The Egyptian Journal of Neurology, Psychiatry and Neurosurgery

RESEARCH

Open Access

Digital subtraction angiography findings of stroke in young adult population: a multi-center record-based study

Kumara Tini[1,2], Eric Hartono Tedyanto[1*], Deddy Andaka[1,2], Nyoman Angga Krishna Pramana[1,3] and I Putu Eka Widyadharma[1]

Abstract

Background Stroke is one of the main causes of disability, in which nearly 2/3 of survivors experience disability and interferes with the patient's daily functional activities. Hypertension, dyslipidemia, obesity, and smoking habits are the main causes of stroke in young adults. Vascular abnormalities are also risk factor for stroke in young adults. Advanced imaging examinations such as cerebral digital subtraction angiography (DSA) can provide a clear picture of the vasculature of the blood vessels of the human brain and provide a real-time picture of the hemodynamic status, blood flow and collateral circulation of the cerebral vessels.

Results There were approximately 999 patients who had DSA cerebral examination during the study period. The total young adult population was 147 [92 males (62.4%) and 55 females (37.6%)]. There were 82 patients with ischemic stroke (60.7%). The main etiology of ischemic stroke in this study was intracranial atherosclerotic disease (ICAD) [44 (53.65%)]. The young adult population had 53 hemorrhagic stroke patients (39.3%). The main cause of hemorrhagic stroke is hypertensive vasculopathy (41.5%), followed by a ruptured cerebral arteriovenous malformation (CAVM) (37.7%). There were 12 patients with cerebral sinus venous thrombosis (CSVT). Headache is the main complaint of patients with venous stroke, followed by seizures and hemiparesis. The transverse sinus is the most common site for occlusion (66.7%).

Conclusion This study describes the characteristics and prevalence of stroke in young adults based on the results of cerebral DSA examination. Stroke in young adults is not uncommon. Several traditional risk factors in old age are now found in young people. Lifestyle modification is needed to reduce the prevalence of stroke in young adults.

Keywords Digital subtraction angiography, Neurointerventional, Stroke, Young adults

Introduction

Stroke is one of the main causes of disability, in which nearly 2/3 of survivors experience disability and interferes with the patient's daily functional activities. The average age of stroke patients is decreasing due to lifestyle and sedentary life in the young population [1]. It is increasingly common to find young people with stroke's risk factor that should normally be found in older populations, such as diabetes, hypertension, dyslipidemia, and others. A bad lifestyle also impacts a person to become obese, which is also a risk factor for stroke [2].

According to a study by Marini and colleagues [3], the prevalence of ischemic stroke is around 20–80%, hemorrhagic stroke is around 3–40%, and subarachnoid hemorrhage is around 10–55%. Based on the AHA/ASA, the prevalence of stroke in young adults

*Correspondence:
Eric Hartono Tedyanto
erichartonoo@gmail.com
[1] Department of Neurology, Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia
[2] Siloam Hospital Denpasar, Bali, Indonesia
[3] Professor Ngoerah General Hospital, Denpasar, Bali, Indonesia

reaches 10–15%, which is quite high [4]. It is also known that the risk factors for stroke in young adults are not much different from those at an older age nowadays. Hypertension, dyslipidemia, obesity, and smoking cessation are the main causes of stroke in young adults. These four risk factors are modifiable risk factors that should be preventable and do not occur in young adults [5].

Hemorrhagic stroke is a type of stroke that is quite common in young adults. Not many studies examine the risk factors for hemorrhagic stroke in young adults. In Asian populations, hypertension is the most common risk factor for hemorrhagic stroke in young adults. Meanwhile, in the European population, vascular malformations are the most common cause of hemorrhagic stroke in young adults. Brain aneurysm and arteriovenous malformation are the main causes of supratentorial bleeding, while cavernous cerebral angioma is the most common cause of infratentorial or brainstem bleeding [6].

Advanced imaging examinations such as cerebral digital subtraction angiography (DSA) can provide a clear picture of the vasculature of the blood vessels of the human brain and provide a real-time picture of the hemodynamic status, blood flow and collateral circulation of the cerebral vessels. DSA can help determine the etiology of stroke, including in young adults so that the management of stroke in young adults can be carried out optimally.

