European Review for Medical and Pharmacological Sciences 2015; 19: 2287-2292

The study of the distribution character of cerebral arterial stenosis in patients with ischemic cerebrovascular disease by means of 64 slices CT

P.-Q. WANG[1], A.-P. WANG[1], Z.-H. CAO[1], P. WANG[1], S. WANG[1], G.-B. ZHANG[1]

[1]Department of Neurology, Xiangyang Hospital Affiliated to Hubei University of Medicine, Xiangyang, Hubei, China

Puqing Wang and *Anping Wang* contributed equally to this work

Abstract. – OBJECTIVE: The aim of this study is to investigate the distribution of cerebral artery stenosis in patients with the ischemic cerebrovascular disease.

PATIENTS AND METHODS: One hundred and forty-four patients with ischemic cerebrovascular disease were enrolled and divided into three age brackets, the youth group (18-44 years old, 12 cases), middle-aged group (45-59 years old, 45 cases), and the old-aged group (≥60 years old, 87 cases). They were then ensued the analysis of the distribution of characteristics of cerebral artery stenosis.

RESULTS: A total of 414 pathological vessels had been detected from the 144 patients with arteriostenosis or occlusion, amongst which were 24 single vascular stenosis (16.7%) and 120 multiple stenosis. (83.3%, $p < 0.01$) The incidence of single arteriostenosis was 16.7%, and the multiple arteriostenosis 83.3%. The incidence rate of single intracranial artery stenosis was significantly higher than that of the coexistence of extracranial and intracranial artery stenosis (60.4% vs. 31.3% vs. 8.3%, $p<0.01$). The respective parts that were subject to intracranial and extracranial artery lesions were: a middle cerebral artery and extracranial vertebral artery. The incidence of pure anterior circulation stenosis and anterior and posterior circulation stenosis was significantly higher than that of pure posterior circulation stenosis (83.3% vs 41.7% vs. 22.9%, $p<0.05$, $p<0.01$). The pure intracranial artery stenosis of young and middle-aged group was significantly higher than that of extracranial artery stenosis of the old-aged group (83.8% vs. 75.6% vs. 49.4%, $p<0.05$). The incidence of pure intracranial artery stenosis of the old-aged group was significantly higher than that of the middle-aged group (12.6% vs. 2.2%, $p<0.05$).

CONCLUSIONS: Cerebral artery stenosis in patients with the ischemic cerebrovascular disease was dominated by multiple stenosis. The incidence of intracranial artery stenosis was significantly higher than that of extracranial artery stenosis. The distribution of cerebral artery stenosis varied with age.

Key Words:
Cerebral artery stenosis, 64 slices CT, Anterior and posterior circulation stenosis.

Introduction

It was reported that intracranial and extracranial arteriostenosis caused by cerebral artery stenosis was one of the important reasons for cerebral infarction[1,2]. Cerebral artery stenosis was prone to rupture and would lead to local thrombosis[3-5]. Patients with severe cerebral artery stenosis would run a higher risk of distal embolization, hemodynamic changes, and sudden vascular occlusion. Therefore, the use of antiplatelet and anticoagulant could not contain the high risk of cerebral apoplexy. In terms of the distribution characteristics of cerebral artery stenosis in patients with intracranial and extracranial arteriostenosis, the reports vary owing to different test methods and subjects. We observed and analyzed intracranial and extracranial arteriostenosis of those patients with the ischemic cerebrovascular disease by means of 64 slices CT, the results are as follows.

Patients and Methods

A total of 144 patients, which were hospitalized in our hospital because of ischemic cerebrovascular disease from September 2008 to January 2009 were enrolled in this study. There were 103 male cases, 41 female cases, with an average age of 60.6±11.9 years old. According to the different ages, they were divided into three groups,

Corresponding Author: Guibin Zhang, MD; e-mail: zgb1969@126.com

the youth group (18-44 years old, 12 cases), middle-aged group (45-59 years old, 45 cases) and the old group (age: ≥60, 87 cases). Amongst them were 83 patients with cerebral infarction, 61 with transient ischemic attack, 22 with combined diabetes, 93 with hypertension, 16 with dyslipidemia, 12 with coronary heart disease, 28 with a record of cerebral infarction, 71 with a history of smoking and 50 with a history of drinking. All cases satisfied the diagnostic criteria for transient ischemic attack and cerebral infarction in The Key Points of All Kinds of Cerebrovascular Disease revised on the fourth national conference in 1995, and were confirmed by head CT and MRI.

