MJMR, Vol. 34, No. 2, 2023, pages (1-8)

Open Access
ISSN:2682-4558

Research Article

Evaluation of Infarction Pattern in Patients with Symptomatic Intracranial Atherosclerosis: TCCD and MRI Study

Nourhan Ali Shamardn[1], Nermin Aly Hamdy[1], Mohamed Abdelfattah Yehia[1], Haytham Mohammad Abdelhamid[2], Mohamed Mahmoud Abdelkader[1] and Muhammad Mamdouh Ismail[1]*

[1] Department of Neurology, Faculty of Medicine, Minia University
[2] Department of Neurology, Faculty of Medicine, Cairo University

DOI: 10.21608/mjmr.2023.193659.1348

Abstract

Background: Intracranial atherosclerosis - or intracranial atherosclerotic disease (ICAD) - is a dynamic disease characterized by progressing atherosclerotic plaques in major intracranial arteries. Patients with ICAD have a 10 - 20% annual risk of stroke. This study aims at studying the demographic, clinical and imaging characteristics (emphasizing the infarction pattern) in patients with symptomatic ICAD. This cross-sectional study was conducted during the period between November 2021 and July 2022 on patients with acute ischemic stroke caused by intracranial stenosis recruited from the stroke units of Minia University and Kasr Alainy hospitals. All patients were subjected to complete history taking, general examination and meticulous neurological examination. All patients were subjected to brain MRI examination and vascular duplex scanning of extracranial and intracranial Carotid and vertebrobasilar systems. The research was conducted after the approval of the Ethical Review Committee of Faculty of Medicine, Minia University. **Results:** Forty two patients have been included in this study; 22 males and 20 females ranging in age between 40 to 90 years. Hypertension was the most common risk factor (59 %). The NIHSS ranged from 2 to 20. MCA was the commonest artery to be symptomatically stenotic (42.9%). Territorial pattern was the dominant pattern (59.5%) especially in the anterior circulation, and had the highest NIHSS scores. **Conclusion:** MCA was the commonest to have symptomatic ICAD. Territorial pattern was the dominant pattern. Territorial pattern had the highest NIHSS scores.

Keywords: Infarction Pattern, ICAD, TCCD, MRI

Introduction

Intracranial atherosclerosis - or intracranial atherosclerotic disease (ICAD) - is a dynamic disease characterized by progressing atherosclerotic plaques in major intracranial arteries. Risk factors for ICAD include age, ethnicity, hypertension and diabetes mellitus. Patients with ICAD have a 10 - 20% annual risk of stroke. The risk is more serious in patients with (70–99%) degree of stenosis. ICAD now considered as the commonest cause of ischemic stroke worldwide [1, 2, 3, 4, 5].

There are five main imaging modalities for diagnosing ICAD: transcranial doppler (TCD) and transcranial color-coded duplex (TCCD) ultrasonography, computed tomography angiography (CTA), magnetic resonance angiography (MRA), vessel wall magnetic resonance imaging (VWMRI) and conventional angiography. The former 4 modalities are non-invasive, but conventional angiography is invasive.

TCCD is a bedside examination, and not expensive. With MRA brain parenchyma

can also be examined simultaneously, with no contrast or radiation exposure. But CTA still has superior spatial resolution over MRA [6, 7, 8, 9, 10].

Four main patterns of ischemic stroke have been identified in patients with symptomatic ICAD: perforator, territorial, border-zone and mixed [11, 12].

This study aims at studying the demographic, clinical and imaging characteristics (emphasizing the infarction pattern) in patients with symptomatic ICAD.

Patients and Methods

This cross-sectional study was conducted during the period between November 2021 and July 2022 on patients with acute ischemic stroke recruited from the stroke units of Minia University and Kasr Alainy hospitals. Age of patients included was ≥ 40, of both sexes. Patients presented with intracerebral hemorrhage, patients with general medical illness (e. g. liver or kidney impairment), autoimmune vasculitis and malignancies have been excluded. We also excluded patients with poor acoustic window as well as patients with extracranial stenosis ≥ 50%. Diagnosis and quantification of the extracranial stenosis followed Sabeti et al., 2004 [13].

All patients were subjected to complete history taking emphasizing stroke risk factors (e.g. hypertension, diabetes, cardiac disease, smoking and prior stroke or transient ischemic attack), general examination including vital signs and cardiac examination, and meticulous neurological examination and National Institutes of Health Stroke Scale (NIHSS).

Laboratory investigations including complete blood picture, liver and kidney functions, glycated hemoglobin and fasting lipid profile have been done.

