Measurement of Cerebral Blood Flow by Ultrasonic Doppler Technique

Hemodynamic Comparison of Right and Left Carotid Artery in Patients with Hemiplegia

Manabu Miyazaki,* Kanamasa Kato**

The Department of Internal Medicine, Kosaiin Hospital, Suita, Osaka*
The Institute of Scientific and Industrial Research, Osaka University, Osaka**

The cerebral hemodynamics in cerebral circulatory insufficiency are investigated using by the various technique, i.e. inert-gas and indicator-injection technique, electroencephalography, cerebral angiography, ophthalmodynamometry and fluorescein-dye test, etc. Since all the above methods are indirect or discontinuous technique, the definite diagnosis of cerebral circulatory insufficiency are difficult.

On the other hand, the measurement of cerebral blood flow by ultrasonic Doppler technique is very unique compared with the above methods, although the technique has still been controversial from the various points of view. The characteristics of the technique are summarized as follows. (1) The dynamic change of the blood flow at the vessel resulting from the various stresses to the circulatory system can be observed instantaneously without any surgical procedure. (2) The cerebral circulation and cerebral arteriosclerosis are objectively and simply evaluated based on the ultrasonic Doppler beat patterns.

In this study, the hemodynamic comparison between right and left carotid artery in hemiplegic patients who were suffered from cerebral apoplexy were made using by ultrasonic Doppler technique. The measurement of blood flow in both upper and lower extremities were made using identical technique.

Materials and Methods
Materials consist of 25 hemiplegic patients suffering from cerebral apoplexy, i.e. cerebral hemorrhage 20 cases, cerebral infarction 4 cases and cerebral embolism 1 case (due to the insufficiency of heart valve). The age of patients were all over 50-years-old except a patient with embolic cerebral infarction (33-years-old). The normotensive patients (under 160 mmHg) consist of 20 cases (80%) with regard to blood pressure.

Methods were as follows. The blood flow of right and left side at following arteries were determined by ultrasonic Doppler technique: carotid artery, brachial artery and femoral or external iliac artery. The measurement of retinal artery pressure by ophthalmodynamometry and determination of retinal arteriosclerosis by Schie's classification were also carried out. In addition, the hemodynamic comparison of the both carotid artery was made in one patient with conspicuous right side tortuous common carotid artery.

Results

1) Hemodynamic comparison of right and left side of carotid and limb artery (Fig.1)

There are no significant differences between right and left blood flow patterns of carotid and limb artery in hemiplegic patients independent of the clinical findings and severity of neurological symptoms.

2) Analysis of the blood flow patterns in internal carotid artery (Fig. 2)

Analysis of the blood flow patterns in internal carotid artery were as follows. Continuous pattern O, intermediate pattern 10 cases and discontinuous pattern 15 cases. *

* The blood flow patterns in internal carotid artery using by ultrasonic Doppler
R. Hemiplegia  61 years old man
Right side  Left side

Fig. 1 The hemodynamic comparison between right and left carotid (limb) artery in hemiplegic patient
1:  A. carotis interna
2:  A. carotis communis
3:  A. brachialis
4:  A. femoralis

Fig. 2 The blood flow patterns of internal carotid artery in hemiplegic patients.

Fig. 3 The relationship between blood flow patterns and retinal arteriosclerosis (Scheie's grade) in hemiplegic patients.

3) Relationship between the blood flow patterns in internal carotid artery and retinal arteriosclerosis (Fig. 3)

The possible correlation between them were observed. From this results, it was postulated that the correlation of retinal arteriosclerosis and cerebral vascular resistance, or cerebral arteriosclerosis, was significant.

4) Comparison of right and left retinal artery pressure (Tab. I)

The pressure difference of right and left retinal artery in the hemiplegic patients and the healthy-looking normal aged (consist of normotensive and hypertensive) were evaluated by following formula.

Pressure difference(%) =
\[
\frac{\text{pressure difference of both retinal arteries}}{\text{high retinal artery pressure}} \times 100
\]

There are no significant differences between right and left retinal artery pressure (systolic and diastolic pressure) in both groups.