Inclusion criteria: patients that were diagnosed as new cerebral infarction or new cerebral infarction and received treatment within 7d. Exclusion criteria: age>80, without any symptoms and physical silent cerebral infarction, large-area of cerebral infarction, atrial fibrillation and subacute infective endocarditis, MoyaMoya, and intracranial artery stenosis caused by aorto-arteritis.

Methods

All patients were given blood routine examination, coagulation routine examination, a complete set of biochemical examination, neck, and head CT and (or) MRI, CT angiography. A 64-slice CT, head and neck CT angiography (superior border of arcus aortae reaching calvarium), post-processing techniques, including volume rendering (VR), three-dimensional multiplanar reconstruction (3D-MPR), curve planar reconstruction (CPR) and three-dimensional maximum intensity projection (3D-MIP), combined with original axial images were employed to observe the stenosis extent, occlusion and other characteristics of artery lumen, and also make quantitative measurement on luminal stenosis. Carotid artery CT image and CT angiography image were measured and evaluated respectively by two imaging diagnosis experts by means of the binding method, and imaging results were confirmed by both doctors.

Image Analysis

Artery under observation included common carotid artery (CCA), internal carotid artery (ICA), middle cerebral artery (MCA), anterior cerebral artery (ACA), posterior cerebral artery (PCA), basilar artery (BA), vertebral artery (VA), subclavian artery (SCA). Extracranial arteries included CCA, ICA (E-ICA), VA (E-VA) and SCA. Intracranial arteries included ICA (I-ICA), MCA, ACA, PCA, VA (I-VA) and BA.

Vascular stenosis diagnostic criteria are based on the North American Symptomatic Carotid artery intima test method. Diameterstenosis = (original lumen diameter – residual lumen diameter stenosis)/ original lumen diameter X 100%. There are five levels of vascular stenosis: normal; mild stenosis (≤29%), moderate stenosis (30% to 69%); severe stenosis (70%-99%); obstruction (100%). If there is a series of diseased arteries, calculate with a maximum degree of narrow gauge.

North American Symptomatic carotid endomembrane test was implemented to calculate the rate of arterial stenosis: stenosis = (original lumen diameter-residual lumen diameter on stenosis area) / original lumen diameter ×100%[4]. The degree of stenosis was divided into five degrees: normal; mild (≤29%); moderate (30% - 69%); severe (70%-99%) and occlusion (100%). If there is a series of diseased arteries, calculate with the largest degree of stenosis.

Statistical Analysis

The SPSS11.5 statistic software was adopted (SPSS Inc., Chicago, IL, USA), and X^2 test was used to test enumeration data. $p<0.05$ was considered as statistically significant.

Results

Common Conditions of the Degree of Intracranial and Extracranial Artery Stenosis

Four hundred and fourteen lesion vessels had been detected from the 144 patients with arteriostenosis or occlusion, amongst which were 131 cases of mild stenosis (31.6%), 134 cases of moderate stenosis (32.4%), 104 cases of severe stenosis (25.1%), 45 cases of occlusion (10.9%). The location of the vascular occlusion: 24 in VA (53.3%), 7 in MCA (15.6%), 6 in ACA (13.3%), 4 in PCA (8.9%), 4 in ICA (8.9%).

Distribution of Intracranial and Extracranial Artery Stenosis

Amongst the 144 patients with arteriostenosis or occlusion, 87 cases had single intracranial arteriostenosis (60.4%), 12 cases had single extracranial arteriostenosis (8.3%), 45 cases had coexistence of intracranial and extracranial arteriostenosis (31.3%). The incidence of single in-

tracranial arteriostenosis and the coexistence of intracranial and extracranial arteriostenosis were higher than that of the single extracranial arteriostenosis. The difference was statistically significant ($p<0.01$).