All patients were subjected to 1.5 Tesla brain MRI examination including the Diffusion-Weighted Imaging (DWI) for identification of the ischemic insult and its location and pattern; and vascular imaging of extracranial and intracranial carotid and vertebrobasilar systems. Duplex scanning was performed by qualified neuro-vascular operators using Philips iU22 machine. The acoustic windows commonly employed were the trans-temporal and the suboccipital. Diagnosis of the intracranial stenosis followed Baumgartner et al., 1999 [14].

The research was conducted after the approval of the Ethical Review Committee of Faculty of Medicine, Minia University (No. dt-20-470). All patients (or their 1st degree relatives) signed an informed consent for intervention including the advantages, disadvantages, and risks of possible complications.

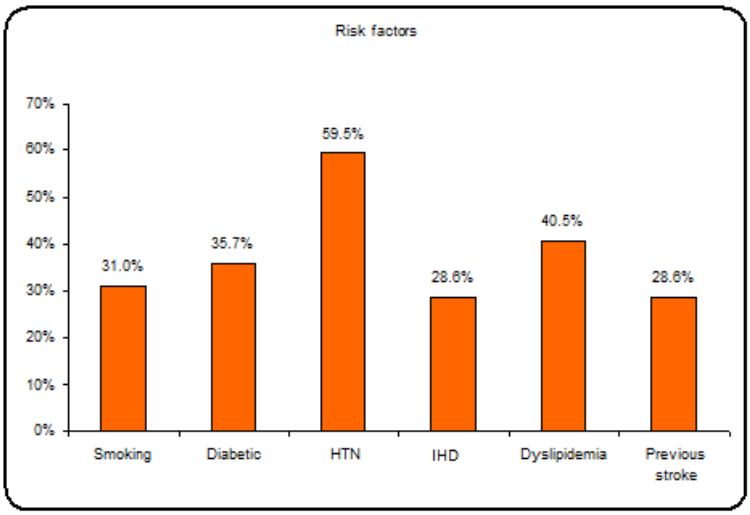
Statistical Analysis

Qualitative data have been presented as number and percentages while quantitative data have been presented as mean, standard deviations and ranges when their distribution was parametric. The comparison between two groups with qualitative data has been done using *Fisher exact test* (the expected count in any cell was less than 5). Comparison between four independent groups with quantitative data and parametric distribution was done with *One WAYANOVA Test.* All statistical calculations were done using computer programs SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 20 for Microsoft Windows. P-value < 0.05 = significant & $P < 0.001$ = highly significant.

Results

Forty two patients have been included in this study; 22 males (52.4%) and 20 females (47.6%). Their ages ranged between 40 to 90 years (mean ± SD = 60.17 ± 13.73). Twenty patients (47.6%) were from Minia and 22(52.4%) were from Cairo.

Figure (1): Distribution of the studied cases according to Risk Factors.



HTN: Hypertension, IHD: Ischemic Heart Disease.

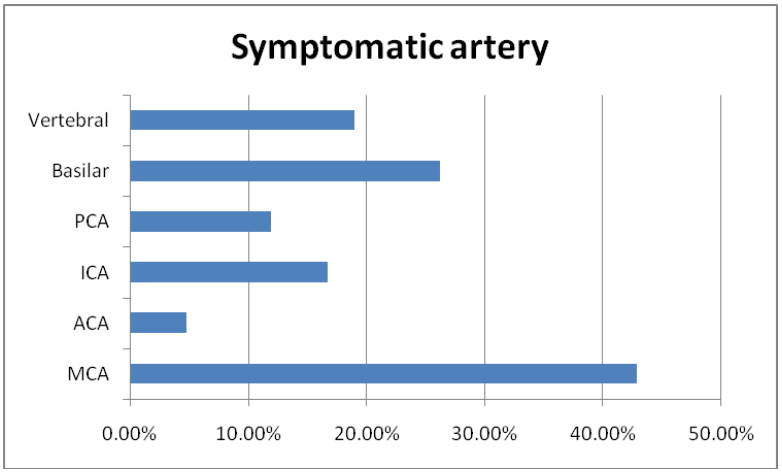
Hypertension was the most common risk factor (59 %), followed by dyslipidemia and diabetes.

The NIHSS ranged from 2 to 20 (with mean11.17 ± 4.75). Language impairment and motor symptoms were the most frequent (83.3% and 81% respectively), while ataxia was the least frequent symptom (14.3%).

Table (1): Distribution of the studied cases according to stenotic arteries.

