EFFECTS OF CEREBRAL COLLATERAL (DSA CEREBRAL ANGIOGRAM) ON CLINICAL PRESENTATION AND NEUROLOGICAL IMPROVEMENT IN ISCHAEMIC STROKE

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ABSTRACT:

Background:
DSA (digital subtraction angiography) remains the gold standard in assessing the status of cerebral collaterals. Several studies have shown that the presence of good collateral circulation in ischemic stroke patients is associated with better functional outcomes with reduction of morbidity and mortality. Therefore, in this study, we aimed to assess the correlation between the collateral status seen on DSA cerebral angiogram with the clinical presentation of stroke and patients' functional outcomes.
Method:
We recruited a cohort of ischemic stroke patients who underwent DSA and collected demographic data, stroke risk factors and clinical data, which includes the National Institutes of Health Stroke Scale (NIHSS) scores, at time of admission. We assessed the collateral status and its grading using DSA and categorized based on established criteria. Subsequently we followed up the patients up at 3 months post stroke event to assess their functional outcomes using the modified Rankin Scale (mRS).
Results:
There was a significant association between good collateral status and favourable outcome in ischaemic stroke patients ($p < 0.05$).
We also found that, there is correlation between the NIHSS (upon discharge) and neurological outcome (MRS at 90 day) with Spearman correlation coefficient of 0.849.
Conclusion:
In conclusion, cerebral collateral status has the ability to prognosticate the functional outcome of ischemic stroke patients.
Keywords:
angiography, digital subtraction, clinical outcome, ischaemic stroke, modified Rankin scale

INTRODUCTION:

'Time is brain' is a very well-known phrase is stroke management strategy emphasizing early management of stroke in term of recanalization of the blocked vessel and to restoring blood flow to the ischemic brain but not yet infarcted. This can be established by means of thrombolytic agents or endovascular thrombectomy. In recent years, another new concept has emerged where 'time is brain', but collateral set the pace'. In other words, the presence of good cerebral collateral will help to sustained blood flow and the brain perfusion immediately after the event of ischaemic stroke, even before the treatment commenced. With further additional help of medical recanalization (intravascular thrombolysis or endovascular thrombectomy) the final core infarcted area will even further reduce. Subsequently, this will further limit the brain damage and subsequently result in fewer and less severe long-term morbidity for the patient [1].

Opposing to the traditional assumption that collateral vessels only develop over time in chronic stenotic condition, there is an observable phenomenon that collateral network develops immediately in acute arterial stenosis or occlusion. This is activated by fluid shear stress, which occurs between the territories of stenotic/occluded arteries and those fed by surrounding intact arteries [2]. Besides that, good collateral status primes to higher recanalization rate, smaller infarction volume and better neurological outcome[1,13.] In their later study, they also found that a well-developed collateral flow can lower the rate of haemorrhagic transformation after thrombolytic and/or endovascular therapies [3].

METHODS:

Written ethical approval and permission were obtained from The Ethics Committee for Research involving Human Subjects of University Putra Malaysia (JKEUPM). We recruited a cohort of ischemic stroke patients who underwent DSA in Hospital Sultan Abdul Aziz Shah, UPM (HSAAS) from 1st January 2021 until December 2022. Acute ischaemic stroke patients who do not have DSA cerebral angiogram performed, stroke patient of other causes and incomplete data were excluded. We collected demographic data, stroke risk factors and clinical data, which includes the National Institutes of Health Stroke Scale (NIHSS) scores, at time of admission. We assess the collateral status and its grading using DSA and categorized patients into good or poor collateral status groups based on established criteria. Subsequently we followed up the patients up at 3 months post stroke event to assess their functional outcomes using the modified Rankin Scale (mRS). We compared between the NIHSS scores (upon discharge) and 3-month mRS scores with the cerebral collateral grades using appropriate statistical tests.

Design

The patient's demographic data and clinical outcome are taken from the hospital database (Shivam and PutraHis). Data regarding the patient age, gender, underlying co-morbid, NIHSS and MRS information were collected. The DSA images were retrieved from the Picture Archiving and Communication System (PACs) Radiology Department in HSAAS. The scoring and grading of DSA cerebral was done by a radiologist who was blindfolded to the patient's clinical presentation information as well as the outcome at 90 days.

The cerebral collateral scoring was done based on The American Society of Interventional and Therapeutic Neuroradiology (ASITN/SIR) classification. The grades then further categorized into poor and good collaterals for analyse purposed; Grade <3 is regards as poor whereas >2 is regards as good, shown in Table 1.