The frequency of intracranial artery lesions and predilection site were listed respectively: 90 cases in MCA (21.7%), 71 cases in I-VA (17.1%), 70 cases in PCA (16.9%), 59 cases in ACA (14.3%), 14 cases in I-ICA (3.4%), 14 cases in BA(3.4%). The frequency of extracranial artery lesions and predilection site were listed respectively: 47 cases in E-VA (11.4%), 26 cases in E-ICA (6.3%), 20 cases of CCA (4.8%), 3 cases in SCA (0.7%).

There were 24 cases of single vascular stenosis (16.7%) and 120 cases of multiple vascular stenosis (83.3%). The incidence of single vascular stenosis was significantly lower than that of the multiple vascular stenosis. The difference was statistically significant ($p<0.01$).

Comparison of the Distribution of Anterior and Posterior Circulation Artery

There were 51 patients with anterior circulation artery (35.4%), 33 patients with posterior circulation artery (22.9%), 60 patients with both (41.7%). The incidence of pure anterior circulation artery and coexistence of the two were significantly higher than that of pure posterior circulation artery. The difference was statistically significant ($p<0.05$, $p<0.01$). Compared with the pure anterior circulation artery, the patients with pure posterior circulation artery decreased significantly, while patients with obstruction increased significantly. The difference was statistically significant ($p<0.05$, Figure 1).

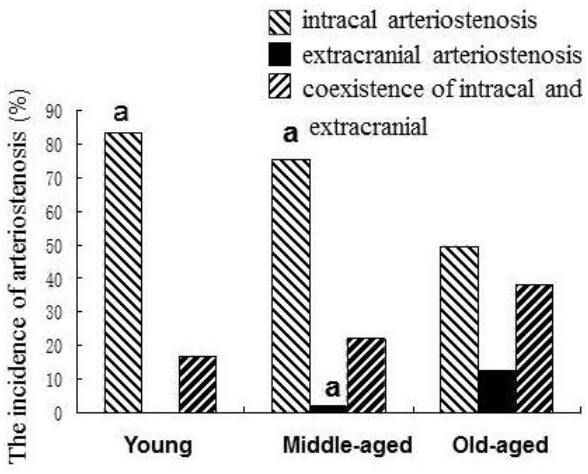

Figure 1. The distribution characteristics of intracranial and extracranial artery stenosis of each age group. Note: compared with the old-aged group, a $p<0.05$

Age Distribution of Cerebral Artery Stenosis

The incidence of pure intracranial artery stenosis in the youth group and the middle-aged group were significantly higher than that in the aged group (83.3% *vs.* 75.6% *vs.* 49.4%, $p<0.05$). The incidence of pure extracranial artery stenosis in the aged group was significantly higher than that of the middle-aged group (12.6% vs. 2.2%, $p<0.05$). The incidence of coexistence of intracranial and extracranial arteriostenosis in the aged group was much higher (37.9%).

Discussion

Previous research has shown that atherosclerosis of the cerebral artery varied with race. The Caucasians were more vulnerable to extracranial carotid artery lesions while the Asians were more vulnerable to intracranial carotid artery lesions[6-9]. In recent years, with the technical development of noninvasive brain artery, and with the increasing studies of cerebrovascular experts, our reports on cerebral arteriosclerosis also have increased annually. Although digital subtraction angiography is internationally recognized as the gold standard of vascular examination, clinical patients still find it quite unacceptable due to its invasion, high price, and relative risk. According to relevant researches, both the sensitivity and specificity of the intracranial vascular occlusion of multi-slice spiral computed tomography are 100%. The sensitivity of intracranial vascular stenosis is (≥50%) 97.1%, specificity 99.5%, and false positive rate 2.4%[10]. Still other studies also revealed that when the vascular flow was slow, the multi-slice spiral computed tomography was more advantageous than digital subtraction angiography in evaluating posterior circulation artery or occlusion lesions[11]. Barlett et al[12] held that multi-slice spiral computed tomography could be a proper alternative to digital subtraction angiography, and it was comparable to digital subtraction angiography in measuring severe stenosis. Therefore, we researched the distribution character of the intracranial and extracranial arteriostenosis by 64 slices CT angiography[13,14] and made a comparison with other researches done by different examination methods.

