Microvascular bypass surgery

Part 1: Anatomical studies

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Microvascular anatomical studies were performed to ascertain the most suitable cortical vessel for extracranial-intracranial arterial bypass (EIAB). The three most commonly used cortical areas (the tip of the frontal lobe, the tip of the temporal lobe, and the area at the angular gyrus) were examined in detail. Because of their accessibility and size, the cortical arteries in the area of the angular gyrus offer the most suitable location for creating an EIAB.

Key Words • extracranial-intracranial arterial bypass • superficial temporal artery • middle cerebral artery anastomosis • revascularization • transient ischemic attacks

PIONEERING studies by Donaghy, Yağargil, et al., suggest that microvascular bypass surgery may benefit patients suffering from transient ischemic attacks (TIA’s) due to occlusive cerebrovascular lesions. Theoretically, microvascular anastomosis gives ischemic cortex an additional collateral blood supply. Provisional indications for such a surgical procedure have been described elsewhere.

In many cases TIA’s and strokes are caused by emboli in the territory irrigated by the middle cerebral artery (MCA). According to the principles of laminar flow, emboli tend to be channeled into the middle region of the internal carotid artery (ICA) and, as a result, are carried primarily through the relatively large orifice of the MCA as it branches off the ICA. Symptomatic occlusive intracranial vascular disease of nonembolic origin also affects the MCA tree. Chronic complete occlusion of the cervical internal carotid artery frequently causes symptoms referable to the MCA distribution; standard endarterectomy is not recommended for this lesion because of poor postoperative patency rates.

In this paper we report on the technical and anatomical factors important in establishing optimal flow and, consequently, an efficient extra-intracranial artery bypass (EIAB). If the EIAB is to be effective in establishing a collateral blood supply to ischemic cortex, the extracranial artery must be anastomosed to...
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some portion of the MCA tree and provide sufficient blood flow to support adequate metabolic function. The cortical branches of the MCA are readily accessible anatomically by means of a small craniectomy, and in order to determine which branch of the MCA is best suited to microvascular anastomosis, we undertook a detailed topographical analysis of the superficial cortical vasculature. The parameters recorded in this study were vessel size, location, and accessibility.

**Materials and Methods**

Fifty cadaver brains were injected with latex and fixed in formalin. The surface arterial vasculature of three cortical regions, namely, the convexity of the frontal lobe, the tip of the temporal lobe, and the region of the angular gyrus (the sites most commonly used for EIAB), were observed with the operating microscope (Fig. 1). The course and size of the superficial cortical vasculature were recorded. A 4-cm cortical zone (Fig. 2) representative of the exposure obtained through a small craniectomy was examined in the tip of the temporal lobe, the frontal lobe, and the area of the angular gyrus.

**Results**

Marked variations in size of the surface cortical arteries were apparent upon microscopic examination. The surface arteries at the tip of the angular gyrus were consistently larger than the arteries of the other two regions observed. The results are summarized in Table 1.

**Discussion**

In determining the cortical arteries best suited for microvascular anastomosis we con-

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**TABLE 1**

*Cortical artery diameter measurements in 50 cadavers*

<table>
<thead>
<tr>
<th>Cortical Artery Diameter (mm)</th>
<th>Tip of Temporal Lobe (% incidence)</th>
<th>Frontal Lobe (% incidence)</th>
<th>Angular Gyrus Temporal Lobe (% incidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 mm</td>
<td>5</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>1.8 mm</td>
<td>5</td>
<td>5</td>
<td>57</td>
</tr>
<tr>
<td>1.4 mm</td>
<td>17</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>1.0 mm*</td>
<td>70</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>0.9 mm</td>
<td>100</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>0.6 mm</td>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

* Critical diameter for long-term patency.
sidered three factors, namely, consistent topography, external diameter, and proximity to superficial temporal artery and occipital artery. The availability of a suitable artery did not prove to be a discriminating factor because all three cortical regions consistently contained one or more acceptable arteries within the designated 4-cm zone.

Other factors being equal, the size of the lumen determines flow through a conduit. According to Poiseuille's law, which states that flow is directly proportional to the fourth power of the radius when all other factors remain constant, a diameter reduction of 50%, that is, from a 2-mm to a 1-mm lumen, will result in a 16-fold reduction in flow. Although the principles defining flow of a Newtonian fluid through a rigid cylinder are not strictly applicable to the complex laminar flow characteristics of a pulsatile circulatory system, this model provides a reasonable approximation of changes that may occur in circulation when various flow parameters are altered.

As indicated in Table 1, the largest cortical arteries course over the angular gyrus, and it is the only cortical area consistently containing superficial arteries with a diameter greater than 1 mm. A diameter of 1 mm approaches the minimum critical diameter required for long-term anastomotic patency. In contrast, arteries available at the tip of the temporal lobe and over the frontal convexity are considerably smaller than those of the angular gyrus region, and these two regions satisfy the 1-mm critical diameter requirement only 70% and 52% of the time respectively.

A second advantage of the cortical vessels in the region of the angular gyrus is their proximity to either the dissected superficial temporal artery or the occipital artery. In contrast, the use of temporal and frontal arteries, because of their rostral location, would impose significant tension on the ocipital artery. The present study indicates that the superficial arteries of the angular gyrus, for instance the posterior temporal artery or the angular artery, are most suitable for EIAB. We have also shown that with a high degree of probability, a 4-cm craniectomy over this region will expose these arteries.

References

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