

## ORIGINAL ARTICLES

# Ischaemic stroke in young adults: A comparative study between Malaysia and Australia

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### Abstract

**Background and Objectives:** There is a paucity of comparative studies on young strokes between populations of different ethnicities and geographical regions. The purpose of this study was to compare the patterns, risk factors and etiologies of ischaemic stroke in younger patients between stroke registries in Malaysia and Australia. **Methods:** From January 2007 to March 2008, all consecutive ischaemic stroke patients from the age of 18 to 49 were studied. **Results:** There were 67 patients for Malaysia and 61 for Australia, with 4 deaths in the Malaysian series (case-fatality of 6%), and no deaths for Australia. The mean age was  $41.5 \pm 8.8$  yrs for Malaysia and  $40.1 \pm 8.8$  years for Australia. The ethnic origin was Malays, Chinese and Indian for Malaysia, and Caucasians (85%) for Australia. The sex ratio was M : F = 1.4 : 1 for Malaysia and 1.54 : 1 for Australia. The differences in risk factors for Malaysia versus Australia were: Diabetes (OR 7.25; 95% CI 2.78-19.45), hypertension (OR 6.42; 95% CI 2.75-15.22) and chronic renal disease (OR 5.2; 95% CI 1.02-35.87). Conversely, smoking was a significant risk factor for Australia (OR 2.75; 95% CI 1.2-6.37). The Malaysian patients have significantly higher proportions of large vessel atherosclerosis and small vessel occlusion by TOAST classification, accounting for 60% of patients, while the Australian series had greater proportions of cardioembolism and patients in the determined aetiologies category, specifically vascular dissection. **Conclusion:** There were significantly more large vessel atherosclerosis and small vessel occlusion among young Malaysians with ischaemic stroke as compared to Australia.

### INTRODUCTION

Cerebral infarction in young adults is responsible for significant socioeconomic loss worldwide. Many studies based on hospital-based registries have demonstrated a broad spectrum of aetiologies and risk factors. In addition, unique aetiologies have also been identified such as moya-moya syndrome, vascular dissections, haematological causes, vasculitis and drugs in varying proportions.<sup>1-10</sup> Globally, studies on young adults with cerebral infarctions in developed and developing countries have observed large variations in the heterogeneity of stroke subtypes and classification. Interestingly, strokes of undetermined aetiology varied widely from 5-44% while combined categories of large vessel atherosclerosis and small vessel occlusion showed similar large variation from 3%-42.5%. The cardioembolic category varied from between 12.6% to 54% among studies while the proportions

in the undetermined or unknown category ranged from 15% to 42.5%. Many conventional and recognised risk factors in young stroke patients have also been described. Overall, the results showed these variations due to many reasons including geographical location, referral bias, study methodologies, classification schemes and the intensity of investigations.

Comparative studies between young adults with cerebral infarction in developed and developing countries involving different ethnic groups and geographical regions were rare. An extensive literature review revealed only one previous study, comparing Thai and Dutch patients. In this study, cardioembolic strokes were more common in Thai patients while atherothrombotic events and traditional risk factors were more significant in the Dutch series.

Accordingly, we hypothesized that cerebral infarction in younger adults (under the age of

50) in urban Australia would be predominantly from large vessel atherosclerosis and small vessel occlusion due to large proportion of patients with conventional risk factors while the young stroke population from urban Malaysia would reveal a lower proportion of atherothrombotic causes and greater numbers of determined strokes based on TOAST criteria secondary to unique aetiologies, common to Asia. This study was undertaken to examine this hypothesis.

## METHODS

This was a comparative, prospective, hospital-based study which included a detailed review of the case records from all consecutive ischaemic stroke patients between the ages of 18 to 49 who were admitted via the neurology service at the University of Malaya Medical Centre from January 2007 to March 2008. The UMMC was a major 900-bed teaching hospital in Kuala Lumpur, serving a population of 800,000 inhabitants. The investigator (KST) also spent 2 months at the National Stroke Institute, Melbourne, Australia in last quarter of 2008 and reviewed all the relevant case records for consecutive patients admitted into the Austin-Repatriation Hospital within the same time period. The Austin-Repatriation Hospital was a major teaching hospital of similar size which served a population of 500,000 within the north-eastern suburbs of the city of Melbourne in Australia.