In this study, it was found out that amongst the 144 patients, the incidence of pure intracranial artery stenosis was significantly higher than that of pure extracranial artery stenosis, indicating that artery stenosis of patients with atherosclerosis ischemic cerebrovascular disease occurred more in intracranial artery. If the incidence of coexistence of intracranial and extracranial arteriostenosis was combined with the incidence of pure intracranial artery stenosis and pure extracranial stenosis, our result was quite close to that of Wang et al[15] under the method of digital subtraction angiography. But the rate of intracranial artery stenosis was higher than our domestic counterpart in comparison. Ma et al[5] and his colleagues found that amongst the 180 patients with cranial artery stenosis and occlusion, pure extracranial artery stenosis accounted for 47.8%, which was significantly higher than pure intracranial artery stenosis 26.9%. After investigating the epidemiology of cerebrovascular stenosis in a certain community, Fan and Huang found out that the intracranial artery stenosis accounted for 62.7%, and the extracranial artery stenosis accounted for 25.5% (Fan CF, Huang YN. Prevalence of cerebral arterial stenosis in 2711 rural community people aged over 40 years in Beijing. Chinese Journal of Geriatric Heart Brain and Vessel Diseases 2007-01). Zhang et al[16] revealed that vasculopathy distributed in extracranial arteries accounted for 49.1%. The remaining was distributed in intracranial arteries. There was no statistical significance of the different distributions. Song et al[17] found out that the incidence of extracranial arterial disease (54.7%) was higher than that of intracranial arterial disease 45.3%. The rate of intracranial and extracranial arterial disease was different from ours, which might be related to the discrepancy in the selection of the observation subjects, the number of samples and the age of the patients. Other studies[18-20] held that the different distribution of intracranial and extracranial arterial disease was related to age. As age increases, the proportion of extracranial artery stenosis would increase accordingly. Moreover, it might also be distinct from other studies concerning the condition of patients. In our research, an effort was predominantly made on patients with mild, moderate and severe ischemic cerebrovascular disease. Most of the studies have neglected the evaluation of the patients' condition, so it shall be given more attention in future work.

Our research revealed that the incidence of pure anterior circulation stenosis was significantly higher than that of pure posterior circulation stenosis. The incidence of coexistence of anterior and posterior circulation stenosis reached 41.7%. This result was consistent with that of Song et al, indicating that the cerebral artery atherosclerosis in patients with the cerebrovascular disease was widespread. During the comparison of anterior and posterior artery stenosis, only the difference of proportion between mild and occlusion had statistical significance.

Our study further analyzed the distribution characteristics of extracranial and intracranial artery stenosis in the different age groups and its trend with age. Results showed that the incidence of pure intracranial artery stenosis in the youth group and the middle-aged group were higher than that in the aged group. The incidence of pure extracranial artery stenosis in the aged group was higher than that in the middle-aged group, and that the incidence of the coexistence of extracranial and intracranial artery stenosis would increase with age. But the difference had no statistical significance. It might be related to the unbalanced number of subjects in the different age groups (sample of the youth group was small). In spite of this, these findings still could be useful, they indicated that the incidence of intracranial artery stenosis would recuse as people grew old, the incidence of pure extracranial artery stenosis and the coexistence of extracranial and intracranial artery stenosis was directly related with age, which means that atherosclerosis of cerebral artery would become more widespread with age. As our country is stepping into the phase of aging of the population, and the proportion of old-aged people is increasing apparently, it is quite possible that the incidence of extracranial artery stenosis will become higher. Age has an influence on extracranial artery stenosis in patients with ischemic cerebrovascular disease, we must pay attention to this fact so that we could detect the asymptomatic carotid artery lesions earlier and take precautions (ICA stent or carotid endarterectomy) to reduce the incidence of secondary ischemic cerebrovascular disease[21-22]. In our research, the incidence of extracranial and intracranial artery stenosis has reached 31.3%, higher than that of our domestic counterpart. Shi et al[23] reported that the incidence of intracranial artery stenosis was 17.1%. We also noticed that the incidence of extracranial and intracranial artery stenosis would increase with age, which would arouse another problem worthy of clinical attention, of intracranial combined extracranial artery lesions and particularly of the diagnosis and treatment of stroke in patients with

carotid artery stenosis caused by series of intracranial artery lesions. The existence of series of intracranial artery lesions makes it harder to tell whether the stroke was caused by carotid artery stenosis or intracranial artery stenosis. Some researchers thought that even patients with the coexistence of intracranial and extracranial artery stenosis overcame carotid artery stenosis by ICA stent or carotid endarterectomy, the risk of stroke was still high[24]. Since Chinese are vulnerable to incidence of coexistence of intracranial and extracranial arteriostenosis, it is quite necessary for us to make a comprehensive evaluation of coexistence of intracranial and extracranial arteriostenosis to ensure that carotid artery stenting could successfully reduce the incidence of stroke. Therefore, patients with the ischemic cerebrovascular disease are always required to accept a clinical cerebrovascular inspection[25,26].