Stenotic arteries		No.	%
Number of stenotic arteries	Single	12	28.6%
	Multiple	30	71.4%
Symptomatic circulation	Anterior circulation	23	54.8%
	Posterior circulation	18	42.9%
	Both	1	2.4%
ICA	No stenosis	34	81%
	Asymptomatic stenosis	1	2.3%
	Symptomatic stenosis	7	16.7%
MCA	No stenosis	17	40.5%
	Asymptomatic stenosis	7	16.7%
	Symptomatic stenosis	18	42.9%
ACA	No stenosis	35	83.3%
	Asymptomatic stenosis	5	11.9%
	Symptomatic stenosis	2	4.8%
Vertebral	No stenosis	26	61.9%
	Asymptomatic stenosis	8	19%
	Symptomatic stenosis	8	19%
Basilar	No stenosis	26	61.9%
	Asymptomatic stenosis	5	11.9%
	Symptomatic stenosis	11	26.2%
PCA	No stenosis	32	76.2%
	Asymptomatic stenosis	5	11.9%
	Symptomatic stenosis	5	11.9%

Figure (2): Distribution of the studied cases according to which artery is symptomatic.



ICA: internal carotid artery. MCA: middle cerebral artery. ACA: anterior cerebral artery. PCA: posterior cerebral artery.

Most of our patients (71.4%) had stenosis in more than one artery. MCA was the commonest artery to be stenotic (25 patients i.e. 69.6%), among them 18 patient (42.9%) were symptomatic.

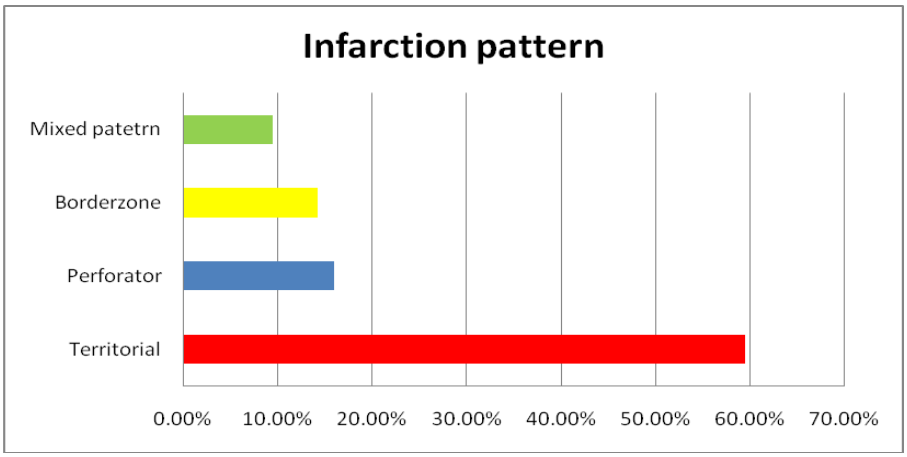
On the other hand, ACA was the least artery to be stenotic (7 patients i.e. 16.7%), among them only 2 patients (4.2%) were symptomatic.

Table (2): Distribution of the studied cases according to Parenchymal imaging findings.

Parenchymal imaging findings		No.	%
Infarction pattern	Territorial	25	59.5%
	Perforator	7	16.7%
	Borderzone	6	14.3%
	mixed	4	9.5%
Infarction site	Cortical	1	2.4%
	Subcortical	20	47.6%
	Combined	21	50.0%
Associated imaging findings	Old infarction	15	35.7%
	SVD	16	38.1%

SVD: small vessel disease

Figure (3): Distribution of the studied cases according to Infarction pattern.



Regarding the infarction site, 20 (47.6%) cases had subcortical infarcts and 21 (50.0%) cases had combined cortical and subcortical infarcts. Only one patient had an isolated cortical infarction. Territorial infarction was the most common pattern (59.5%) followed by perforator, border-zone and the mixed pattern.

Table (3): Comparison between infarction patterns of anterior vs. posterior circulation.

Infarction pattern	Anterior circulation (N=23)	Posterior circulation (N=18)	P value
Territorial	16	9	0.004**
Perforator	0	7	
Borderzone	5	0	
Mixed	2	2	

Territorial pattern was the dominant pattern among those with anterior circulation symptomatic stenosis. But in patients with posterior circulation symptomatic stenosis both territorial and perforator patterns were the most prevalent.

Table (4): Relation between NIHSS and infarction pattern.

		NIHSS		Test value	P-value
		Mean ± SD	Range		
Infarction pattern	Territorial	12.42 ± 4.72	5 – 20	3.220	0.034*
	Perforator	6.57 ± 3.55	2 – 13		
	Borderzone	10.8 ± 2.78	8 – 15		
	Mixed pattern	11.2 ± 4.84	5 - 19		

There was a statistically significant difference between NIHSS scores in different patterns of infarctions; the lowest scores were among those with perforator infarction patterns, while those with territorial pattern had the highest scores.

