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Research Article

# Dopplerometric Assessment of Cerebral Hemodynamics in Ischemic Stroke

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## Abstract

**Background:** As you know, cardiovascular diseases are a common cause of death and disability, among them a special place is occupied by stroke.

**Objective:** to determine the quantitative parameters of blood flow of the main brain vessels in patients with left hemispheric ischemic stroke (HIS). Methods: transcranial dopplerography (TD) of the middle cerebral artery (MCA) and middle cerebral vein (MCV), the Rosenthal's vein, the Galena's vein and Straight sinus (SS) was performed in 89 patients with HIS. The comparative group (CG) was organized from 52 patients without cardiovascular diseases. The maximum systolic velocity (Vs), the end diastolic velocity (Vd), the resistance index (RI) in MCA, and the Vs of the main brain veins were determined.

**Results:** Sistolic blood flow velocity in the mid-cerebral artery in 85.4% of patients was below 70 cm/s and averaged, 54.9 ± 7.1 cm/s. In 9.2% of cases, the size of the affected area in the left hemisphere did not exceed 1 cm according to the results of tomography, and in 90.8% of cases it ranged from 1 cm to 2 cm According to the results of TD, MSA stenosis was detected in 78 (87.6%) cases, which was confirmed by MRI angiography. Among the patient with the Hemispheric ischemic stroke the Rosenthal's vena was visualized in 81 (91,0%) cases, the Galen's vena – in 83 (93,3%) cases, the median cerebral vein (MCV) - in 75 (84,3%) and the Straight sinus - in 79 (88,9%) cases, respectively. In a patients of the comparative group, visualization of this veins was successful in 42 (80.8%), 47 (90.4%), 31 (59.6%) and 32 (61.5%) cases, respectively. In a patients with HIS, all the main cerebral veins were visualized significantly (P <0.05 and P <0.001) more often than in the CG (with the exception of the Galen vein). In a patient with HIS Vs in the deep median cerebral vein was 25.3+3.6 cm/s; in the basal vein of the brain -24.9+2.6 cm/s; in the large vein of the brain -26.3+2.1 cm/s; in the direct sinus, 32.1 ± 2.6 cm/s, respectively.

**Conclusion:** Stenosis of the middle cerebral artery, a decrease in systolic blood flow velocity less than 70 cm/s, an increase in resistance index more than 0.70 and in the pulsation index more than 1.35 is a frequent finding in ischemic stroke. The correspondence between the severity of the stroke and the value of the systolic blood flow velocity in the cerebral veins was revealed. Good visualization of the main cerebral veins is due to the increase in blood flow velocity in them.

**Keywords:** Transcranial Dopplerography; Hemispheric Ischemic Stroke; Cerebral Hemodynamics

## Abbreviation

TD: Transcranial Dopplerography; HIS: Hemispheric Ischemic Stroke; CH: Cerebral Hemodynamics.

## Introduction

It is known that about 20% of cardiac output through the carotid arteries enters the brain. The degree of cerebral stenosis de-

termines the volume of blood flow to the brain. At the same time, the severity of clinical symptoms depends not only on the degree of arterial hemodynamic impairment, but also on the state venous blood flow from the brain. Previous studies have shown that the clinical symptoms of ischemic stroke are determined not only by the volume of blood flowing through the arterial vessels, but also by the outflow of blood through the venous vessels from the brain [1,2]. Developed by Singer O.C., *et al.* (2005) the clinical scale provides the accuracy of determining the occlusion of the cerebral artery about 85% [3]. Research results Allen LM., *et al.* (2012) using CT and MR angiography made it possible to determine the area of arterial occlusion, the mechanisms of stroke development and the prevalence of the affected area [4]. In recent years, transcranial dopplerography has been used to determine cerebral hemodynamics in various pathological conditions [5,6].

Objective to determine the quantitative parameters of blood flow of the main brain vessels in patients with left hemispheric ischemic stroke.