Conclusions

To sum up, a 64 slices CT could accurately reflect the distribution character of the intracranial and extracranial arteriostenosis so that it is more favorable for clinical application. Cerebral artery stenosis in patients with the ischemic cerebrovascular disease is dominated by multiple stenosis. The incidence of pure intracranial artery stenosis is significantly higher than that of pure extracranial artery stenosis. The incidence of pure intracranial artery stenosis would increase with age while the incidence of coexistence of intracranial and extracranial arteriostenosis is in direct relationship with age. Our study still has a few criticism, such as the thinness of the sample and the lack of randomness of the subjects, which may have an influence on our judgment of the relationship between cerebral artery stenosis and the distribution character of age. They are subject to the confirmation of large samples and random contrast that may provide a more comprehensive, accurate and representative information for clinicians.

Conflict of Interest

The Authors declare that they have no conflict of interests.

References

1) Tang B, Zhang H, Jiang L. The correlation between the mouth diameters of leftatrial appendage and stroke risk score in patients with atrial fibrillation. Eur Rev Med Pharmacol Sci 2015; 19: 790-794.
2) Zhao L, Hu FX. α-Lipoic acid treatment of aged type 2 diabetes mellitus complicated with acute cerebral infarction. Eur Rev Med Pharmacol Sci 2014; 18: 3715-3719.
3) Liu CY, Chen CQ. Intra- and extracranial atherosclerotic stenosis in China: epidemiology, diagnosis, treatment and risk factors. Eur Rev Med Pharmacol Sci 2014; 18: 3368-3379.
4) Sahin M, Yazicioglu MV, Acar G, Demir S, Kalkan ME, Ozkan B, Alici G, Akgun T, Akcakoyun M, Boztosun B. Safety of balloon pre-dilatation in the treatment of severe carotid artery stenosis. Eur Rev Med Pharmacol Sci 2013; 17: 788-793.
5) Ma YD, Wang J, Du ZH, Cao XY, Zhou DB, Li BM. Mechanical thrombectomy with Solitaire stent for acute internal carotid artery occlusion without atherosclerotic stenosis: dissection or cardiogenic thromboembolism. Eur Rev Med Pharmacol Sci 2014; 18: 1324-1332.
6) Zhao DL, Deng G, Xie B, Ju S, Yang M, Chen XH, Teng GJ. High-resolution MRI of the vessel wall in patients with symptomatic atherosclerotic stenosis of the middle cerebral artery. J Clin Neurosci 2015; 22: 700-704.
7) Springo Z, Tarantini S, Toth P, Tucsek Z, Koller A, Sonntag WE, Csiszar A, Ungvari Z. Aging exacerbates pressure-induced mitochondrial oxidative stress in mouse cerebral arteries. J Gerontol A Biol Sci Med Sci 2015 Jan 28. pii: glu244. [Epub ahead of print].
8) Osbun JW, Kim LJ. Internal carotid artery stenting for intracranial atherosclerosis. Methodist Debakey Cardiovasc J 2014; 10: 245-250.
9) Zeng W, Wen X, Gong L, Sun J, Yang J, Liao J, Qian C, Chen W, Song B, Gao F. Establishment and ultrasound characteristics of atherosclerosis in rhesus monkey. Biomed Eng Online 2015; 14: S13.
10) Nguyen-Huynh MN, Wintermark M, Enhlish J, Lam J, Vittinghoff E, Smith WS, Johnston SC. How accurate is CT angiography in evaluating intracranial atherosclerotic disease? Stoke 2008; 39: 1184-1188.
11) Bash S, Villablance JP, Jahan R, Duckwiler G, Tillis M, Kidwell C, Sayre, J. Intracranial vascular stenosis and occlusive disease: evaluation with CT angiography, MR angiography, and digital subtraction angiography. AJNR Am J Neuroradiol 2005; 26: 1012-1021.
12) Bartlett ES, Wallters TD, Symons SP, Fox AJ. Diagnosing carotid stenosis near-occlusion by using CT angiography. AJNR Am J Neuroradiol 2006; 27: 632-637.
13) Kuroda Y, Hosoya T, Oda A, Ooki N, Toyoguchi Y, Murakami M, Kanoto M, Sugawara C, Honma T, Sugai Y, Nemoto K. Inverse-direction scanning improves the image quality of whole carotid CT angiography with 64-MDCT. Eur J Radiol 2011; 80: 749-754.
14) Yu XY, Tang WJ, Liu L, Zhu L, Huang BC, Zhao QF, Yin B, Li YX, Geng DY. [Association between clinical ischemic events and carotid calcification evaluated by 64 slices CT angiography]. Zhonghua Xin Xue Guan Bing Za Zhi 2009; 37: 1018-1021.