Discussion

Forty two patients have been included in this study; 22 males and 20 females. Their ages ranged between 40 to 90 years. The most common risk factors seen in our patients were hypertension, dyslipidemia and diabetes. That was in agreement with

López-Cancio et al., 2012 who studied risk factors in patients with asymptomatic ICAD in Spanish population; and Tsivgoulis et al., 2014 who did the same but in patients with symptomatic ICAD in Caucasian population [15, 16]. It was also in agreement with Zürcher et al., 2019 who studied patients with both anterior and posterior circulation ischemic strokes [17].

The NIHSS score ranged from 2 to 20 in our sample. Language impairment and motor symptoms were the most frequent, while ataxia was the least frequent symptom. That could be explained by our results in which MCA was the commonest artery to have symptomatic stenosis; and that was also consistent with Yew and Cheng 2009, who found that dysphasia, dysarthria and hemiparesis were the most common presenting features in patients with ischemic strokes [18].

Regarding the distribution of studied patients according to stenotic arteries, MCA was the commonest artery to be symptomatically stenotic (18 patients); followed by basilar artery (11 patients), and then both the vertebral and internal carotid arteries. That was exactly the same order reported by Banerjee and Chimowitz, 2017 in their review about stroke caused by atherosclerosis of major intracranial arteries [2].
Regarding the infarction pattern, territorial infarction was the most common (59.5%) followed by perforator, borderzone and the mixed pattern. That was in agreement with Kim et al., 2012 who studied 657 patients with ischemic stroke caused by ICAD in a 9-center Korean study. Territorial pattern has been seen in 65.3% of patients, followed by the perforator pattern in 21.0%, then the borderzone and mixed patterns[19]. López-Cancio et al., 2014 also studied 136 patients with symptomatic ICAD. Territorial pattern was the most prevalent in 50.7% of patients, followed by the perforator pattern in 25%, then the borderzone and mixed patterns [12].

In our sample, territorial pattern was the dominant pattern among those with anterior circulation symptomatic stenosis. But in patients with posterior circulation symptomatic stenosis both territorial and perforator patterns were the most prevalent. The higher prevalence of perforator pattern in patient's posterior circulation symptommatic stenosis was also in agreement with the results obtained by López-Cancio et al., 2014 who describes the extension of atherosclerotic plaques to perforators as an important mechanism of ischemia in the posterior circulation [12].

In our study, there was a statistically significant difference between NIHSS scores in different patterns of infarctions; the lowest scores were among those with perforator infarction patterns, while those with territorial pattern had the highest scores. That can be simply explained by larger size of the territorial pattern caused by occlusion of the main intracranial arteries. These results augment findings by Hussain et al., 2018 who studied the correlation between clinical and radiological features of different infarcts patterns. Territorial infarcts were associated with the poorest clinical outcome [20].

Conclusions

MCA was the commonest to have symptomatic ICAD, followed by basilar artery, and then both the vertebral and internal carotid arteries. Territorial pattern was the dominant pattern among those with anterior circulation symptomatic stenosis. But in patients with posterior circulation symptomatic stenosis both territorial and perforator patterns were the most prevalent. Territorial pattern had the highest NIHSS scores.

References

1. Turan TN, Lynn MJ, Nizam A, Lane B, Egan BM, Le NA, Lopes-Virella MF, Hermayer KL, Benavente O, White CL, Brown WV, Caskey MF, Steiner MR, Vilardo N, Stufflebean A, Derdeyn CP, Fiorella D, Janis S, Chimowitz MI; SAMMPRIS Investigators. Rationale, design, and implementation of aggressive risk factor management in the Stenting and Aggressive Medical Management for Prevention of Recurrent Stroke in Intracranial Stenosis (SAMMPRIS)

