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HAND GRIPPING EFFECT ON CEREBRAL BLOOD FLOW IN PATIENTS WITH ISCHEMIC STROKE

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ABSTRACT

Purpose: We assessed the motor stimulus to blood flow velocity (BFV) changes of bilateral middle cerebral arteries (MCAs) by transcranial Doppler (TCD) sonography in patients with acute ischemic cerebrovascular events and normal subjects.
Methods: Thirty-two patients (9 female, 23 male; aged 56.1±2.5 years) with acute ischemic cerebrovascular events in the MCA territory, and 17 (8 female, 9 male; aged 50.0±3.2 years) control subjects were investigated. Bilateral TCD sonography from both MCAs were monitored during 10 cycles of 20 seconds when subjects are performing hand gripping with a frequency of one per second, and subsequently 20 seconds when they are rest to assess BFV changes on activated cortical motor areas. BFV increase was calculated off-line for each subjects.
Results: There is no significant age and gender difference between patients and controls. Eighteen patients had lacunar infarction, 7 patients had cortical and subcortical infarction, and 7 patients had cortical infarction. In the patients mean flow velocities, flow velocities at stimulation and flow velocities at rest were found significantly lower than that of controls on both side. In contrast to these results relative flow velocity increase was not significantly different between patients and controls. However, relative flow velocity increase was slightly lower on the lesion side in the patients than that of controls.
Conclusion: We, however, have a small sample size, and this test requires the subject cooperation. In addition the stroke types of the patients are heterogeneous. Nevertheless, our results suggest that unilateral cerebrovascular ischemic insult can affect blood flow in both MCAs in patients with acute ischemic events in the MCA territory.
Key words: Blood flow velocity, transcranial Doppler sonography.

Introduction

Transcranial Doppler sonography (TCD) provides information about blood flow velocity (BFV) changes in individual cerebral arteries as representation of cerebral blood flow to visual stimulation [1,2]. Moreover, TCD method is able to provide temporal information about the dynamics of the response [3].

However TCD has been used by means of visually evoked responses, less motor evoked response has been reported [4,5]. Therefore, we aimed to assess the motor evoked BFV changes in both middle cerebral arteries (MCAs) using TCD monitoring in patients with acute ischemic cerebrovascular events and in normal subjects.

Subjects and Methods

Thirty-two patients (9 female, 23 male; aged 56.1±2.5 years) with acute ischemic cerebrovascular events in the MCA territory (mean±SD; 3.7±2.2, days; range 1-10 days), and 17 (8 female, 9 male; aged 50.0±3.2 years) control subjects were investigated. Control subjects had neither active medical diseases nor histories of neurological disorders. All patients and control subjects had a routine clinical and hematological examination and a cranial computed tomography was performed on all patients.

A long term TCD monitoring device (Multidop X4 DWL and TCD8 software, Elektronische Systeme GmbH, Sipplingen) was used for simultaneous recording of both MCAs using bilateral 2-MHz probes that were tightly fixed by a headband. Through the temporal bone both M1 segment of MCAs (flow direction toward the probe) were insonated at a depth of 48 to 58 mm. The proven MCA insonation was required to flow velocity increase on both sides during measurement of motor evoked flow during hand gripping as opposed to rest (Figure 1).

All subjects were monitored during 10 cycles of 20 seconds when subjects are performing hand gripping (moving the thumb along the other fingers) with a frequency of one per second, and subsequently 20 seconds when they are rest to assess BFV changes on activated cortical motor areas (Figure 2).

Calculations were performed off-line, and individual reactivity was defined with a relative increase of blood flow velocities (DIBFV) which were calculated as percentage change of baseline value [DIBFV=100*(Vs-Vr)/Vr]. Where Vs means maximum velocity when hand gripping; Vr, minimum velocity at rest; and Vmean, mean

