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EC NEUROLOGY
Research Article

Role of Transcranial Dopplerography in Stroke

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Received: January 25, 2021; **Published:** March 31, 2021

Abstract

Introduction: Stroke is the second leading cause of disability in individuals with cardiovascular disease. Assessment of the state of cerebral hemodynamics is important for the selection of a method for treating acute stroke. Transcranial dopplerometry allows non-invasive visualization of the great vessels of the circle of Willis and obtain information on the quantitative parameters of blood flow in triplex mode.

Objective: To assess the quantitative parameters of blood flow in the middle cerebral artery in patients with ischemic stroke in triplex mode.

Materials and Methods: The results of dopplerometry of the middle cerebral artery (MCA) were studied in 69 patients with ischemic stroke. The age of the patients varied within 41-60 years (the average age 53,4±3,7), of which 41 (59.4%) were men and 28 (40.6%) were women. The MCA diameter, end systolic (Vs) and diastolic (Vd) velocities, mean systolic velocity (TAMX), resistance and pulsative indexis (RI, PI) of blood flow were calculated. The comporative group consisted of 41 patients without cardiovascular diseases, atherosclerotic plaques in carotid arteries of the same age (51,2±4,1 years).Doppler ultrasound was conducted on a Philips HD 11XE device using a sector (2 - 4 MHz) transducer.

Results: The diameter of the MCA on the side of ischemic stroke was 2.9±0.3 мм, on the contralateral side - 4.6±0.5 мм, and in a comparative group – 5.1±0.4 мм, respectively. In 56 (81.2+4.7%) cases Vs in the MCA did not exceed 70 cm/s and in average was 54.9±5.3cm/s. In 91,1% of this patients according to MRI data, the size of the affected lesion in the left hemisphere varied within 1.0-2.0 cm, in 8.9% of cases was less than 1.0 cm. In 13 (18.8+4.7%) cases of stroke Vs varied within 71-106 cm/s and averaged 86.7± 8.3 cm/s. In 30,8% of this patients the size of the affected lesion varied within 1.0-2.0 cm, in 69.2% of cases was less than 1.0 cm.

The resistive index (RI) of the blood flow in the MCA in a side of ischemic stroke was 0.71± 0.05, in a contralateral side - 0.56 ± 0.04 and in a comparative group - 0.53±0.04; the pulsative index (PI) -1.18±0.08; 0.91 ± 0.06 and 0.86 ± 0.05, respectively. The minute volume of blood flow (Vvol см3/мин) in the MCA was 39.5 ±7.6 cm3/min; 101.6 ±8.9cm3/min and 109.5 ±8.1 cm3/min, respectively.

Conclusion: Ischemic stroke in most cases occurs against the background of narrowing of the lumen of the middle cerebral artery, in which the maximum and average systolic blood flow velocity, the minute volume of blood flow on the side of the lesion is significantly lower than on the opposite side and in healthy individuals.

When comparing severe and mild stroke, a significant difference was also revealed between hemodynamic parameters towards a decrease in systolic velocity and volumetric blood flow in severe stroke.

Keywords: *Transcranial Dopplerometry; Ischemic Stroke; Middle Cerebral Artery*

Introduction

In developed countries, arterial ischemic stroke is among the top three causes of death. In 80% of cases, ischemic strokes occur due to atherosclerosis of large arteries, occlusion of small vessels [1]. Intravenous thrombolytic therapy during the first 6 hours promotes rapid revascularization of ischemic brain tissue [2-4]. About 20% of cardiac output enters the cerebral circulation and the volume of blood flow to the brain directly depends on the degree of stenosis of the great vessels of the cerebral vessels. Computed tomography and magnetic resonance imaging are the main methods for diagnosing cerebrovascular diseases. They make it possible to assess the degree of stenosis and perfusion of the brain tissue, which is very important for determining treatment tactics [5-7].

In recent years, a neurological clinic has used transcranial Doppler sonography to assess hemodynamic disturbances in the vessels of the Willis circle in ischemic stroke [8,9]. In these works, the speed indicators of blood flow in the large vessels of the brain are often demonstrated. Among the quantitative parameters of hemodynamics, the assessment of the minute volume of blood flow in ischemic stroke is an urgent issue.

Objective

To assess the quantitative parameters of blood flow in the middle cerebral artery in patients with ischemic stroke in triplex mode.

