CLINICAL STUDY OF CARDIAC ULTRASOUND DIAGNOSIS OF CARDIOGENIC EMBOLIC CEREBRAL INFARCTION

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ABSTRACT

Purpose: *This paper aims to conduct a clinical study on the cardiac ultrasound diagnosis of cardiogenic embolic cerebral infarction.*

Methods: *This study performs a retrospective analysis on patients with acute cerebral infarction admitted to Department of Neurology of our Hospital between January 2012 and October 2014. All patients are examined with Toshiba APLL050SSA- 700A Color Doppler ultrasound diagnostic apparatus for carotid artery and vertebral artery ultrasonography.*

Results: *The therapeutic efficiency of cardiogenic cerebral infarction with large infarction size is lower than that of cardiogenic cerebral infarction with small infarction size and lacunar infarction. There is no significant difference in the therapeutic response of cardiogenic cerebral infarction distributed in different circulation areas ($P > 0.05$).*

Conclusions: *Responsible vessel occlusion has no predictive significance for infarct size, but it is helpful to predict the therapeutic effect. The therapeutic effect on responsible vessel occlusion is usually far from satisfactory.*

Keywords: *Cardiac ultrasound diagnosis, Cardiogenic embolic cerebral infarction, Clinical study.*

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Introduction

Stroke can be divided into two categories: hemorrhagic stroke and ischemic stroke, of which the latter can account for 70% -80%. Ischemic stroke includes atherosclerotic cerebral infarction, cerebral embolism, lacunar infarction, and asymptomatic cerebral infarction. Infarction caused by heart-induced emboli is the most common type of cerebral embolism. More than 70% of the emboli produced by the heart are embolized in the brain, which enter into the intracranial artery via the circulatory system to cause acute occlusion, causing acute ischemic necrosis and neurological dysfunction of blood supply area of blood vessels, which is one of the more serious complications of heart disease. It is estimated that by 2030, stroke-induced disability will rank the fourth among all diseases[1]. The latest epidemiological results show that stroke has become the first cause of death in China, posing great economic burden to the country and family. Stroke can be divided into hemorrhagic stroke and ischemic stroke. Cardiogenic cerebral infarction (see Figure 1) is a special subtype of TOAST classification, whose onset time is short but symptoms quickly reach the peak, leaving many sequelae that are serious and easy to recur. It often threatens patients' lives. This type has a high short-term mortality rate and a high recurrence rate in the later period, and the diagnosis of this disease is often made according to the onset time and clinical symptoms. It will be easy to be diagnosed if the patient has embolism at other sites, or risk factors in the heart.

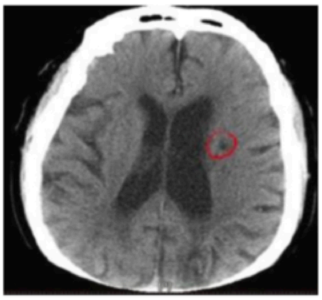

Figure 1: Cardiogenic cerebral infarction.

In elderly patients with a history of cerebral arteriosclerosis such as hypertension, hyperlipidemia, and diabetes for many years, the severe cerebral arterial stiffness and heart disease often coexist,then it will not be easy to make a correct etiological diagnosis for such cases(2). It is particularly important to promptly diagnose the cause of the disease and take favorable measures to intervene in the development of the disease and control the risk factors of the disease so as to prevent recurrence.

According to TOAST's etiological classification, MRI, magnetic resonance angiography (MRA), diffusion weighted imaging (DWI) and other imaging methods can be applied to the diagnosis of acute cerebral infarction and to determine its type(3)). MRA has a sensitivity and specificity of 80% and 100% respectively for the diagnosis of stenosis and occlusion of blood vessels in the brain. According to LEE et al., the accuracy of the final results of the CT / MRI examination is 48% for TOAST subtype analysis. If DWI examination alone is added, the accuracy can reach 83%. If MRA examination alone is added, the accuracy can reach 56%. If both are added, the accuracy can reach up to 94%. When MRA and DWI are performed in patients with large-artery atherosclerosis or arteriolar apoplexy among other acute stroke types, the coincidence degree between emergency diagnosis and final diagnosis is increased to 94%. Therefore, imaging examination method has important significance in the etiology of ischemic stroke. According to the imaging examination method, the imaging features of cardiogenic cerebral infarction can be defined, which can provide help for clinics. At present, there are some imaging studies on the clinical manifestations and predilection site of cardiogenic cerebral infarction in early stage(4).