Methods

This multi-center study was taken from medical records of cerebral DSA examination results from January 2019 to December 2021. This study was received an ethical clearance from local ethic committee. All young patients (aged 18–45 years) underwent cerebral DSA examination with complete medical record data, such as age, gender, chief complaint during a stroke, risk factors, stroke diagnosis based on previous imaging (CT scan or head MRI), description of cerebral DSA examination results, and conclusions from DSA examination results were included in this study. Patients with incomplete data were excluded. The data were then extracted and divided into two groups, arterial stroke and venous stroke. Then, arterial stroke is divided into ischemic and hemorrhagic stroke. The data will be processed using the SPSS application version 26 (SPSS Inc, 2019, Chicago, USA). Descriptive analysis of the qualitative data was calculated using the frequency and percentage statistics, while the quantitative data were presented using the mean and standard deviation.

Results

There were approximately 999 patients who had DSA cerebral examination during the study period. The total young adult population was 147 [92 males (62.4%) and 55 females (37.6%)]. The median age in this study was 37 years. Ischemic stroke was the most common type (55.7%), followed by hemorrhagic stroke (36.05%) and vein stroke (8.17%). Large vessel disease was most commonly found in ischemic stroke (36.7%). Carotid artery, M1 and M2 were considered as large vessel, whereas M3, M4 and perforators artery were considered as small vessel. The characteristic results of this research study can be seen in Table 1.

There were 82 patients with ischemic stroke (60.7%). The main etiology of ischemic stroke in this study was intracranial atherosclerotic disease (ICAD) [44 (53.65%)]. Of the 44 ICAD patients, about 22 (26.2%) had total occlusion, and about 14 (16.7%) had mild stenosis. Moyamoya disease is also one of the causes of ischemic stroke in the young population (6.1%). The characteristic of ischemic stroke is shown in Table 2.

There were 53 hemorrhagic stroke patients (39.3%). Age-adjusted prevalence was equally divided between populations aged < 25, 26–35, and 36–45. The main cause of hemorrhagic stroke was hypertensive vasculopathy (41.5%), followed by a ruptured cerebral arteriovenous malformation (CAVM) (37.7%). Normal finding on DSA means that the cause of bleeding was caused by the hypertensive vasculopathy, not a

Table 1 Study characteristics of stroke in young adults

	Number
Sex	
Male	92 (62.4%)
Female	55 (37.6%)
Age	
Median	37 (14–43)
≤ 25 years	23 (15.4%)
26–35 years	35 (24.2%)
36–45 years	89 (60.4%)
Types of strokes	
Artery Stroke	135 (91.83%)
Ischemic stroke	82 (55.7%)
Large vessel disease	54 (36.7%)
Small vessel disease	28 (19.04%)
Hemorrhagic stroke	53 (36.05%)
Intracerebral hemorrhage	45 (30.61%)
Subarachnoid hemorrhage	8 (5.4%)
Vein stroke	
Cerebral venous sinus thrombosis (CVST)	12 (8.17%)

Table 2 Characteristic of ischemic stroke in young adults based on DSA finding

Variable	Number (%)
Sex	
Male	54 (65.8%)
Female	28 (34.2%)
Age	
Mean (SD)	38.42 (36.92–39.91)
Median (SD)	40 (6.8)
≤25 years	3 (3.6%)
26–35 years	13 (15.8%)
36–45 years	66 (80.6%)
DSA findings	
Extracranial	5 (6.1%)
Anterior circulation	5 (6.1%)
Posterior circulation	0 (0%)
Intracranial	77 (93.9%)
Intracranial atherosclerotic disease	44 (53.65%)
Anterior circulation	37 (45.12%)
Posterior circulation	7 (8.53%)
Stenosis	
Mild stenosis	14 (16.7%)
Moderate stenosis	3 (3.6%)
Severe stenosis	5 (6%)
Total occlusion	22 (26.2%)
Small vessel disease	28 (33.3%)
Others	
Moyamoya disease	5 (6.1%)

vascular abnormality. The characteristics of hemorrhagic stroke are shown in Table 3.