Materials and Methods

The results of dopplerometry of the middle cerebral artery (MCA) were studied in 69 patients with ischemic stroke. The age of the patients varied within 41-60 years (the average age 53,4±3,7), of which 41 (59.4%) were men and 28 (40.6%) were women. The MCA diameter, end systolic (Vs) and diastolic (Vd) velocities, mean systolic velocity (TAMX), resistance and pulsation indexis (RI, PI) of blood flow were calculated. The control group consisted of 41 patients without cerebrovascular diseases, atherosclerotic plaques in carotid arteries of the same age (51,2±4,1 years).

Doppler ultrasound was conducted on a Philips HD 11XE device using a sector (2 - 4 MHz) transducer.

Results

The diameter of the MCA on the side of ischemic stroke was 2.9±0.3 мм, on the contralateral side - 4.6±0.5 мм, and in a comparative group – 5.1±0.4 мм, respectively. In 56 (81.2+4.7%) cases Vs in the MCA did not exceed 70 cm/s and in average was 54.9±5.3cm/s. In 91,1% of this patients according to MRI data, the size of the affected lesion in the left hemisphere varied within 1.0-2.0 cm, in 8.9% of cases was less than 1.0 cm. In 13 (18.8+4.7%) cases of stroke Vs varied within 71-106 cm/s and averaged 86.7± 8.3 cm/s. In 30,8% of this patients the size of the affected lesion varied within 1.0-2.0 cm, in 69.2% of cases was less than 1.0 cm (Figure 1).

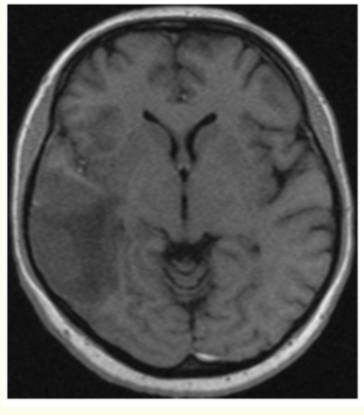

Figure 1: *MRI with ischemic stroke in the left MCR basin (left hypodence zone).*

The resistive index (RI) of the blood flow in the MCA in a side of ischemic stroke was 0.71± 0.05, in a contralateral side - 0.56 ± 0.04 and in a comparative group - 0.53±0.04; the pulsative index (PI) -1.18±0.08; 0.91 ± 0.06 and 0.86 ± 0.05, respectively.

The minute volume of blood flow (Vvol см^3/мин) in the MCA was 39.5 ±7.6 cm3/min; 101.6 ±8.9cm3/min and 109.5 ±8.1 cm3/min, respectively (Figure 2 and 3).

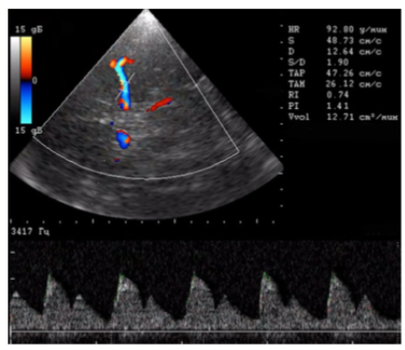

Figure 2: *TCD: 64 years old women; Left-sided hemispheric ischemic stroke; Deep incision in early diastole. Vs=48.73 cm/c; RI-0.74; PI-1.41.*

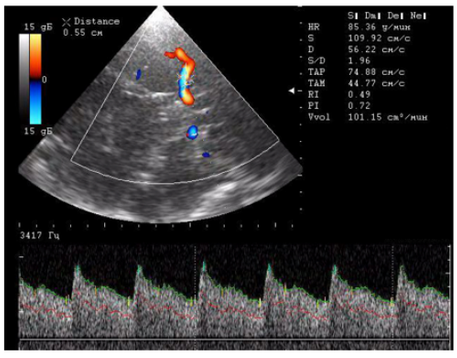

Figure 3: *Registration of normal blood flow in the middle cerebral artery. Vs - 109.92 cm/s; Vd - 56.22 cm/s; TAM - 44,77 cm/s, RI - 0.49; PI 0.72; S/D - 1.96, Vvol - 101.15 cm3/min.*

On the basis of clinical neurological symptoms in terms of severity, all patients were divided into three groups: group I included 19 patients with severe form; group II - 34 patients with moderate severity and group III - 16 patients with mild ischemic stroke. A relationship was established between the severity of stroke and hemodynamic parameters of blood flow in the MCA (Table 1 and 2).