Statistical analysis

Data were collected and analysed by using SPSS (Statistical Package for the Social Science, version 20, IBM, and Armonk, New York). Quantitative data were expressed as mean ± standard deviation (SD). Nominal data were given as number (n) and percentage (%). Chi-Square test was implemented on such data. Predictors of functional outcome were determined by logistic regression analysis using Spearman correlation.

Results

A total of 68 samples were analysed in this study and had met both inclusion and exclusion criteria. The calculated mean for age was 62.78 years old. The majority of patients (48(70.6%)) were male. Only 8 patients (11.7%) who presented with AIS have no underlying medical problems whereas the remaining 60 patients (88.3%) have underlying medical problems namely hypertension, diabetes mellitus, dyslipidaemia, IHD and AF. Majority of patient 66.2% has underlying hypertension.

Table 2 shows no significant difference of patient demographic which includes age, gender, co morbidities with the cerebral collateral status. The p value of the age is 0.472 and gender =0.384 which are statistically not significant; $p > 0.05$. For co-morbidities such as history of CVA and atrial fibrillation (p=1.0), hypertension (p=0.430), diabetes mellitus (p=0.951), dyslipidaemia (p=0.102), ischaemic heart disease (p=0.419); there are also found to be statistically not significant; $p > 0.05$.

Based on Chi-Square test, there is correlation between the cerebral collateral and neurological outcome (MRS at 90 day) as shown in Table 3. The association between cerebral collateral and MRS score is statistically significant with p=0.009 which is smaller than the significant value ($p<0.05$). Based on Chi-Square test, there is correlation between the NIHSS (upon discharge) and neurological outcome (MRS at 90 day), as shown in Table 4. The association between cerebral collateral and MRS score is statistically significant with p=0.002.

Table 5 shows correlation between the NIHSS (upon discharge) and neurological outcome (MRS at 90 day). Based on Spearman rank correlation, the Spearman correlation coefficient is 0.849 which indicates a strong positive correlation between the NIHSS and modified Rankin score (mRS) at 90 days.

DISCUSSION:

The current approach in treating acute stroke primarily by restoring cerebral blood flow to prevent patients from experiencing permanent neurological impairments caused by an ischemic event in the affected part of the brain. This can be established by recanalization, be it by medical thrombolysis or mechanical thrombectomy. In the recent years, cerebral collateral has been discussed as key factor to successful reperfusion therapy.

Based on our results, we are able to demonstrate the significant association between cerebral collateral status and the neurological outcome. This further strengthen the previous study [1,4,5,6,7,8,11,15]. We then proceeded with the Spearman correlation to further assess the correlation. Result shows negative correlation between these two parameters; where good collateral score given at presentation will produce lower mRS - good functional outcome.

Another significant correlation that was found in this study is between the NIHSS (upon discharge) and the clinical outcome (p value is <0.02). This means that NIHSS (upon discharge) can predict the neurological outcome. Spearman correlation coefficient of 0.849 indicating high correlation and suggests a strong relationship between these two variables. In simple word, high NIHSS with predict high MRS (poor functional outcome). This is similar to previous records [1,9,10,12,14], where NIHSS score post admission day 7 of at least 6, can anticipates a poor long-term outcome after stroke. Possible explanation

is that those high NIHSS already has larger ischaemic area whereas those with lower NIHSS will have smaller ischaemic area. Larger ischaemic area with subsequently lead to more long-term disability or death. However, we need not to consider this as only dependent factor as there are other multiple additional factors which would determine the outcome. This further emphasize that, those who has higher NIHSS should be handle promptly. The ability to detect early stroke and the early commencement of treatment may cause reperfusion of the brain and prevent further brain injury. According to American Heart Association (Guidelines for the Early Management of Patients with Acute Ischemic Stroke: 2019), a cut off value for NIHSS score in commencing thrombolytic agent and endovascular thrombectomy is when NIHSS > 6. Score > 6 indicates a moderate to severe stroke. As mentioned earlier in the discussion, those with higher NIHSS score are at increased risk of poor outcomes, such as disability or death. Therefore, prompt recanalization therapy is crucial to improve their chances of recovery.