## Patients and Methods

Transcranial dopplerography (TD) of the middle cerebral artery (MCA) and middle cerebral vein (MCV), the Rosenthal's vein, the Galena's vein and Straight sinus (SS) was performed in 89 patients with hemispheric ischemic stroke (HIS). The age of the subjects varied within 43-78 years, there were 41 men (46.1%), women 48 (53.9%). The comparative group (CG) was organized from 52 patients without cardiovascular diseases. The following quantitative blood flow parameters were determined: systolic and diastolic velocity (Vs, Vd), mean systolic velocity (TAMX), resistant and pulsation indices (RI and Pi) in MCA and Vs of the main cerebral veins. Statistical analysis consisted in unvaried comparisons of unpaired groups, performed with the Fisher's exact test for categorical data. The significance level, two-tailed, was set at ≤ 0.05 for moderately significant, at ≤ 0.01 for significant and at ≤ 0.001 for highly significant.

## Results

Sistolic blood flow velocity in the mid-cerebral artery in 85.4% of patients was below 70 cm/s and averaged, 54.9 ± 7.1 cm/s. In 9.2% of cases, the size of the affected area in the left hemisphere did not exceed 1 cm according to the results of tomography, and in 90.8% of cases it ranged from 1 cm to 2 cm According to the results of TD, MSA stenosis was detected in 78 (87.6%) cases, which was confirmed by MRI angiography. TCD in 37 (41.6%) cases showed moderate or severe stenosis of first segment of the left MCA, which was confirmed in 35 cases with MRI angiography (Figure 1, 2). On the 3rd week from the beginning of the stroke, repeated transcranial dopplerography was performed. Under dynamic observation, fatal outcome was noted in three cases, serious complications in 34 patients.

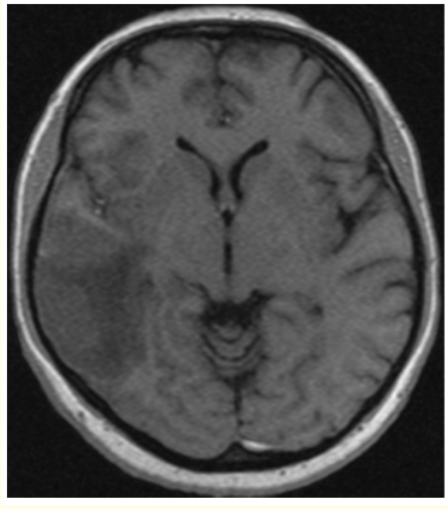

**Figure 1:** MRI with ischemic stroke in the left MCR basin (left hypodence zone).

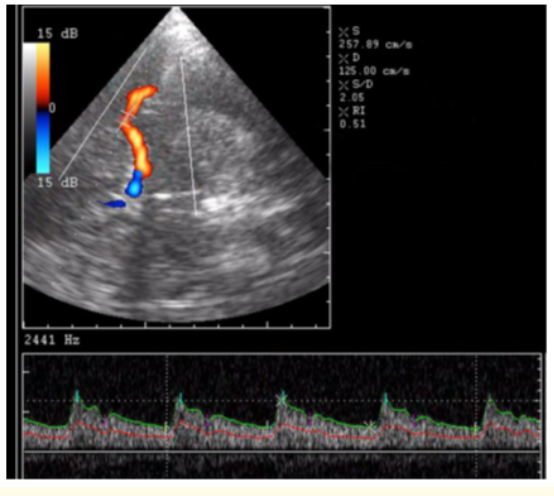


**Figure 2:** Ttanscranial dopplerography of a patient with left hemispheric ischemic stroke. Stenosis of first segment of left middle cerebral artery. Vs - 257 cm/c.

Comparison of hemodynamic parameters of patients with an unfavorable course between the first day and the third week of stroke did not reveal any significant differences At the same time, the data of patients with stroke significantly (P<0,001) differed from those of the comparative group (Table 1).

| The hemodynamic parameters of blood flow in second segment of MCA | HIS unfavorable outcome (n =36) | HIS favorable outcome (n =53) | CG (n =52) |
|---|---|---|---|
| Vs, **cm**/s | 49.3 ± 6.1<br>P<0,05 | 87,5 ± 5,9 | 104,5 ± 4,9 |
| Vd, cm/sec | 6.9 ± 1.7<br>P<0,01 | 31,6 ± 2,3 | 48,7 ± 2,3 |
| TAMX, cm/sec | 30,5±3,6<br>P<0,01 | 58,9 ± 6,7 | 64,9 ± 5,8 |
| RI | 0.86+0.07<br>P<0,05 | 0,64 ± 0,05 | 0,53 ± 0,04 |
| PI | 1,39 ± 0,12<br>P<0,01<br>P<0,001 | 0,98 ± 0,07 | 0,86 ± 0,05 |

**Table 1:** Hemodynamic parameters in second segments of MCA in patients with hemispheric ischemic stroke unfavorable outcome on the affected side and in a comparative group.

