Efficacy of Superficial Temporal to Middle Cerebral Artery Anastomosis against Hemodynamic Stroke

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Abstract

The effect of superficial temporal artery-middle cerebral artery anastomosis on regional cerebral blood flow (rCBF) was measured on 31 patients with ischemic cerebrovascular diseases. rCBF was measured on the precentral and superior temporal gyri during surgery using the thermal diffusion technique. The mean rCBF was significantly lower than controls before anastomosis, but increased significantly after. Severer clinical symptoms were associated with lower rCBF. The rCBF increased significantly in patients with transient ischemic attack, reversible ischemic neurological deficit, and minor and major completed stroke. All 31 patients demonstrated dysautoregulation, both before and after anastomosis. However, the rCBF had increased above the ischemic threshold during hypotension, achieving a reserve capacity to prevent hemodynamic stroke.

Key words: STA-MCA anastomosis, cerebral blood flow, autoregulation, hemodynamic stroke

Introduction

Extracranial-intracranial (EC/IC) bypass surgery has been used to treat a large number of patients with ischemic cerebrovascular disease since 1967. However, the results of the international EC/IC bypass study have questioned the usefulness of EC/IC bypass in the prevention of future strokes. This study measured the regional cerebral blood flow (rCBF) during surgery on the precentral and superior temporal gyri before and after bypass surgery for ischemic diseases, and investigated the local hemodynamics including autoregulation before and after bypass.

Materials and Methods

This study included 31 patients undergoing superficial temporal artery (STA)-middle cerebral artery (MCA) anastomosis for occlusive cerebrovascular diseases in our facility. All patients had symptoms of hemispheric ischemia ipsilateral to the lesion. There were 23 males and eight females aged 42 to 75 years (mean 59.5 yrs). Clinical symptoms were transient ischemic attack (TIA) in 10 patients, reversible ischemic neurological deficit (RIND) in 12, minor completed stroke in six, and major completed stroke in three. Angiographic findings were internal carotid artery (ICA) occlusion in 15 patients, inaccessible ICA stenosis (≥ 50%) in eight, MCA occlusion in five, and MCA stenosis in three.

Eight patients aged 35 to 74 years (mean 56.4 yrs) with nonruptured intracranial aneurysm were used as controls. The rCBF in the control patients was measured on the precentral gyrus where angiography showed no circulatory disturbance.

The STA-MCA anastomosis was performed more than 4 weeks after onset when the neurological symptoms were stable. The patency of the anastomosis was checked by angiography after the procedure in all patients.

The rCBF was measured during surgery by the thermal diffusion technique using a flow probe with a Peltier stack on the precentral and superior temporal gyri before and after bypass. The rCBF was first measured at normotension. To investigate the autoregulation of rCBF, the mean systemic arterial blood pressure (MBP) was then reduced using tri-
metaphan camsylate, and the rCBF on the precentral gyrus was continuously measured. The PaCO₂ was maintained at 35-40 mmHg without significant change before and after anastomosis at any MBP.

The significance of increases in rCBF was tested using Student's t-test.

**Results**

Table 1 shows the rCBF (mean ± SD) for the control and ischemic disease patient groups. The mean rCBF of the ischemic group was significantly lower on both the precentral and superior temporal gyri compared to the control group before STA-MCA anastomosis, and increased significantly after anastomosis.

Patients with RIND, and minor and major completed stroke demonstrated significantly lower rCBF before anastomosis compared to controls. More severe clinical symptoms were associated with lower rCBF. After anastomosis, the rCBF increased significantly in patients with TIA, RIND, and minor and major completed stroke.

Patients with MCA occlusion had a much lower rCBF before anastomosis than other groups (ICA occlusion or stenosis, and MCA stenosis). The rCBF increased in all groups, significantly in the ICA and MCA occlusion patients. However, the rCBF in the MCA occlusion patients did not exceed that in the controls.