trial. Circ Cardiovasc Qual Outcomes. 2012; 5(5): e51-60.
2. Banerjee C, Chimowitz MI. Stroke caused by atherosclerosis of the major intracranial arteries. Circ Res. 2017; 120: 502–513.
3. Abd-Allah F, Ibrahim EM, Zidan O, Mohamed MA, Mohamdy AA, Farrag MA, Aboulfotooh AM, Gomaa HA. Screening of asymptomatic intracranial arterial stenosis among high risk subjects: a pilot study from Egypt. Journal of Vascular and Interventional Neurology. 2018; 10(1): 68.
4. Narwal P, Cutting S, Prabhakaran S, Yaghi S. Diagnosis and Management of Active Intracranial Atherosclerotic Disease: A Case Study. Stroke. 2018; 49(6): e221-e223.
5. Beaman C, Yaghi S, Liebeskind DS. A Decade On: The Evolving Renaissance in Intracranial Atherosclerotic Disease. Stroke: Vascular and Interventional Neurology. 2022; 2(6): e000497.
6. Arenillas JF. Intracranial atherosclerosis: current concepts. Stroke. 2011; 42: S20–S23.
7. Bathala L, Mehndiratta MM, Sharma VK. Transcranial doppler: Technique and common findings (Part 1). Ann Indian Acad Neurol. 2013;16(2):174-9.
8. Bang OY. Intracranial atherosclerosis: current understanding and perspectives. Journal of stroke.2014; 16(1): 27.
9. Edjlali M, Qiao Y, Boulouis G, Menjot N, Saba L, Wasserman BA, Romero JM. Vessel wall MR imaging for the detection of intracranial inflammatory vasculopathies. Cardiovascular Diagnosis and Therapy. 2020; 10(4): 1108.
10. Song JW, Wasserman BA. Vessel wall MR imaging of intracranial atherosclerosis. Cardiovascular Diagnosis and Therapy. 2020; 10(4): 982.
11. Liebeskind DS, Cotsonis GA, Saver JL, Lynn MJ, Turan TN, Cloft HJ, Chimowitz MI, Warfarin–Aspirin Symptomatic Intracranial Disease (WASID) Investigators. Collaterals dramatically alter stroke risk in intracranial atherosclerosis. Annals of neurology. 2011; 69(6): 963-74.
12. López-Cancio E, Matheus MG, Romano JG, Liebeskind DS, Prabhakaran S, Turan TN, Cotsonis GA, Lynn MJ, Rumboldt Z, Chimowitz MI, Warfarin-Aspirin Symptomatic Intracranial Disease (WASID) Trial Investigators. Infarct patterns, collaterals and likely causative mechanisms of stroke in symptomatic intracranial atherosclerosis. Cerebrovascular Diseases. 2014; 37(6):417-22.
13. Sabeti S, Schillinger M, Mlekusch W, Willfort A, Haumer M, Nachtmann T, Müllner M, Lang W, Ahmadi R, Minar E. Quantification of internal carotid artery stenosis with duplex US: comparative analysis of different flow velocity criteria Radiology. 2004; 232 (2): 431-9.
14. Baumgartner R, Mattle H, Schroth G. Assessment of ≥50% and <50% intracranial stenoses by transcranial color-coded duplex sonography. Stroke, 1999; 30(1): 87-92.
15. López-Cancio E, Galán A, Dorado L, Jiménez M, Hernández M, Millán M, Reverté S, Suñol A, Barallat J, Massuet A, Alzamora MT, Dávalos A, Arenillas JF. Biological signatures of asymptomatic extra- and intracranial atherosclerosis: the Barcelona-AsIA (Asymptomatic Intracranial Atherosclerosis) study. Stroke. 2012; 43:2712–2719.
16. Tsivgoulis G, Vadikolias K, Heliopoulos I, Katsibari C, Voumvourakis K, Tsakaldimi S, Boutati E, Vasdekis SN, Athanasiadis D, Al-Attas OS, Charalampidis P, Stamboulis E, Piperidou C. Prevalence of symptomatic intracranial atherosclerosis in Caucasians: a prospective, multicenter, transcranial Doppler study. J Neuroimaging.2014;24:11–17.
17. Zürcher E, Richoz B, Faouzi M, Michel P. Differences in ischemic anterior and posterior circulation strokes: a clinico-radiological and outcome analysis. Journal of Stroke and Cerebrovascular Diseases. 2019; 28(3): 710-8.
18. Yew KS, Cheng E. Acute stroke diagnosis. Am Fam Physician. 2009; 80(1): 33-40.
19. Kim JS, Nah HW, Park SM, Kim SK, Cho KH, Lee J, Lee YS, Kim J, Ha SW, Kim EG, Kim DE, Kang DW, Kwon SU, Yu KH, Lee BC. Risk factors and

stroke mechanisms in atherosclerotic stroke: intracranial compared with extracranial and anterior compared with posterior circulation disease. Stroke. 2012; 43(12): 3313–8.

20. Hussain Z, Hilal K, Ahmad M, Sajja d Z, Sayani R. Clinicoradiological Correlation of Infarct Patterns on Diffusion-weighted Magnetic Resonance Imaging in Stroke. Cureus. 2018; 10(3): e2260.