The study protocol included a standard computerised case record form for subject evaluation by the admission team with subsequent review and follow up by the principal investigator (KST). The investigator subsequently reviewed case records admitted over the same time frame with identical inclusion criteria at Austin and Repatriation Hospital in Melbourne, Australia. The patients were accumulated prospectively in Melbourne and entered into the stroke database. Identical inclusion criteria were used in both study sites. The patients were also classified in accordance to TOAST criteria. The ethics committee of both participating institutions approved the study.

Inclusion criteria were all ischaemic stroke patients from age 18-49 years confirmed by CT scan or MRI. Stroke was defined in accordance to WHO criteria as "a focal neurological deficit of sudden onset with symptoms lasting 24 hours or longer or leading to death." Risk factors were defined in the following manner. Hypertension was defined as previous BP above 140/90 mm Hg

or in the presence of previous specific therapy. Dyslipidemia was defined as total cholesterol level of  $\geq 5.2$  mmol/l, triglyceride levels  $\geq 1.8$  mmol/l and HDL  $\leq 1$  mmol/l. Diabetes mellitus was defined as elevated fasting blood glucose above 6.1mmol/l or HbA1c  $\geq 7\%$  or previously on oral hypoglycaemic or insulin injections. Current smokers were defined as patients who smoked  $\geq 10$  cigarettes per day for more than 1 year. Significant alcohol consumption was defined as  $\geq 30$  g of ethanol per day.

Investigations included imaging studies to evaluate the intracranial, extracranial and cardiac status of stroke patients from both centres. Seventy percent of the Malaysian patients had either transthoracic or transoesophageal echocardiography while 74% underwent extracranial carotid ultrasonography, CT angiography, or MR to complete a full cerebrovascular evaluation. The percentages were higher for the Australian cohort with more than 95% of patients having been evaluated with the above investigations. In the cases that have not been adequately investigated, the responsible clinicians made the final decision on the classification category. Other investigations included chest radiography, ECG, fasting lipid profile, fasting glucose, HbA1c, thrombophilia screen and immunologic studies (anti-nuclear, anti-DNA and anti-ENA antibodies) were also performed in patients as clinically indicated.

The stroke events were classified according to the TOAST classification.<sup>11</sup> The categories were: (1) Large-vessel atherosclerosis: Atherosclerosis with stenosis; (2) Small-vessel disease: Lacunar syndrome and normal CT/MRI or relevant lesion  $<1.5$ cm and absent source of emboli; (3) Cardioembolism; (4) Other determined causes; (5) Undetermined causes: Two or more causes identified, negative evaluation, or incomplete evaluation.

The salient points to qualify for the relevant criteria were defined as follows:

### *Macroangiopathy (Large-artery atherosclerosis)*

Macroangiopathy was defined as the presence of an occlusion or a stenosis with 50% diameter reduction of a brain-supplying artery corresponding to clinical symptoms and with location and morphology typical of atherosclerosis on Doppler ultrasound or angiography. Diagnostic studies had to exclude potential sources of cardiogenic embolism.

### *Cardioembolism*

Cardioembolism was defined as the presence of a high- or medium-risk source of cardiac embolism as defined in the original TOAST classification.<sup>11</sup> Potential large-artery atherosclerotic sources of thrombosis or embolism had to be absent.

### *Small-vessel disease*

Microangiopathy was defined as the presence of one of the traditional lacunar syndromes (eg, pure motor stroke, pure sensory stroke, sensorimotor stroke, ataxic hemiparesis, and dysarthria-clumsy hand syndrome), infarction(s), less than 1.5 cm of diameter or normal CT/MRI examination and absence of acute cerebral cortical dysfunction. Potential cardiac sources for embolism should be absent, and evaluation of the large extracranial arteries should not demonstrate stenosis of more than 50% in an ipsilateral artery.

### *Other determined etiologies*

This category included spontaneous or traumatic vascular dissections, vasculitis, hematologic disorders, coagulopathies or other relevant diseases. These diagnoses had to be revealed by diagnostic studies such as angiography or blood tests. Cardiac sources of embolism and large-artery atherosclerosis had to be excluded by other studies.

### *Undetermined aetiology*

This category included patients in whom a likely etiology could not be determined despite extensive evaluation, or in whom the treating physician felt that not all necessary investigations have been performed. This category also included cases in which a patient had 2 probable stroke etiologies, and it could not be determined which of them was causative.