But there are few analyses combining DWI, especially MRA. The studies on the recurrence of ischemic stroke focus on a unified analysis, and fewer are based on TOAST subtype analysis. There are some reports on cardiogenic risk factors for cerebral infarction recurrence abroad, which are not in line with the situation of patients in China.

Methods

Research object

Diagnostic criteria for acute cerebral embolism in Key Points for Diagnosis of Various Cerebrovascular Diseases are as follows:

- Most of the cerebrovascular diseases have a sudden onset.
- Most of the cerebrovascular diseases have no prodromal symptoms.
- Patients with the cerebrovascular disease often has a clear consciousness or transient consciousness disturbances.
- There are related symptoms and signs of carotid artery system and / or vertebral-basilar artery system.
- The lumbar puncture cerebrospinal fluid often does not contain the blood, if it contains the red blood cells, then the diseases can be regarded as the hemorrhagic cerebral infarction.
- Emboli, whether cardiogenic or non-cardiogenic, have the symptoms of other emboli that occur to other organs, skin and mucous membrane.

TOAST classification criteria: The high and moderate risk factors of cardiogenic cerebral infarction are shown in Table 1. All the selected cases are also in line with the diagnostic criteria for acute cerebral embolism in Key Points for Diagnosis of Various Cerebrovascular Diseases and the cardiogenic cerebral infarction criteria for TOAST classification, which have high and moderate risk factors for cardiogenic cerebral infarction(5).

A total of 58 patients with cardiogenic cerebral infarction admitted to the Department of Neurology of our Hospital from January 1, 2012 to October 31, 2014 are selected as subjects. There are 34males (58.62%) and 24 females (41.38%) aged 49-91 years old with an average age of 73.80±10.06 years old. Cardiac risk factors: There are 46 cases of high-risk factors, wherein there are 37 cases of persistent atrial fibrillation, 4 cases of mitral stenosis with atrial fibrillation, 2 cases of acute myocardial infarction complicated with atrial fibrillation, and 3 cases of hypertrophic cardiomyopathy with atrial fibrillation. There are 12 cases of moderate risk factors, wherein there are 11 cases of simple atrial fibrillation and 1 case of atrial flutter. Among the 58 patients with cardiogenic cerebral infarction, 14 patients have a history of cerebral infarction and all patients have lacunar infarction without obvious sequelae. There are 44 cases with other complications, wherein there are 16 cases of simple hypertension, 5 cases of hypertension complicated with diabetes, 9 cases of hypertension complicated with hyperlipidemia, 4 cases of hypertension complicated with hyperlipidemia and hyperhomocysteinemia, 8 cases of simple diabetes, and 2 cases of diabetes complicated with hyperlipidemia.

Risk factors	The risk factors in
Mechanical artificial valve	Mitral valve prolapse
Mitral stenosis with atrial fibrillation	Mitral annulus calcification
Atrial fibrillation	Mitral stenosis (no atrial fibrillation)
Sinus syndrome	Simple atrial fibrillation
Myocardial infarction (within 4 weeks)	Atrial flutter
Left ventricular segmental dyskinesia	ovale
Left ventricular thrombus	Nonbacterial thrombotic endocarditis
Dilated cardiomyopathy	Congestive heart failure
Infective endocarditis	Myocardial infarction (4-6 months)
Left atrial mucinoma	Atrial septal aneurysm
Left atrial thrombus	Left ventricular segmental dyskinesia
-	Biocardial valve

Table 1: Risk factors of embolic origin of cardiogenic cerebral infarction.

