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HAND GRIPPING EFFECT ON CEREBRAL BLOOD FLOW IN NORMAL SUBJECT

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Summary

Purpose: The changes of regional cerebral blood flow (rCBV) related to metabolic demand depends on both integrity of neuronal function and vascular blood flow. Therefore, we assessed the motor stimulus to blood flow velocity (BFV) changes of bilateral middle cerebral arteries (MCA) by transcranial Doppler (TCD) sonography in normal subjects.
Methods: Sixteen subjects (8 female, aged 48.0±3.8 years; 8 male, aged 54.4±4.8 years) were investigated. Bilateral TCD sonography from both MCA 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: Hand gripping showed a significant BFV increase on both MCA (p=0.000). These values were 19.2% on the left side, and 19.2% on the right side. There was no significant side to side difference between the absolute BFV values both at rest and during hand gripping. The left side, however, showed slightly higher absolute BFVs than that of right side. Additionally, the absolute BFVs and BFV increases were not significantly different between male and female subjects. However, male subjects had a lower BFVs at rest and during hand gripping comparing to female subjects.
Conclusion: We, however, have a small sample size, and this test requires the subject cooperation. Our results suggest that hand gripping can successfully affect blood flow in both MCA without side to side differences. Finally, our suggestion is this test might be useful to assess the neurovascular integrity.
Key words: Blood flow velocity, transcranial Doppler sonography.

Introduction

Neuronal function is coupled with increased regional cerebral blood flow (rCBF) related to metabolic demand, so-called vasoneuronal coupling. Till now, a few numbers of imaging methods were used to assess vasoneuronal coupling, such as single photon emission computerized tomography (SPECT), positron emission tomography (PET) and functional magnetic resonance imaging (MRI) [1-3]. Although these techniques have a relatively high spatial resolution, have a low temporal resolution due to long measuring periods.

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 [4, 5]. Moreover, TCD method is able to provide temporal information about the dynamics of the response [6].

However TCD has been used by means of visually evoked responses, no motor evoked responses has been reported. Therefore we aimed to assess the motor evoked BFV changes in both middle cerebral arteries (MCAs) using TCD monitoring in normal subjects.

Subjects and Methods

Sixteen right-handed normal subjects, who had neither active medical diseases nor histories of neurological disorders, (9 female, mean±SEM age, 48.0±3.8 years; 9 male, mean±SEM age, 54.4±4.9 years) were investigated.

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 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 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.

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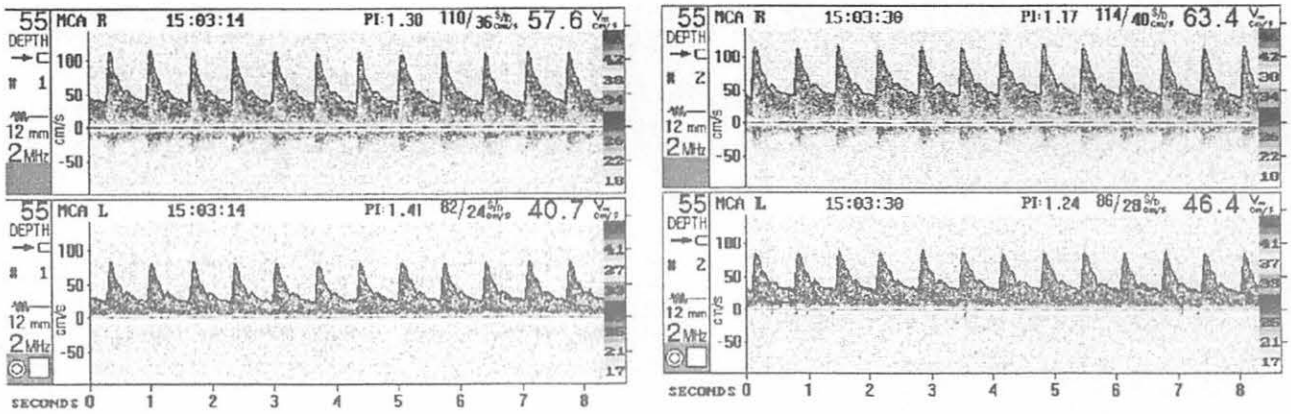

Figure 1: MCA velocity signals are recorded in the M1 segment. Left spectral recordings correspond to rest and the right one to hand gripping. Note the increase in the mean velocity when hand gripping. Depth indicates insonation depth given in millimeters; →[, flow direction; PI, pulsatility index; Vm,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

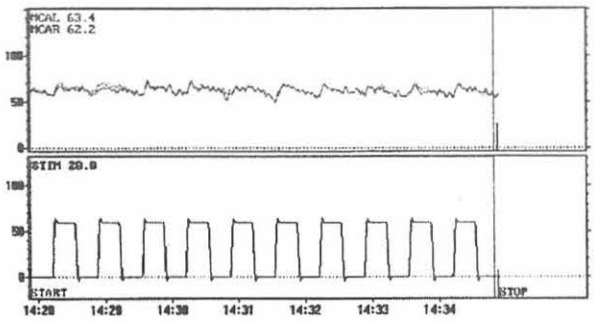

Figure 2: Continuous recordings of BFVs simultaneously in the left and right MCA during 10 cycles. Each cycle consists of a sequence of rest (20 seconds), followed by the hand gripping (20 seconds). Gripping the hands induced a regular increase of the velocities.