### *Statistical analysis*

Student's t-test (for numerical variables) and chi-square test were used for categorical variables. All statistical tests were two-tailed and performed with the Epi Info Version 3.5.1 statistical program. P values  $\leq 0.05$  were regarded as significant. Odds ratio with 95% confidence interval (CI) were used to estimate the effects of each factor.

## **RESULTS**

From January 2007 to March 2008, the Malaysian site accumulated 71 consecutive patients and

recorded 4 deaths. The deceased patients were excluded from further analysis as inadequate investigations were performed and consequently, insufficient information was available. The deaths were categorised within the TOAST classification as "undetermined cause". The Australian series had no mortality. The demographics of the study patients were listed in Table 1. From the patients that were discharged alive (n=67), the mean age of Malaysian patients was  $41.5 \pm 7.4$  years (range 16 to 49 years), while that of the Australian patients was  $40.1 \pm 8.8$  years (range 19 to 49 years). The Male to Female sex ratio of the Malaysian patients was 1.4 : 1, and that of the Australian patients was 1.5 : 1. The ethnic composition of the two study series were listed in Table 1. The 9 non-Caucasians in the Australian series were of Asian origin. Three Malays and one Chinese patient died in the Malaysian series, converting to a case fatality rate of 6%, while no deaths were recorded from the Australian series.

The major risk factors and the comparison of variables between the two young stroke series were listed in Table 2. As shown, the major risk factors for the Malaysian series were: hypertension (65%), diabetes (52.2%), dyslipidemia (37.3%), smoking (22.4%), coronary artery disease (10.4%) and chronic renal impairment (10.4%). The cardioembolic risk factors included bacterial endocarditis and valvular heart disease, occurring in 1.5 to 3%. Major risk factors in Australia were: smoking (44.2%), dyslipidemia (26.2%), hypertension (23%), diabetes (13.1%) and coronary artery disease (6.5%).

Univariate statistical analysis with chi-square test on the distribution of risk factors between the study series demonstrated significantly higher proportions of patients with hypertension (OR 6.42;95% CI: 2.75-15.22) and diabetes (OR=7.25;95%CI:2.78-19.45) in young Malaysian patients. The Australian patients had significantly higher proportions of smokers (OR 2.75;95% CI 1.2-6.37). (Table 2)

As for the atherothrombotic causes of ischaemic stroke, the Malaysian series showed a significantly higher proportion of large vessel atherosclerotic disease and small vessel occlusion by TOAST classification. (Table 3) Conversely, the most common stroke sub-type in the Australian series was strokes with determined aetiology. Of the patients in this category, 7 out of 14 (50%) had vascular dissection (Table 3). In the category of stroke of undetermined aetiology, although the Australian series had higher proportion under this category, it was not statistically significant.

**Table 1: Demographic characteristics of Malaysian and Australian young stroke patients**

	UMMC, Kuala Lumpur, N = 67	Austin Hospital, Melbourne, N = 61
Age (Mean ± SD)	41.5 ± 7.4 years	40.1 ± 8.8 years
Gender	39 males 28 females	37 males 24 females
Distribution of race	Malay = 33 (46.5%) Chinese = 15 (21.1%) Indians = 23 (32.4%)	Caucasian = 52 (85.2%) Non Caucasian = 9 (14.8%)
Distribution of different ages	16-30 years = 5 (7%) 31-40 years = 19 (26.7%) 41-44 years = 15 (21.1%) 45-49 years = 32 (45%)	16-30 years = 10 (16.4%) 31-40 years = 17 (27.9%) 41-44 years = 6 (9.8%) 45-49 years = 28 (45.9%)

**Table 2: Distribution of risk factors and comparison of Malaysian and Australian young stroke patients**

Risk Factor	UMMC, Kuala Lumpur, N = 67 n (%)	Austin Hospital, Melbourne, N = 61 n (%)	Odds Ratio (CI) P value
Hypertension	44 (65.7%)	14 (22.5%)	6.42 (2.75-15.22) 0.0014
Diabetes mellitus	35 (52.2%)	8 (13.1%)	7.25 (2.78-19.45) 0.0007
Dyslipidemia	25 (37.3%)	16 (26.2%)	NS
Previous stroke / TIA	5 (7.5%)	2 (3.3%)	NS
Coronary artery disease	7 (10.4%)	4 (6.5%)	NS
Chronic renal disease	7 (10.4%)	2 (3.3%)	5.2 (1.02-35.87) 0.05
Smoker	15 (22.4%)	27 (44.2%)	2.75 (1.2-6.37)*
Valvular heart disease	2 (3%)	2 (3.3%)	NS
Endocarditis	1 (1.5%)	1 (1.6%)	NS
Prosthetic valves	0	3 (4.9%)	NS
Oral contraceptive pill	1 (1.5%)	5 (8.2%)	NS
Alcohol	2 (3%)	5 (8.2%)	NS