15) Wang G, Wang Y, Jiang W. The distribution and characteristic of cerebral artery stenosis in patients with ischemic cerebrovascular disease. Chin J Geriatr Heart Brain Vessel Dis 2003; 5: 315-317.

16) Zhang X, Zhang B, Wang X, Tong CG, Qi JX, Guo HY, Hu Y. The analysis of the distribution characteristics of cerebral artery stenosis and dangerous factors. Chin J Cerebrovasc Dis 2010; 7: 467-472.

17) Song G, Wang Y, Dong K, Jiang WJ, Du B, Chen QD. The distribution of cerebral artery stenosis in patients with the ischemic cerebrovascular disease. Chin J Geriatr Heart Brain Vessel Dis 2008; 10: 680-683.

18) Chen Z, Yun W, Zhao J, Xiang HB, Zhang ZQ, Qian CZ, Ding XS. The clinical Analysis of acute cerebral angiogram in patients with a cerebral infraction. Chin J Geriatr Heart Brain Vessel Dis 2009; 11: 12-14.

19) Zhao L, Zhao Y, Zhang H. Effect of stent-assisted angioplasty on cognitive status and serum levels of amyloid beta in patients with intracranial and extracranial artery stenosis. Neuropsychiatr Dis Treat 2015; 11: 471-475.

20) Antonopoulos CN, Kakisis JD, Sfyroeras GS, Moulakakis KG, Kallinis A, Giannakopoulos T, Liapis CD. The impact of carotid artery stenting on cognitive function in patients with extracranial carotid artery stenosis. Ann Vasc Surg 2015; 29: 457-469.

21) Shakur SF, Hrbac T, Alaraj A, Du X, Aletich VA, Charbel FT, Amin-Hanjani S. Effects of extracranial carotid stenosis on intracranial blood flow. Stroke 2014; 45: 3427-3429.

22) Koch S, Bustillo AJ, Campo B, Campo N, Campo-Bustillo I, McClendon MS, Katsnelson M, Romano JG. Prevalence of vertebral artery origin stenosis and occlusion in outpatient extracranial ultrasonography. J Vasc Interv Neurol 2014; 7: 29-33.

23) Shi H, Li D, Li S, Ling F. The analysis of the cause and characteristic of 1000 patients with the ischemic cerebrovascular disease by means of DSA. Chin J Cerebrovasc Dis 2005; 2: 437-440.

24) Zhou Lx, Zhou Y, Hu YH. The incidence of the neck A stenosis, series of intracranial stenosis A, combining other intracranial and extracranial artery stenosis. Chin J Intern Med 2010; 49: 103-106.

25) Nomura S, Inoue T, Ishihara H, Koizumi H, Suehiro E, Oka F, Suzuki M. Reliability of laser speckle flow imaging for intraoperative monitoring of cerebral blood flow during cerebrovascular surgery: comparison with cerebral blood flow measurement by single photon emission computed tomography. World Neurosurg 2014; 82: e753-757.

26) Sacchetti E, Turrina C, Valsecchi P. Cerebrovascular accidents in elderly people treated with antipsychotic drugs: a systematic review. Drug Saf 2010; 33: 273-288.