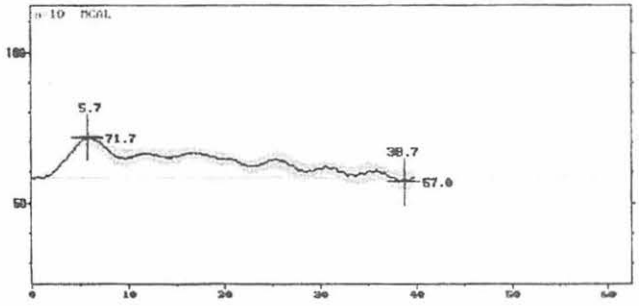

Figure 3: The figures show the waveform of the averaged responses of 10 cycles recorded the M1 segment of both MCA during hand gripping and rest in a subject. The figures show significant increases of BFVs of MCA (mean value, the shaded areas indicate ± 2SEM). The maximum and minimum values were calculated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

Results

There was no significant age and gender differences. Doppler data of the subjects were shown in Table 1. Male subjects had slightly lower BFVs during stimulation and rest than those of the female subjects, as well mean velocities or relative increase of BFV. On the left side all parameters were slightly higher than that of right side in both male and female subjects. However, none of these differences reached significant levels.

Table 2 shows the marked increase of the flow velocities when applied motor task. No significant differences were found between male and female subjects, as well between left and right sides.

Discussion

Motor stimuli produced a marked increase of BFV in both MCAs without a significant side to side difference in normal subjects. However, there was a trend toward higher response on the left side. This finding is in accordance with the left hemispheric dominance for motor function.

Neuronal function is coupled with increased regional cerebral blood flow (rCBF) related to metabolic demand, so-called vasoneuronal coupling. Briefly, the activation of neurons result accumulated potassium ions in the extracellular space. Astrocytes take up this excess potassium

Table 1: footnotes
Two-tailed unpaired t-test for group means.
Values are mean±SEM, (n) means number of the subjects

	Male (9)	Female (9)	Total (18)
Left side			
ΔIBFV	16,9±1,5	21,5±4,2	19,2±2,2
Vmean	59,2±3,6	63,8±5,9	61,5±3,4
Vr	55,6±3,5	59,1±5,7	57,3±3,3
Vs	64,9±4,0	70,9±6,2	67,9±3,7
Right side			
ΔIBFV	16,2±1,5	22,2±3,5	19,2±2,0
Vmean	56,6±4,6	60,0±6,8	58,3±4,0
Vr	53,2±4,4	55,4±6,7	54,3±3,9
Vs	61,9±5,2	67,0±7,5	64,4±4,5

Table 2 footnotes
Two-tailed paired t-test for group means
Values are mean±SEM, (n) means number of the subjects

	Vr	Vs	P value
Male			
Left	55,6±3,5	64,9±4,0	0,000
Right	53,2±4,4	61,9±5,2	0,000
Female			
Left	59,1±5,7	70,9±6,2	0,000
Right	55,4±6,7	67,0±7,5	0,000
Total			
Left	57,3±3,3	67,9±3,7	0,000
Right	54,3±3,9	64,4±4,5	0,000

and store it. The end-feet of astrocytes that contact blood vessels and the pial membrane have a much higher potassium conductance than the astrocyte cell surface. The astrocytes therefore extrude from their end-feet the excess potassium. Depending upon neuronal activity, the potassium concentration increase, and therefore the diameter of the vessels increase resulting increase blood flow so that metabolic demand can be provided [7, 8].

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 [9]. 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 [9, 10].

Furthermore, the changes of the regional cerebral blood flow depend on the severity and/or qualification of the stimulus. When one only thinks gripping oneself hands, the stimulated area of the motor cortex may be limited. The results of this type stimulus are expected to be lower. We, however, did not performed such stimuli. Nevertheless, the stimulation procedures above mentioned need the patients' cooperation. This is the important limitation for our study.

In conclusion, we assessed the motor evoked symmetrical and sex-independent increase of blood flow velocity, 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. Our results suggest that hand gripping can successfully affect blood flow in both MCA without side to side differences.

Finally, our suggestion is this test might be useful to assess the integration between neuronal and vascular structure in any disorder affecting the neuron, astrocyte, or regional vessels. Furthermore, systemic diseases such as atherosclerosis of the large basal cerebral arteries, hypertension, diabetes mellitus, or heart failure may result measurable abnormal cerebral regulation even they were clinically regulated.

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