\*In favour of Melbourne series

**Table 3: TOAST classification of subtypes of ischaemic stroke and its comparison in Malaysian and Australian patients**

TOAST classification	UMMC Kuala Lumpur, N = 71* n (%)	Austin Hospital, Melbourne N = 61 n (%)	Odds ratio (95% CI) P value
Large vessel atherosclerosis	19 (28.3%)	6 (9.8%)	3.35 (1.14-10.25) 0.02
Small vessel occlusion	22 (32.8%)	9 (14.8%)	2.59 (1.01-6.79) 0.046
Cardioembolism	9 (12.6%)	13 (21.3%)	NS
Determined Aetiology	4 (5%)	14 (22.9%)	6.75 (1.68-31.46)*
• Radiation vasculopathy	0	1 (1.6%)	NS
• Cerebral venous thrombosis	3 (4.2%)	1 (1.6%)	NS
• Vasculitis	1 (1.4%)	3 (4.9%)	NS
• Vessel dissection	0 (0%)	7 (11.5%)	P=0.01
• Drugs	0 (0%)	1 (1.6%)	NS
Stroke of undetermined Aetiology	18 (26.4%)	19 (31%)	NS

\*Includes 4 deaths in the Malaysian series classified as unknown

NS = not significant

## DISCUSSION

Both the study centres were tertiary referral hospitals and the consecutive cases recruited were reflective of routine clinical practice in the evaluation of young stroke patients within the urban, health care setting of a developed country (Australia) and a major teaching hospital of a middle income developing country (Malaysia).<sup>12</sup> The population of Melbourne, the capital of the state of Victoria was 3.9 million (2006) with 34% born outside Australia.<sup>13</sup> The majority of the population was of European descent, mainly of British, Greek and Italian. The minority Asian populations were mainly ethnic Chinese, Vietnamese, Indian and Sri Lankan. The Asian population has increased in the last two decades. This population demographics was also reflected in the City of Banyule and its surrounding suburbs where the Austin-Repatriation Hospital was located and provided the neurological services. In this location, 70% of the population was under the age of 50.<sup>14</sup> The University of Malaya Medical Centre served the township of Petaling Jaya, Selangor, which has a population of 536 000 (2006), with ethnic distribution of 53.5% Malay, 30.7% Chinese and 14.6% Indian. The

population of Malaysia as a whole was 27.7 millions (2008), with 63.3% within the age strata of 15-64 years.<sup>15</sup>

Previous studies of young adults with ischaemic stroke had varying definitions of the upper limit of “young”, ranging between 30 and 50 years. We opted for a more inclusive age range from 18-49 to make the collected data broadly comparable with majority of other published studies. To our knowledge, there are few previous studies comparing young stroke patients from two different countries. The strengths of this study include a single experienced observer and extensive work-up of the patients. A previous comparative study in 1993<sup>7</sup> noted a larger prevalence of cardioembolic strokes in Thai patients while the Dutch series have a greater prevalence of atherothrombotic disease. However, the major limitation in the study was a high proportion of incomplete investigations in Thailand, with echocardiogram (17.9%), conventional digital subtraction angiography (14.3%) and brain CT (73%) performed in their patients.

The distribution of cardioembolism in our centres were 12.6% (Malaysia) and 21.3% (Australia, Table 3), were of lower range compared

to young ischaemic stroke studies of 14%-54% reported in the West and Asia (Table 4). We also found no significant difference in cardioembolism between Malaysia and Australia. (Table 3) While cardioembolism was the third most common aetiology in Malaysia, it represented 21.3% and the second most common cause in Australia. In the Baltimore-Washington Cooperative Young Stroke Study<sup>18</sup> in USA, cardioembolism accounted for 31.1% of cases, and was the most common aetiology of cerebral infarction in young adults. On the other hand, Ghandehari *et al* from Iran<sup>19</sup> found cardioembolism to be even more important and this accounted for 52% of the aetiology of young stroke. The main cause for cardioembolism in Iran was rheumatic heart disease.