This study found CAVM more frequent in men (80%) than women (20%), most commonly found in the < 25 years old population (50%). CAVM was more common in the supratentorial (80%) and anterior circulation (80%). Cerebral aneurysms were more common in women (66.7%) than men (33.3%). In this study, about 55.6% had a high risk of rupture (> 7 mm) and 33.3% were located at ICA supraclinoid.

There were 12 patients with venous stroke or cerebral sinus venous thrombosis (CSVT) in young adults. Age prevalence was most often found in the population aged 36–45 years (41.7%). Headache was the main complaint of patients with venous stroke, followed by seizures and hemiparesis. The transverse sinus was the most common site for occlusion (66.7%). Women (58.3%) had more frequent venous strokes than men (41.7%). The characteristics of vein stroke can be seen in Table 4.

Table 3 Characteristics of hemorrhagic stroke in young adults based on DSA finding

Variable	Number (%)
Hemorrhagic stroke	
Sex	
Male	33 (62.3%)
Female	20 (37.7%)
Age	
Mean (SD)	30.77 (28.41–33.14)
≤25 years	17 (32.1%)
26–35 years	18 (34%)
36–45 years	18 (34%)
Types of hemorrhagic strokes	
Subarachnoid hemorrhage	8 (15.1%)
Intracerebral hemorrhage	45 (84.9%)
DSA finding	
Cerebral aneurysm	9 (17%)
Arteriovenous malformations	20 (37.7%)
Cerebral cavernous malformations	1 (1.9%)
Dural arteriovenous fistula	1 (1.9%)
Normal Finding	22 (41.5%)

Table 4 Characteristic of vein stroke (CSVT) in young adults based on DSA finding

	Number (%)
Age	
≤25 years	3 (25%)
26–35 years	4 (33.3%)
36–45 years	5 (41.7%)
Sex	
Male	5 (41.7%)
Female	7 (58.3%)
DSA finding	
Transverse sinus	8 (66.7%)
Superior sagittal sinus	3 (25%)
Cavernous sinus	1 (8.3%)
Symptoms	
Headache	9
Seizure	5
Hemiparesis	2
Ophthalmoplegia	1
Proptosis	1

Discussion

Stroke in young adults is not rare, accounting for approximately 10–15% of all stroke populations. This study's stroke prevalence in youth was 14.7% (147 per 999).

According to Ekker and colleagues, there has been an increase in the prevalence of stroke in young adults in the past decade, reaching 23%. The increasing prevalence of stroke at this young age needs attention, as the young population is productive age. If there is a functional disability in their lives, it will have an impact on various things [7].

Males are most likely to experience a stroke, both in young adults and in the population as a whole. In this study, the ratio of men and women was 2:1. The most common modifiable risk factor was hypertension, followed by dyslipidemia and smoking. In previous studies, hypertension was known to be a risk factor for ischemic stroke, most often in young adults, around 42%. Apart from hypertension, obesity and diabetes mellitus were also a scourge for the young population. A study by Mitchell and colleagues stated that obesity was strongly associated with the risk of ischemic stroke in young adults (odds ratio 1.65) [8, 9]. This was consistent with the findings in our study, where the most common risk factor found based on data from medical records from DSA examination results was hypertension, which was around 66.7%. Several risk factors usually found in the older population are now more common in the younger population. This was related to a lifestyle that is not good with sedentary life habits in young adults. Everything is now being helped by technology, making the young population increasingly live a bad lifestyle. This becomes a concern in preventing stroke by educating the importance of lifestyle modification from an early age [10].

