration rate; IQR: Interquartile range

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