In the Australian series, the most common cause of ischaemic stroke in young adults was "heterogenous" and was classified under the "determined causes of stroke" in the TOAST criteria. Vascular dissection accounted for up to half of these cases, 30% of whom had a history of trauma. On the other hand, there was no case of vascular dissections identified in the Malaysian series. This difference may be due to genetic variations. Studies to identify genetic mutations of recognised connective tissue disorders such as Ehlers-Danlos syndrome<sup>20-22</sup> have been negative. On the other hand, ultrastructural morphological aberrations of dermal connective tissue have been reported in 50% of subjects with spontaneous cervical artery dissections.<sup>23</sup> Social-cultural factors such as more frequent contact sports may also be a factor in the greater proportions of vascular dissections among young ischaemic stroke patients in Melbourne, Australia.<sup>20,21</sup>

In the Malaysian series, small vessel occlusion (32.8%) was the most common subtype of stroke among young adults with cerebral infarction. This finding was consistent with a study in Taiwan by Lee *et al.*<sup>2</sup> which observed that small vessel disease accounted for 22.4% of all young ischaemic stroke, and was more common than large vessel atherosclerotic disease. Other studies which also reported a higher prevalence of small vessel occlusion as compared to large vessel atherosclerosis were from Brazil<sup>4</sup>, Saudi Arabia<sup>5</sup> and within Afro-Caribbean populations in the United States.<sup>23</sup> On the other hand, the South Korean and Western studies recorded higher proportions of large vessel atherosclerotic diseases (Table 4). It should be noted that large vessel atherosclerosis and small vessel occlusion shares the same risk factor profile as observed in a study by Jackson *et al.*<sup>24</sup>

Taken together, the proportion of small vessel occlusion and large vessel atherosclerotic disease were 32.8% and 28.3% respectively in Malaysia, with atherosclerosis accounting for 61.1% of the young stroke patients. The National Health and Morbidity survey in 1996, Malaysia documented that 33 percent of the Malaysian population above the age of 30 years suffered from hypertension.<sup>25</sup> A similar study in Australia estimated that 30% of the population above the age of 25 years had hypertension in 1999-2000.<sup>26</sup> Thus, the overall prevalence of hypertension appeared to be similar between the two countries. The prevalence of diabetes was estimated to be 7.4% in Australians of the same age group.<sup>27</sup> Recent nationwide cross sectional population-based studies in Malaysia estimated the prevalence of diabetes at 15.2% in 2008, which was considerably higher when compared to Australia. Previous Malaysian nationwide surveys in 1996 and 1986 demonstrated a prevalence of 8.2% and 6.3% respectively.<sup>28,29</sup> The Asia Pacific Cohort Collaboration Study also confirmed this rising prevalence of diabetes and its complications, a similar ongoing regional trend which has affected all neighbouring countries.<sup>30</sup>

Overall, there was a higher proportion of patients with conventional atherothrombotic risk factors of diabetes, hypertension associated with related complications such as chronic renal failure among Malaysians as compared with Australians. Furthermore, the background population in Malaysia was also observed to have a rising prevalence of diabetes, reaching twice the prevalence as compared to Australia in the recent years.<sup>28,29</sup> Subjects with diabetes also have a higher rate of hypertension compared to subjects without diabetes.<sup>28,29</sup> Thus, these findings within the background population could partially explain the differences in the proportion of large vessel atherosclerotic disease and small vessel occlusion between Kuala Lumpur and Melbourne in our study.

As the higher prevalence of diabetes in Malaysia as compared to Australia was only seen in the recent years; and there was a lag time for the diabetes to contribute to the development of atherosclerosis; young Malaysians with diabetes as a risk factor may in addition have a greater propensity to developing premature atherosclerotic cerebrovascular disease as compared with Australians. This hypothesis is supported by another comparative study by Ng *et al.*<sup>32</sup> which compared *older* Malaysian and Australian stroke patients. This study demonstrated that 26.4% and 28.1% of all strokes