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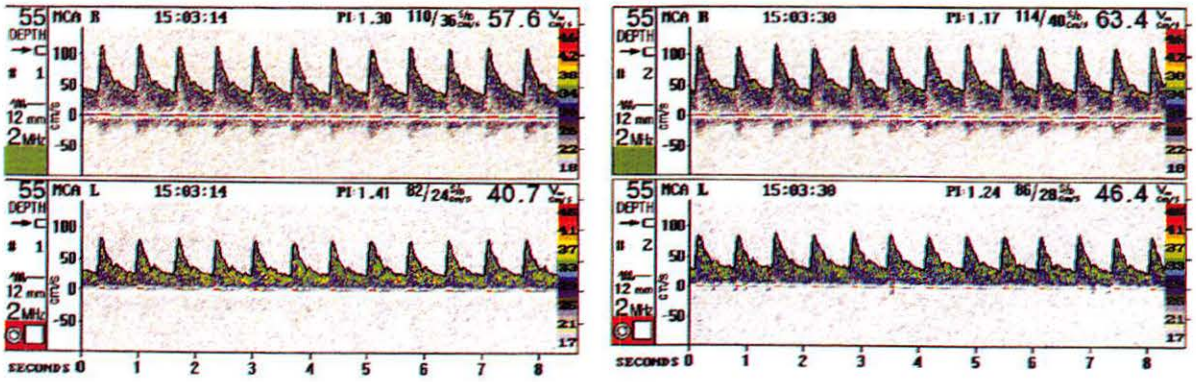

Figure 1: MCA velocity signals are recorded in the M1 segment. Left spectral recordings correspond to rest and the right one to hand gripping. Note the increase in the mean velocity when hand gripping. D indicates insonation depth given in millimeters; Æ[, flow direction; PI, pulsatility index; Vm, mean velocity.

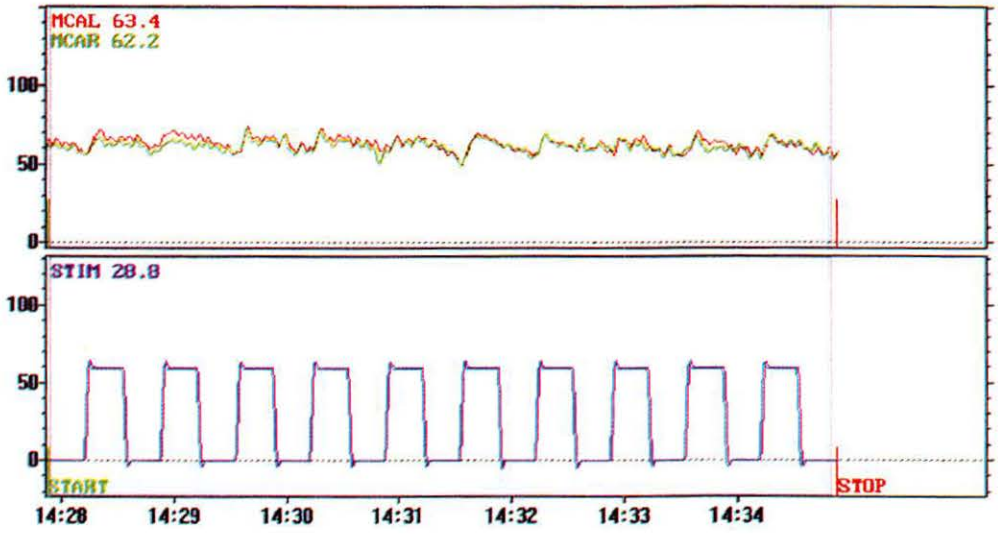

Figure 2: Continuous recordings of BFVs simultaneously in the left and right MCA during 10 cycles. Each cycle consists of a sequence of rest (20 seconds), followed by the hand gripping (20 seconds). Gripping the hands induced a regular increase of the velocities.

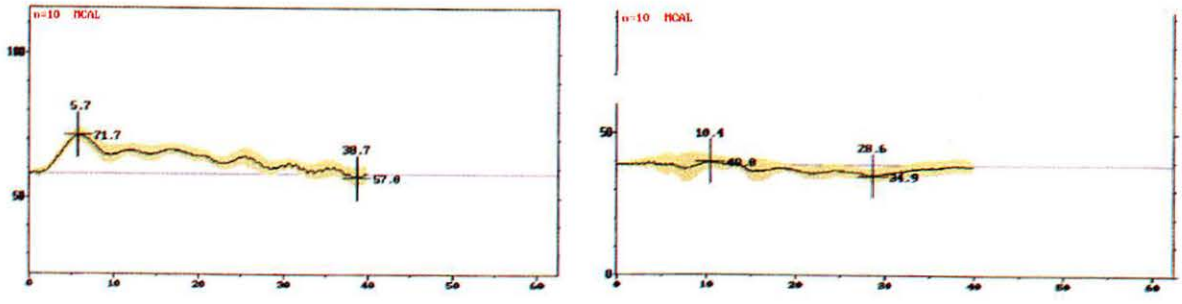

Figure 3: The figures show the waveform of the averaged responses of 10 cycles recorded the M1 segment of the left MCA during hand gripping and rest in a patient (right) and in a control subject (left). The figures show significant increases of BFVs of MCAs (mean value, the shaded areas indicate ± 2SEM). The maximum and minimum values were calculated as a single value at stimulation and rest, respectively.

velocity, which is calculated by the special software of this system, during procedure as shown figure 3.