Hemodynamic Parameters	Middle Cerebral Artery		MCA
	Affected Side	Unaffected Side	CG
D, мм	2.9 ± 0.3	4.6±0.5 P<0,05	5,1 ±0.4
Vs (cm/c)	69.3 ± 5.8	101.2 ± 6.1 P<0,001	106,2 ± 5,9
Vd (cm/c)	20.2 ± 2.6	48.6 ± 4.3 P<0,05	49,7 ± 4,2
TAM (cm/c)	41.6± 3.7	67.6 ± 4.5 P<0,01	64,9 ± 5,8
PI	1.18 ± 0.08	0.91 ± 0.06	0,86 ± 0,05
RI	0.71 ± 0.05	0.56 ± 0.04	0,53 ± 0,04
Vvol см^3/мin	39,5 ± 7.6	101,6 ± 8.9 P < 0,001	109,5 ± 8.1

Table 1: *Hemodynamic parameters of the arteries of the circle of Willis.*

Hemodynamic Parameters In MCA	Ischemic Stroke		
	Severe N=19	Moderate N=34	Mild N=16
	1	2	3
D, mm	2.4 ± 0.3	2.7 ± 0.3	3,1 ± 0.3
Vs (cm/c)	58.2 ± 4.1 P<0,01	62.1 ± 5.2	85.4 ± 8.2
Vd (cm/c)	15.3 ± 2.1 P<0,001	18.9 ± 2.3	26,9 ± 2,5
TAM (cm/c)	34.1 ± 3.6 P<0,001	37.4 ± 3.6	52,1 ± 3,9
PI	1.26 ± 0.08	1.15 ± 0.06	1,12 ± 0,07
RI	0.74 ± 0.05	0.69 ± 0.04	0,68 ± 0,04
Vvol cm^3/min	27,4 ± 6.9 P<0,05	43,2 ± 7.4	48,3 ± 8.1

Table 2: *The Hemodynamic parameters in MCA in patients with Ischemic Stroke depending on the severity of ischemic stroke.*

As can be seen from the table, the diameter of the MCA among patients with severe stroke was less than the moderate and mild form, but the difference was statistically insignificant.

The indices of resistance to blood flow in severe stroke exceed the corresponding indices of mild forms no significantly: for RI - 0.74 ± 0.05 vs 0.69 ± 0.04 and 0.68 ± 0.04; for PI – 1.26 ± 0.08vs 1.15 ± 0.06 and 1,12 ± 0,07.

The systolic and diastolic blood flow velocity and minute volume of blood flow in MCA in patients with severe stroke was significantly lower than in moderate and mild stroke: for Vs - 58.2 ± 4.1 cm/c vs 62.1 ± 5.2 cm/c and 85.4 ± 8.2 cm/c (P < 0,01); for Vd – 15.3±2.1 cm/c vs 18.9 ± 2.3 cm/c and 26.9 ± 2.5 cm/c (P < 0,001); for TAM – 34.1 ± 3.6 cm/c vs 37.4 ± 3.6 cm/c and 52.1 ± 3.9 cm/c (P<0,001); for Vvol – 27,4 ± 6.9 cm/min vs 43,2±7.4 cm/min and 48,3 ± 8.1 cm^3/min.

Discussion

Ultrasonography in color Doppler mode allows visualizing the vascular lumen, registering blood flow in the stenotic area, and assessing its degree. An experienced specialist from the transtemporal approach within a few minutes at the patient's bedside can obtain information about the state of the main vessels of the circle of Willis [10]. Doppler results provide information on occlusion, recanalization, and reperfusion after thrombolysis. The method also allows dynamic monitoring of the state of cerebral hemodynamics at different periods of stroke [11-15].

In our studies, a relationship was established between hemodynamic parameters of blood flow and the severity of ischemic stroke: the more severe the ischemic stroke, the lower the systolic velocity and minute volume of blood flow, and higher the index of resistance and pulsation.

Conclusion

Ischemic stroke in most cases occurs against the background of narrowing of the lumen of the middle cerebral artery, in which the maximum and average systolic blood flow velocity, the minute volume of blood flow on the side of the lesion is significantly lower than on the opposite side and in healthy individuals.

When comparing severe and mild stroke, a significant difference was also revealed between hemodynamic parameters towards a decrease in systolic velocity and volumetric blood flow in severe stroke.

Conflict of Interest

The authors declared no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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Volume 13 Issue 4 April 2021