**Table 4: Distribution of ischaemic stroke subtypes in young adults from hospital based studies**

Year	Country of study	Age range in years	Sample size	Male : Female ratio	Stroke subtype (%)				
					LA A	SVO	CE	ODE	UE
1993	Thailand	17-50	56	2.1 : 1	25*	28	15	32	
	Holland <sup>10</sup>	15-50	55	1.1 : 1	38*	16	31	15	
N = 111									
1994	Saudi Arabia <sup>5</sup>	15-45	70	1.7 : 1	12.9	24.3	17.1	30.0	15.7
1995	United States <sup>16</sup>	15-44	329	1.3 : 1	8.2	21.6	20	24	26
1996	Brazil <sup>4</sup>	15-40	106	1.1 : 1	8.5	12.5	28.3	34.9	16
1996	Mexico <sup>8</sup>	15-40	300	0.9 : 1	3*	24	40	32	
1997	United States <sup>17</sup>	18-44	116	1.1 : 1	16	3	14	44	23
1998	United States <sup>18</sup>	15-44	428	1 : 1	3.8	19.8	31.1	13.3	32
2000	South Korea <sup>6</sup>	15-45	149	3 : 1	20.8	17.4	18.1	26.8	16.8
2002	Taiwan <sup>2</sup>	15-45	241	2.5 : 1	7.9	22.4	19.5	24.5	25.7
2006	Iran <sup>19</sup>	15-45	124	1.1 : 1	9.7*	54	8.1	28.2	
2007	Qatar <sup>7</sup>	15-45	40	4 : 1	–	42.5	–	5	42.5
2007	Spain <sup>9</sup>	15-45	272	–	21	17	26	36	
2009	Malaysia	18-50	71	1.4 : 1	28.3	32.8	12.6	5	26.4
	Australia	18-50	61	1.5 : 1	9.8	14.8	21.3	22.9	31
N=132									

\* studies classified ischaemic strokes as atherothrombotic strokes without specifying LAA or SVO

\*\* present comparative study

LAA = Large artery atherosclerosis; SVO = Small-vessel occlusion; CE = Cardiac embolism; ODE = Other determined aetiology; UE = Undetermined aetiology

in Malaysia can be categorized as large vessel atherosclerotic disease and small vessel occlusion subtypes respectively. In comparison, Australians had a higher proportion of cardioembolic strokes predominantly from atrial fibrillation. There were also significant differences with a higher prevalence of conventional risk factors for stroke in the Malaysian patients, including diabetes, dyslipidemia and smoking in this older cohort

of patients which was performed in 1994. At that time, the prevalence of diabetes between the two countries was observed to vary less widely. The prevalence was 8.6% in Malaysia while Australia had a prevalence ranging from 5.1%-5.4% in the age group above 40 years<sup>32,33</sup> giving weight that Malaysians with diabetes may have a greater propensity to developing atherosclerotic disease. Our study in young Malaysian ischaemic stroke

patients revealed an identical pattern of stroke subtypes in comparison to this earlier study, supported by the wider availability of transcranial Doppler ultrasound, computed tomography (CT) and magnetic resonance (MR) angiography a decade later.

There was disproportionately higher proportions of ethnic Indians among the Malaysian young stroke patients (32.4% vs 14.6% in neighbouring Petaling Jaya) in our present study. A recent study demonstrated that the genetic predisposition of metabolic syndrome among the South Indian population may be specifically related to the Thr54 allele carriers of the Ala54Thr variant of the FABP2 gene.<sup>34</sup> Most Malaysian Indians also originated several generations ago from South India. There was also a recent case-control study by Lipska *et al*<sup>35</sup> identifying metabolic syndrome as an important risk factor in young adults with ischemic stroke in South India.

When comparing with the Australian series, the Malaysian study patients had a higher (6% vs 0%) but statistically non-significant difference in case fatality. Death during acute admission in young stroke patients can be attributed to many factors including the underlying aetiology of stroke and the benefits of more organised stroke care found in Melbourne. On the other hand, severity of the strokes and its related co-morbidities may affect the patient negatively. However, the difference in case fatality should be interpreted with caution, given the small number of patients in both groups. Overall, the main limitation of this study was the small sample size. In addition, there were also differences in the resources available in the two study sites.

In conclusion, this comparative study observed that premature atherosclerosis with large artery disease and small vessel occlusion contributed to the majority of cases of cerebral infarction in younger Malaysian adults with a unique stroke pattern similar to older adults in Malaysia. This proportion was significantly higher when compared to Australia. This can be partly due to higher prevalence of traditional, modifiable risk factors in Malaysia. It is also proposed that Malaysians with these risk factors may be more predisposed to premature atherosclerotic cerebrovascular complications. In the category of determined aetiologies, vascular dissections were more common in Australia. These findings were likely to be related to genetic and socio-cultural factors. Further studies with larger samples sizes and identification of novel risk factors are important in improving the understanding of young adults with ischaemic stroke.

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