Clinical symptoms: there are no prodromal symptoms, and all have acute onset, with dynamic onset in 21 cases and quiet state in 37 (Asleep) cases[6]. Neurological deficits quickly peak in a short period of time. First symptoms and signs: See Table 2 for details. There are 34 cases (58.62%) with more than two symptoms.

symptoms	hemiplegia	aphasia	Disturbance of consciousness	Have a headache	tic	Hemiasthesia
Example number (%)	49 (84.48)	26 (44.83)	16 (27.59)	4 (6.90)	6 (10.34)	23 (39.66)

Table 2: Clinical symptoms and signs.

Research methods

All patients are examined using Toshiba APLL050SSA-700A color Doppler ultrasound diagnostic apparatus (L8.4 frequency conversion probe) within 5 days after onset of disease. Probe frequency: Carotid artery 4-8MHz; Vertebral artery 4-8 MHz. Sample volume: 1-2mm. The bilateral common carotid artery, the bifurcation of carotid artery, the origin of internal carotid artery, the external carotid artery and the extracranial vertebral artery of patients are examined in supine position.

Patients are selected based on the following diagnostic criteria:

- Level 0: normal;
- Level 1: Carotid artery intima-media thickens and vertebral artery flow velocity decreases;
- Level 2: There are 1-2 plaques in carotid artery, with the diameter of the largest plaque being ≤ 10mm, most of which are hard plaque. Level 3 and above are excluded, including the presence of multiple carotid plaque, mostly soft or mixed plaque; there is a significant stenosis in the carotid lumen.

Routine head MRI plain scan is conducted using Marconi Eclipse 1.5T superconducting magnetic resonance imaging system, with a standard 16-channel head coil, in a sequence including T1WI, T2WI, DWI, and 3D-TOF MRA examination, for about 9 minutes[7]. The specific parameters are shown in Table 3. The MRA detects the entire Willis ring, including the middle cerebral artery, the anterior cerebral artery, the posterior cerebral artery, and the internal carotid artery terminal segment. A CT scan of the skull is performed using a Toshiba Aquilion 64-row multi-spiral CT machine, with a slice thickness of 6.0 mm and an interval of 2.0 mm, 30 mAs, and 120 kV. Some cases are reviewed before the first visit and before discharge.

Experimental test and judgment

The criteria of North American Symptomatic Carotid Endarterectomy Trial are adopted, that is, the diameter of the narrowest part (N) and the diameter of the normal blood vessel (D) at the distal end of the vertebral-basilar artery are measured, which are then applied to the formula: Stenosis rate (%) = (1-N / D) × 100% to calculate stenosis rate. The degree of stenosis is divided into: mild 10%-29%, moderate 30%-69%, severe 70%-99% and completely occluded 100%. In the cardiogenic cerebral infarction group, the cases, which are confirmed by MRA with occlusion of the focus-responsive arteries and the corresponding clinical manifestations of acute intracranial arterial occlusion, are classified as the responsible vessel occlusion subgroup. The cases, which are confirmed by MRA with normal or mild stenosis of the responsible arterial trunk, are classified as the responsible vessel non-occlusion subgroup. The cases with moderate to severe stenosis of the arterial trunk as confirmed by MRA are excluded. The patients who do not meet the diagnostic criteria of TOAST cardiogenic cerebral infarction are classified as non-cardiogenic cerebral infarction group, regardless of whether MRA confirms that the focal responsible vascular trunk is normal, stenotic or occlusive. Single infarction has a single continuous hyperintense focus as shown by DWI; multiple infarction has a discontinuously ≥ 2 hyperintense focus as shown by DWI. According to the infarction site of unilateral MCA blood supply, infarction in the ACA blood supply area, infarction in the blood supply area of the middle cerebral artery (MCA) and simultaneous infarction in the blood supply area of the anterior middle cerebral artery can be divided into divided into cortical infarction, subcortical infarction, and cortical-subcortical infarction. According to the infarct area, the infarction can be divided into: lacunar infarction, with the maximum infarct cross-sectional area of ≤ 1.5 cm2; small-size infarction with the largest infarction cross-sectional area of 1.5 cm2-3.0 cm2; and the large-size infarction, with the largest infarction area> 3.0 cm^2.

The neurological physician uses the National Institutes of Health Stroke Scale (NIHSS) to evaluate the neurological function of patients at admission and before discharge. The therapeutic effect is assessed based on changes in NIHSS scores of patients at discharge and admission, based on Neurological Deficit Scale and Clinical Efficacy Scale of Stroke Patients and in combinations with the present study.