Two-tailed unpaired t-test and two-tailed paired t-test was applied to statistical analyses where appropriate, and $p<0.05$ was accepted for statistical significance.

Results

There is no significant age and gender difference between patients and controls. Eighteen patients had lacunar infarction, seven patients had cortical and subcortical infarction, and seven patients had cortical infarction. The summaries of the motor evoked responses were shown in the table 1.

Table 1: The summaries of the motor evoked responses

	Lesion side or left side		Non-lesion side or right side	
	Patients (n=32)	Control subjects (n=17)	Patients (n=32)	Control subjects (n=17)
Vs (cm/sec)	54.8±3.2 [1]	65.1±4.6	54.5±2.1 [4]	69.7±3.4
Vr (cm/sec)	47.3±2.6 [2]	54.9±4.0	45.9±1.8 [5]	59.2±3.0
Vmean (cm/sec)	50.9±2.9 [3]	58.9±4.1	49.9±1.8 [6]	63.3±3.2
ΔIBFV (%)	16.0±1.4	18.9±1.6	19.2±2.0	18.0±1.2

Two-tailed t-test for group means
Values are mean±SEM, (n) means number of the subjects
[1] p=0.007 (patients versus controls)
[2] p=0.005 (patients versus controls)
[3] p=0.01 (patients versus controls)
[4] p=0.02 (patients versus controls)
[5] p=0.021 (patients versus controls)
[6] p=0.02 (patients versus controls)

Hand gripping showed a marked increase of the blood flow velocities in both MCAs in all subjects ($p<0.001$ for all vessels) without a significant side to side difference. In the patients mean flow velocities, flow velocities at stimulation and flow velocities at rest were found significantly lower than that of controls on both side. In contrast to these results, relative flow velocity increase was not significantly different between patients and controls. However, relative flow velocity increase was slightly lower on the lesion side in the patients than that of controls.

Discussion

Motor stimuli produced a marked increase of BFV in both MCAs without a significant side to side difference in all subjects. These BFV increases are suitable as normal values. In an earlier report, unilateral hand gripping was investigated [4]. They found similar BFV increases (11.3±4.9%) in 12 normal persons. The another study showed similar BFV increases (17.6±9.1%) during bilateral hand gripping in 16 normal subjects [5]. In these studies, hand gripping was performed for 2 minutes. In our study, we used a different methodology to prevent possible habituation, which may occur when hand gripping continues for 2 minutes. However, our results are not different from those of earlier studies. Additionally, our patient group was heterogeneous. Patients with lacunar infarction had nearly normal BFV increases in both sides, while patients with cortical and subcortical infarction or patients with cortical infarction had lower BFV increases in lesion side comparing to non-lesion side or comparing to controls (Data not shown because of the small number of these subgroups are not sufficient to discuss).

Since BFV increase values were lower in normal persons and in patients, hand gripping appears as a weaker stimulus for MCA blood flow increases. However, hand gripping causes an increased metabolism of the activated neurons. Neuronal function is coupled with increased regional cerebral blood flow (rCBF) related to metabolic demand, so-called vasoneuronal coupling. [6]. When considering the autoregulatory vasodilatation and vasoconstriction are limited to small cortical vessels, the relationship between blood flow velocity and blood flow of the basal cerebral arteries are linear [7]. The changes of the diameter of these basal cerebral arteries can be neglect and therefore relative blood flow changes in these arteries reflect the relative blood flow as shown in the studies using transcranial Doppler monitoring [8]. This physiologically mechanism may be highly effective in providing actual needed blood flow.

Despite the lower sensitivity of hand gripping for cerebrovascular reactivity in terms of TCD monitoring, our results suggest that cerebrovascular reactivity was not abnormally altered in patients with acute ischemic events in the MCA territory.

In conclusion, we assessed the motor evoked symmetrical increases of blood flow velocities, reflecting blood flow, on both middle cerebral arteries, using transcranial Doppler sonography which is non-invasive and reproducible diagnostic tool, due to metabolic demand of the activated motor areas. We, however, have a small sample size, and this test requires the subject cooperation. In addition, the stroke types of the patients in our

study are heterogeneous. Nevertheless, our results suggest that unilateral cerebrovascular ischemic insult can affect blood flow in both MCAs in patients with acute ischemic events in the MCA territory.

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