Nevertheless, it's important to note that the decision to treat a patient with stroke is based on a variety of factors, not just the NIHSS score. Other factors such as the time since symptom onset, the patient's age and medical history, and imaging findings are also taken into consideration when determining the appropriate treatment approach. For an effective stroke management approach, it is crucial to begin with a comprehensive strategy that includes early recognition and accurate diagnosis in the out-of-hospital setting, followed by continued care in the emergency department and throughout the inpatient admission process. As such, it is imperative for personnel such as Emergency Medicine and Trauma Service (EMTS) professionals, Medical Emergency Coordination Centre (MECC) or Ambulance Dispatch Centre (ADC) staff, pre-hospital care responders, and emergency department (ED) personnel to be well-equipped with the necessary skills and knowledge to promptly identify stroke cases and provide appropriate care. In term of hospital management, a dedicated stroke team in essential in making sure that the flow of patient treatment is smooth and effective in order to salvage the brain tissue (CPG Management of Stroke 2020).

Based on our result, we can see that some of the result shows discrepancies from some of the previous study. This may be attributed to a small sample size due to selection bias as this study is conducted in a new tertiary referral centre. Furthermore, a small sample size may not be sufficient to analyse the subtle differences among various factors that being studies and further contribute to inconsistent result with no significant outcome.

CONCLUSION:

Our study has shown that good collateral status is associated with good functional outcome supporting the previous established study. Therefore, identifying cerebral collateral need to be highlight in the management of acute ischaemic stoke. Also, in this study, NIHSS is one of the significant indications of neurological outcome. Hence, accurate assessment of NIHSS is mandatory during the initial presentation of stroke. The ability to triage the patient accordingly based on NIHSS can helps the physician to initiate treatment in the correct group, hoping that this will helps to improve the functional outcome of stroke patient.

DATA AVAILABILITY:

Further information regarding the data used for this work can be obtained from the corresponding author upon reasonable request.

FUNDING:

This work received no external funding.

CONFLICT OF INTEREST:

The authors have no conflicts of interest to declare and are in agreement with the contents of the manuscript.

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TABLE LEGEND:

Table 1: Cerebral collateral scoring and grade

Grade	Angiographic collaterals (Digital subtraction angiography)	Category
0	No collateral visible to the ischaemic site	Poor
1	Slow collaterals to the periphery ischaemic site with persistence	
2	Rapid collaterals to the periphery of ischaemic site with persistence some of the defect and to only a portion of the ischaemic territory	
3	Collaterals with slow but complete angiographic blood flow of the ischaemic bed by late venous phase	Good
4	Complete and rapid collateral blood flow to the vascular bed in the entire ischaemic territory by retrograde perfusion	

Table 2: Patient demographic according to collateral status.

Demographic	**Good collateral status (n= 22)**	**Poor collateral status (n=46)**	**P value**
Age	60.91±17.38	63.67±13.36	0.472
Sex			
Male	14 (63.6)	34 (73.9)	0.384
Female	8 (36.4)	12 (26.1)	
Co-morbidities			
CVA-HX	0 (0.0)	1 (100.0)	1.000
HPT	16 (72.7)	29 (63.0)	0.430
DM	10 (45.5)	19 (41.3)	0.951
Dyslipidemia	14 (63.6)	18 (39.1)	0.102
IHD	7 (31.8)	9 (19.6)	0.419
AF	2 (9.1)	(10.9)	1.000

Table 3: Association between the CC category with neurological outcome (MRS 90 days).

Cerebral collateral	**MRS (n, %)**		χ^2	**P value**
	Poor	Good		
Poor (n, %)	32, 69.6%	14, 30.4%	6.773	0.009*
Good (n, %)	8, 36.4%	14, 63.6%		

*Significant at $p<0.05$ (Chi-square)
-Percentage within CC category.

Table 4: Association between the neurological outcome with NIHSS.

MRS	**NIHSS (n, %)**		χ^2	**P value**
	Low	High		
Poor (n, %) Good (n, %)	5 (26.3) 14 (73.7)	35 (71.4) 14 (28.6)	11.504	0.002*

*Significant at p<0.05 (Chi-square)
-Percentage within NIHSS category.

Table 5: Spearman rank NIHSS and modified Rankin score (mRS).

			NIHSS	**Modified rankin score test person**
Spearman's rho	**NIHSS**	Correlation coefficient	1.000	0.849**
		Sig. (2-tailed)	.	0.000
		N	64	64
	Modified Rankin score test person	Correlation coefficient	0.849**	1.000
		Sig. (2-tailed)	0.000	.
		N	64	68

** Correlation is significant at the 0.01 level (2-tailed).