The criteria are as follows:

- Basic recovery: The score of NIHSS is reduced by 91% -100%, and the degree of disability was 0;
- Significant progress: The score of NIHSS is reduced by 46% -90%, and the degree of disability is 1-3;
- Progress: The NIHSS score is reduced by 18-45%;
- Ineffective: NIHSS score is reduced or increased by 17%;
- Deterioration: NIHSS score is increased by more than 18% or the patient dies[8]. (Effective treatment = basic recovery + significant progress + progress)

Result analysis

Infarction area

There are 11 cases of responsible vessel occlusion subgroup, wherein there are 9 cases (81.82%) of large-size infarction, 2 cases (18.18%) of small-size infarction, and no lacunar infarction. large-size infarction accounts for the vast majority. There are 47 cases of responsible vessel non-occlusion subgroup, wherein there are 24 cases (51.06%) of large-size infarction, 13 cases (27.66%) of small-size infarction, and 10 cases (21.28%) of lacunar infarction. Large-size infarction accounts for the majority in both groups, particularly in the former group. In the cardiogenic cerebral infarction group, there was no statistical correlation between the occlusion of the responsible blood vessel and the infarction size, P>0.05[9] (See Table 3 for details).

Relationship between occlusion and prognosis of the responsible blood vessel trunk

Infarction area	11 cases in occlusion group	47 cases of unoccluded subgroup	
Large area	9/11（81.82%）	24/47(51.06%)	x^2=2.30， P=0.13
Large area	2/11（18.18%）	23/47(48.94%)	

Table 3: Comparison of the size of cerebral infarction area between cardiogenic infarction and infarction area with or without occlusion of the responsible vessels.

In the responsible vessel occlusion subgroup, there are 4 effective cases (36.36%), 2 ineffective cases (18.18%) and 5 deteriorated cases (45.45%). In the responsible vessel non-occlusion subgroup, there are 29 effective cases (61.70%), 15 ineffective cases (31.91%) and 3 deteriorated cases (6.38%) (As shown in Table 4).

Treatment effect	11 cases in occlusion group	47 cases of unoccluded subgroup	
Effective treatment	4/11（36.36%）	29/47（61.70%）	
invalid	2/11（18.18%）	15/47（31.91%）	Z=-2.234,P=0.025
deterioration	5/11（45.45%）	3/47（6.38%）	

Table 4: Comparison of therapeutic effects of cardiac infarction with occlusion of the responsible vessels.

Relationship between the infarction size and the prognosis

Infarction area	Effective treatment	invalid	deterioration	
Large area	14/33（42.42%）	13/3（39.39%）	6/33（18.18%）	
Small area/cavity clearance	19/25（76.00%）	4/25（16.00%）	2/25（8.00%）	Z=-2.432,P=0.015

Table 5: Relationship between the size of infarction area and therapeutic effect.

Among the large-size infarction cases, there are 14 effective cases (42.42%), 13 ineffective cases (39.39%) and 6 deteriorated cases (18.18%). Among the small-size infarction cases, there are12 effective cases (80.00%), 1 ineffective case (6.67%) and 2 deteriorated cases (13.33%). Among the lacunar infarction cases, there are 7 effective cases (70.00%) and 3 ineffective cases (30.00%) (10) (See Table 5 for details).

Conclusions

Cardiogenic cerebral infarction usually occurs in the anterior circulation brain area, and it is usually multiple infarction. The distribution of the focus is similar to that of non-cardiogenic cerebral infarction in transvascular, transcirculatory and transcerebral hemispheres. Cardiogenic cerebral infarction is usually a large-size infarction. The cortical-subcortical infarction that occurs in the MCA blood supply area has a certain prompting effect on cardiogenic cerebral infarction. The therapeutic efficiency of cardiogenic cerebral infarction with large infarction size is lower than that of cardiogenic cerebral infarction with small area and lacunar infarction. Responsible vessel occlusion has no predictive significance for infarct size, but it is helpful to predict the therapeutic effect. The therapeutic effect on responsible vessel occlusion is usually far from satisfactory.

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