While there are modifiable risk factors, there are also non-modifiable risk factors, such as vascular disorders. Vascular disorders are closely related to a person's genetic predisposition to experience vascular abnormalities. The most common examples of vascular abnormalities are CAVMs and cerebral aneurysms. In this study, CAVM findings on DSA examination results were around 37.7%, the second most common cause of hemorrhagic stroke after hypertensive vasculopathy. Normal findings on DSA results indicate that the bleeding is due to a hypertensive vasculopathy. Other findings from DSA were cerebral aneurysm, CCM, and DAVF. The prevalence of stroke in young adults in this study reached 39.3%, very far from the prevalence of stroke at an older age (about 10–20%) [11]. Apart from vascular abnormalities, which usually rupture and are found in young adults, shifts in risk factors such as hypertension which are usually found in older ages, are now more common in younger ages, thus making the prevalence of hemorrhagic stroke in young adults higher than the older ages. This high prevalence rate of hemorrhagic stroke requires a more optimal management strategy. A cerebral DSA examination is necessary to determine the presence of vascular malformation. Several conditions may be performed Actions after cerebral DSA examination, for example, embolization of the CAVM or coiling of a cerebral aneurysm to prevent recurrent rupture [12].

Venous stroke, or cerebral sinus venous thrombosis (CSVT), is relatively rare, ranging from 0.5 to 1% of strokes. Women are more common than men experiencing CSVT. Diagnosis of CSVT is often delayed because of unclear presentations. Because the pathophysiology of CSVT is increased intracranial pressure, the main clinical presentation of CSVT is headache (90%), followed by seizures (40%) [13]. This study also found that headache is the common presentation, followed by seizure, hemiparesis, ophthalmoplegia, and proptosis. CSVT is rare but should not be underestimated. Cerebral DSA examination can also help diagnose CSVT, where you can immediately see the flow of cerebral sinuses in real time.

Cerebral DSA is an advanced diagnostic imaging technique that can visualize the cerebral blood vessels with a diameter of 4–5 mm, even the ophthalmic arteries with a diameter of 1 mm. Cerebral DSA is the gold standard in assessing a cerebrovascular disorder [14]. In real-time, cerebral DSA can show the physiology of cerebral blood flow and the collateral system, whether it is good or not, so cerebral DSA is also the gold standard for detecting the occlusion of blood vessels. In vascular abnormality, such as CAVM, cerebral DSA examination is superior to CT or MR angiography of the head. Cerebral DSA can visualize the flow status of the CAVM, where is the feeding source of the artery, whether there is an intranidal aneurysm or not, and can also see the venous drainage, whether to the superficial veins or deep veins, with a sensitivity value of nearly 100%, which will later determine this status. CAVM's next action. CT or MR angiography cannot visualize this clearly [15, 16]. Cerebral DSA examination is very necessary for evaluating the cerebral blood vessels to determine the etiology of stroke, especially stroke in young adults, wherein several studies, including this study, one of the main causes of ischemic stroke is vascular occlusion and in bleeding stroke is vascular abnormality.

Mortality of stroke in young adults reaches 20%. Primary prevention is the most important strategy in reducing the prevalence of stroke in young adults [3]. Educating about the importance of changing lifestyles is very important so that risk factors that are normally found in old age do not shift to a younger age. The etiology of stroke in young adults must be adequately identified and controlled [17].

Conclusion

This study describes the characteristics and prevalence of stroke in young adults based on the results of cerebral DSA examination. Stroke in young adults is not uncommon. Several traditional risk factors in old age are now found in young people. Lifestyle modification is needed to reduce the prevalence of stroke in young adults. Cerebral DSA examination is the gold standard in determining stroke etiology in young adults.

Abbreviations

AcommA	Anterior communicating artery
CAVM	Cerebral arteriovenous malformation
CCM	Cavernous cerebral angioma
CVST	Cerebral venous sinus thrombosis
DSA	Digital subtraction angiography
ICA	Internal carotid artery
MCA	Middle cerebral artery
PcommA	Posterior communicating artery
SD	Standard deviation
VA	Vertebral artery

Acknowledgements

We would like to thank Department of Neurology, Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia, for support in conducting this research.

Author contributions

KT: conception and design, critical revision of the article for important intellectual content, final approval of the article. EHT: drafting of the article. DA: conception and design. NAKP: drafting of the article. IPEW: critical revision of the article for important intellectual content, final approval of the article.