*Japanese Circulation Journal Vol. 29, April 1965*
Table I  The difference between right and left retinal artery pressure in both hemiplegic patients and normal old men.

<table>
<thead>
<tr>
<th></th>
<th>No. of cases</th>
<th>Systolic pressure</th>
<th>Diastolic pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td>Hemiplegic patients</td>
<td>23</td>
<td>0~16.4%</td>
<td>7.0%</td>
</tr>
<tr>
<td>Normal old men</td>
<td>14</td>
<td>0~12.5%</td>
<td>6.9%</td>
</tr>
</tbody>
</table>

\[
\text{Pressure difference (\%)} = \frac{\text{higher pressure} - \text{lower pressure}}{\text{higher pressure}} \times 100
\]

Right side  Left side

1
2
3
4.5

Fig. 4  The hemodynamic comparison of both carotid artery in one patient with tortuous common carotid artery of right side.

5) Hemodynamic comparison of both carotid artery in one patient with tortuous common carotid artery of right side (Fig. 4)

The significant difference was observed between right and left blood flow patterns of common carotid artery in this case.

Discussion

The cerebral circulation in cerebral vascular disorders are investigated by various methods, i.e. the decrease of cerebral blood flow and cerebral oxygen-glucose consumption by inert-gas or indicator-injection method, the time delay of cerebral circulation at focal site by fluorescein-dye test and the decrease of retinal artery pressure by ophthalmodynamometry. Except these quantitative method, electroencephalography and cerebral angiography were also used to evaluate pathophysiology in cerebral vascular disorders. However, hemodynamic comparison of right and left side in hemiplegic patients using by above methods should be difficult, since these methods were either indirect or discontinuous technique.

In this study, the blood flow patterns of right and left carotid artery in hemiplegic patients

Japanese Circulation Journal Vol. 29, April 1965
who were suffered from cerebral apoplexy are equal in magnitude and symmetric in shape. The results indicate the hemodynamic equalization of intra and extracranial circulation. The results of ophthalmodynamometry also support above concept. The hemodynamic equalization of cerebral circulation in hemiplegic patients may be resulted from the following factors, i.e. cerebral collateral circulation in which Willis’s circle play a most important role\textsuperscript{4,5,10,15} and homeostatic circulatory regulation at focal site, \textsuperscript{16,17} etc. In addition, pathomorphological characteristics of cerebral apoplexy in Japan, which frequently occurs in central nucleus,\textsuperscript{18} are to be considered, because the cerebral circulatory equalization resulting mainly from collateral circulation may well be sufficient under this pathophysiological condition. On the other hand, the hemodynamic change in one patient with tortuous common carotid artery suggests that the change of blood flow pattern at focal vessel should have been occurred in case of the extracranial vascular lesion, e.g. aortoocranial disease. In another words, the ultrasonic Doppler technique may be useful for detection of the extracranial vascular lesions.

The discrepancy of neurological symptoms with hemodynamics of cerebral and limb artery, i.e. equal in magnitude and symmetric in shape of blood flow patterns in carotid and limb artery, suggests that the neurological symptoms in hemiplegic patients suffering from cerebral apoplexy do not directly reflect with cerebral circulatory insufficiency, but cerebral focal disorders.\textsuperscript{10,19} In addition, it is to be considered that the uncrossed pyramidal component subserves an ipsilateral innervation of motor functions in hemiplegic patients, i.e. variation of pyramidal decussation.\textsuperscript{20}

**Conclusion**

In this study, the hemodynamic comparison between right and left carotid artery in hemiplegic patients who were suffering from cerebral apoplexy and one patient with conspicuous right side tortuous common carotid artery are investigated using by ultrasonic Doppler technique. Based on the results, the clinical usefulness of the method was discussed.

**REFERENCES**

16) Meyer. J. S., 4) P. 80. 5) P. 46.
19) Sokoloff. L., P. 34 in Reference 5)

*Japanese Circulation Journal Vol. 29, April 1965*