**Figure 1** shows the autoregulation of rCBF on the precentral gyrus investigated intraoperatively.

**Table 1** rCBF in ischemic patients undergoing STA-MCA anastomosis

<table>
<thead>
<tr>
<th>Patient group</th>
<th>rCBF before anastomosis (ml/100 g/min)</th>
<th>rCBF after anastomosis (ml/100 g/min)</th>
<th>Difference Before/after bypass</th>
<th>With control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group (n = 8)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>precentral gyrus</td>
<td>46.5 ± 8.6</td>
<td>-</td>
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<td></td>
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<tr>
<td>Ischemic group (n = 31)**</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>precentral gyrus</td>
<td>38.6 ± 12.9</td>
<td>50.2 ± 13.7</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>superior temporal gyrus</td>
<td>38.0 ± 14.5</td>
<td>50.1 ± 14.5</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Clinical symptoms:</td>
<td></td>
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<tr>
<td>TIA (n = 10)</td>
<td>44.4 ± 18.1</td>
<td>59.5 ± 14.1</td>
<td>p &lt; 0.01</td>
<td>NS</td>
</tr>
<tr>
<td>RIND (n = 12)</td>
<td>36.0 ± 10.2</td>
<td>42.4 ± 11.1</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>minor completed stroke (n = 6)</td>
<td>35.0 ± 5.2</td>
<td>43.5 ± 7.8</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>major completed stroke (n = 3)</td>
<td>33.9 ± 1.0</td>
<td>51.0 ± 9.5</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
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<tr>
<td>Angiographic findings:</td>
<td></td>
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<tr>
<td>ICA occlusion (n = 15)</td>
<td>38.5 ± 7.8</td>
<td>50.2 ± 10.8</td>
<td>p &lt; 0.01</td>
<td>NS</td>
</tr>
<tr>
<td>ICA stenosis (n = 8)</td>
<td>39.5 ± 13.8</td>
<td>49.5 ± 10.3</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>MCA occlusion (n = 5)</td>
<td>26.6 ± 8.1</td>
<td>38.5 ± 7.4</td>
<td>p &lt; 0.01</td>
<td>NS</td>
</tr>
<tr>
<td>MCA stenosis (n = 3)</td>
<td>50.3 ± 20.1</td>
<td>71.1 ± 11.1</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Values are means ± SD. *MBP 106.6 ± 9.7 mmHg, PaCO₂ 34.5 ± 4.9 mmHg. **MBP 103.6 ± 12.0 mmHg, PaCO₂ 38.2 ± 2.9 mmHg. NS: not significant.

*Neurol Med Chir (Tokyo)* 33, December, 1993
by induced hypotension. RCBF before STA-MCA anastomosis decreased gradually following induction of hypotension. After anastomosis, the rCBF similarly decreased. Autoregulation was disturbed both before and after anastomosis. However, the rCBF easily declined to a value close to the ischemic threshold in the hypotensive stage before anastomosis, but after, only fell to a value safely above the ischemic threshold.

No patient suffered postoperative mortality or morbidity. Three months after surgery, outcomes were good recovery in 25 patients, moderately disabled in four, and severely disabled in two according to the Glasgow Outcome Scale. No neurological deterioration occurred postoperatively. All patients were followed up (mean 4.1 yrs, range 1.2–6 yrs), but no recurrence, new ischemic symptoms, or worsening neurological deficit has occurred in any patient.

Discussion

Our ischemic cerebrovascular disease patients demonstrated that severer clinical symptoms were associated with a much lower preoperative rCBF. The clinical symptoms reflected the primary occlusive finding and collateral circulation on angiograms. ICA and MCA occlusion and ICA stenosis patients had a mean rCBF lower than that of the controls. The preoperative rCBF is thought to be controlled by the occlusion location and grade, and also by the collateral circulation. In our series, six patients manifested no low-density area on computed tomographic scans. Their mean rCBF in the precentral gyrus was 34.5 ± 11.1 ml/100 g/min before anastomosis and angiographic findings were relatively severe; ICA occlusion in three patients, ICA stenosis in two, and MCA occlusion in one. Nevertheless, all patients had good collateral circulation on angiograms. The symptoms were therefore thought to be due to the hemodynamic effect.

The effect of EC/IC bypass on autoregulation of rCBF has never been measured during surgery. Healthy people demonstrate autoregulation of rCBF but in ischemia autoregulation is disturbed, the so-called dysautoregulation. Our study used trimetaphan camysylate which easily induces a hypotensive state, and is thought to have no direct effect on the cerebral vessels. Usually, a 40% decrease in normal CBF is the maximum long-term reduction in flow considered to be safe. Our control rCBF was 46.5 ml/100 g/min, so the ischemic threshold was 27.9 ml/100 g/min. Before bypass, the mean rCBF at MBP 80 mmHg was 29.8 ml/100 g/min, rather close to this ischemic threshold. After anastomosis, the mean rCBF at MBP 80 mmHg was 38.5 ml/100 g/min, adequately above the ischemic threshold. In our study, the STA-MCA anastomosis did not improve autoregulation immediately after bypass. However, the rCBF was maintained higher than the ischemic threshold even in the hypotensive stage immediately after bypass. None of our 31 patients experienced recurrent or worsening neurological symptoms after surgery including during follow-up. Therefore, the increase in rCBF due to the bypass prevented ischemic events even in the postoperative hypotensive stage, and provided reserve capacity against hemodynamic stroke. We believe that EC/IC bypass surgery is useful in the prevention of hemodynamic stroke.

References

11) Yamagata S, Kikuchi H, Karasawa J, Ihara I, Nagata


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