Funding

No funding sources.

Availability of data and materials

Data will be made available upon the request to the corresponding author on editor's request.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethical Committee of Faculty of Medicine, Udayana University (Number 2023.02.1.0811). Informed consent was obtained from the participants after explaining the study aims and outcomes. The identity of the subjects was ensured and the results were stored in a secure place with access only to the main author of this study.

Consent for publication

Not applicable.

Competing interests

No competing interests.

Received: 15 June 2023 Accepted: 6 December 2023
Published online: 18 December 2023

References

1. Smajlović D. Strokes in young adults: epidemiology and prevention. Vasc Health Risk Manag. 2015;11:157–64.
2. Harsha Kumar HN, Kalra B, Goyal N. A study on stroke and its outcome in young adults (15–45 Years) from coastal South India. Indian J Commun Med. 2011;36(1):62–5.
3. Marini C, Russo T, Felzani G. Incidence of stroke in young adults: a review. Stroke Res Treat. 2011. https://doi.org/10.4061/2011/535672.
4. Smajlovic D, Salihovic D, Ibrahimagic OC, Sinanovic O. Characteristics of stroke in young adults in Tuzla Canton Bosnia and Herzegovina. Coll Antropol. 2013;37:515–9.
5. George MG. Risk factors for ischemic stroke in younger adults a focused update. Stroke. 2020;51:729–35.
6. Tatlisumak T, Cucchiara B, Kuroda S, Kasner SE, Putaala J. Nontraumatic intracerebral haemorrhage in young adults. Nat Rev Neurol. 2018;14(4):237–50.
7. Ekker MS, Verhoeven JI, Vaartjes I, Van Nieuwenhuizen KM, Klijn CJM, De Leeuw FE. Stroke incidence in young adults according to age, subtype, sex, and time trends. Neurology. 2019;92(21):e2444–54.
8. George MG, Tong X, Bowman BA. Prevalence of cardiovascular risk factors and strokes in younger adults. JAMA Neurol. 2017;74(6):695–703.
9. Mitchell AB, Cole JW, McArdle PF, Cheng YC, Ryan KA, Sparks MJ, et al. Obesity increases risk of ischemic stroke in young adults. Stroke. 2015;46(6):1690–2.
10. Aigner A, Grittner U, Rolfs A, Norrving B, Siegerink B, Busch MA. Contribution of established stroke risk factors to the burden of stroke in young adults. Stroke. 2017;48(7):1744–51.
11. An SJ, Kim TJ, Yoon BW. Epidemiology, risk factors, and clinical features of intracerebral hemorrhage: an update. J Stroke. 2017;19(1):3–10.
12. Shaligram SS, Winkler E, Cooke D, Su H. Risk factors for hemorrhage of brain arteriovenous malformation. CNS Neurosci Ther. 2019;25(10):1085–95.
13. Stack CA, Cole JW. The clinical approach to stroke in young adults. Stroke. 2021. 53–78 p.
14. Raman A, Uprety M, Calero MJ, Villanueva MRB, Joshaghani N, Villa N, et al. A systematic review comparing digital subtraction angiogram with magnetic resonance angiogram studies in demonstrating the angioarchitecture of cerebral arteriovenous malformations. Cureus. 2022. https://doi.org/10.7759/cureus.25803.
15 Lee SJ, Liu B, Rane N, Mitchell P, Dowling R, Yan B. Correlation between CT angiography and digital subtraction angiography in acute ischemic strokes. Clin Neurol Neurosurg. 2021;200:106399.
16. Chowdhury AH, Ghose SK, Mohammad QD, Habib M, Khan SU, Rahman KM. Digital subtraction angiography is superior to magnetic resonance angiography in diagnosis of cerebral arteriovenous malformation. Mymensingh Med J. 2015;24(2):356–65.
17. Naess H, Waje-Andreassen U. Review of long-term mortality and vascular morbidity amongst young adults with cerebral infarction. Eur J Neurol. 2010;17(1):17–22.

Publisher's Note