Among the patient with the Hemispheric ischemic stroke the Rosenthal's vena was visualized in 81 (91,0%) cases, the Galen's vena – in 83 (93,3%) cases, the median cerebral vein (MCV) - in 75 (84,3%) and the Straight sinus - in 79 (88,9%) cases, respectively. In a patients of the comparative group, visualization of this veins was successful in 42 (80.8%), 47 (90.4%), 31 (59.6%) and 32 (61.5%) cases, respectively. In a patients with HIS, all the main cerebral veins were visualized significantly (P <0.05 and P <0.001) more often than in the CG (with the exception of the Galens vena) (Table 2). In a patient with HIS Vs in the deep median cerebral vein was 25.3+3.6 cm/s; in the basal vein of the brain -24.9+2.6 cm/s; in the large vein of the brain -26.3+2.1 cm/s; in the direct sinus, 32.1 ± 2.6 cm/s, respectively (Table 3).

| The frequency of visualization of the main brain veins, % | HIS (n =89) | CG (n =52) |
|---|---|---|
| Galen's vena | 83 (93,3 ± 2,7) | 47 (90,4 ± 4,1) |
| Rosenthal's vein | 81 (91,0 ± 3,0)<br>P< 0,05 | 42 (80,8 ± 5,4 |
| Median cerebral vein | 75 (84,3 ± 3,8)<br>P1-3< 0,001 | 31 (59,6 ± 6,8) |
| Straight sinus | 79 (88,9 ± 3,5)<br>P1-2< 0,05 | 32 (61,5 ± 6,7) |

**Table 2:** The frequency of visualization of the main brain veins in patients with hemispheric ischemic stroke and comparative group.

| The systolic blood flow velocity, cm/s | HIS (n =89) | CG (n =52) |
|---|---|---|
| Galen's vena | 26,3 ± 2,1<br>P<0,05 | 19,5 ± 1,9 |
| Rosenthal's vein | 24,9 ± 2,6<br>P<0,01 | 15,8 ± 2,3 |
| Median cerebral vein | 25,3+3,6<br>P<0,01 | 13,7 ± 1,8 |
| Straight sinus | 32,1 ± 2,6<br>P<0,05 | 24,3 ± 2,5 |

**Table 3:** The maximum blood flow velocity in the large brain veins in a patients with hemispheric ischemic stroke and comparative group.

## Discussion

In earlier studies, the role of Doppler sonography in assessing the patency of cerebral vessels in patients with acute stroke was shown. Trained medical staff can perform an ultrasound examination of the brain's blood vessels within minutes [7-9]. A high correlation was found between the extracranial venous blood flow and the degree of cerebral venous insufficiency in patients with multiple sclerosis [10].

Cerebral perfusion and venous outflow resistance, factors, that determine cerebral venous pressure. This affects the speed of the venous blood flow and contributes to the development of cerebral edema in patients with ischemic stroke. In ischemic stroke, there is an inverse relationship between arterial and venous cerebral blood flow - the first decreases more often, the second increases. We have established a positive relationship between the systolic blood flow velocity in the main veins of the brain and the severity of ischemic stroke.

## Conclusion

Stenosis of the middle cerebral artery, a decrease in systolic blood flow velocity less than 70 cm/s, an increase in resistance index more than 0.70 and in the pulsation index more than 1.35 is a frequent finding in ischemic stroke. The correspondence between the severity of the stroke and the value of the systolic blood flow velocity in the cerebral veins was revealed. Good visualization of the main cerebral veins is due to the increase in blood flow velocity in them.

## Acknowledgment

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## Conflict of Interest

The authors declare no conflicts of interest.

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