Transzygomatic-Subtemporal Approach for Middle Meningeal-to-P2 Segment of the Posterior Cerebral Artery Bypass: An Anatomical and Technical Study

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ABSTRACT

We evaluated the use of a bypass between the middle meningeal artery (MMA) and P2 segment of the posterior cerebral artery (PCA) as an alternative to an external carotid artery (ECA-to-PCA) anastomosis. Five adult cadaveric heads (10 sides) were used. After a temporal craniotomy and zygomatic arch osteotomy were performed, the dura of the floor of the middle cranial fossa was separated and elevated. The MMA was dissected away from the dura until the foramen spinosum was reached. Intradurally, the carotid and sylvian cisterns were opened. After the temporal lobe was retracted, the interpeduncular and ambient cisterns were opened and the P2 segment of the PCA was exposed. The MMA trunk was transected just before the bifurcation of its anterior and posterior branches where it passes inside the dura and over the foramen spinosum. It was anastomosed end to side with the P2 segment of the PCA. The mean caliber of the MMA trunk before its bifurcation was 2.1 ± 0.25 mm, and the mean caliber of the P2 was 2.2 ± 0.2 mm. The mean length of the MMA used to perform the bypass was 32 ± 4.1 mm, and the mean length of the MMA trunk was 39.5 ± 4.4 mm. This bypass procedure is simpler to perform than an ECA-to-P2 revascularization using long grafts. The caliber and length of the MMA trunk are suitable to provide sufficient blood flow. Furthermore, the course of the bypass is straight.

KEYWORDS: Artery graft, bypass, middle meningeal artery, posterior cerebral artery

Pathologies causing vertigo or dizziness can originate centrally or peripherally. Patients with these symptoms often seek treatment in neurology, neurosurgery, or otolaryngology clinics. Vertebro-basilar insufficiency is one of the most common causes of central vertigo or dizziness, and several bypass procedures have been described for its treatment. The most common posterior circulation bypass is between the P2 segment of the posterior cerebral artery (PCA) and the external carotid artery (ECA) or vertebral artery (VA). Because it provides high blood flow, the P2 segment has been used as an anastomotic site. Either the VA or the ECA is used for the proximal anastomosis.¹⁻⁵ However, these techniques are limited by the graft materials (saphenous vein or radial artery), which are long and tend to be associated with a low patency rate.^{3,5,6} Therefore, we used cadavers to examine the suitability of the diameter and length of the middle meningeal artery (MMA) for use in an MMA-to-PCA bypass as an alternative to an ECA-to-PCA anastomosis in cadavers.

MATERIALS AND METHODS

Five adult cadavers were dissected bilaterally. In the supine position the head was turned ~70 degrees away from the side of dissection and tilted toward the floor. A preauricular temporal craniotomy skin incision was used. The skin and subcutaneous tissue flap were dissected forward, along with the pericranium and the superficial layer of the temporal fascia. As the zygomatic bone was approached, the deep layer of the temporal fascia was incised. The deep fascia and periosteum were dissected from the bone of the zygomatic arch, and the zygoma was completely exposed from its root to the zygomaticomaxillary suture. In the fascial region, the deep fascia was dissected from the masseter muscle. The skin flap was then dissected and reflected forward, along with the superficial temporal artery (STA) and the superior branches of the facial nerve. These structures were thus

preserved without injury. The masseter muscle was divided from its attachment to the zygomatic bone, and the temporal muscle was elevated from the temporal fossa.

A temporal craniotomy was extended from just above the external ear canal to the keyhole area. Usually, two bur holes were made (one in the keyhole region, and one in the posterior temporal region). A notch was made in the anterior temporal area. The bone was then cut and removed. Some of the pterional bone was removed with drills and rongeurs. The temporalis muscle was dissected away from the temporal bone and zygomatic arch.

Next, a zygomatic osteotomy was performed. Anteriorly, a V-shape was cut just posterior to the zygomaticomaxillary suture and included the lateral rim of the orbit. Posteriorly, the osteotomy was lateral to the condylar fossa. The zygomatic bone was removed and preserved for subsequent reattachment. The dura of the floor of the middle cranial fossa was then separated under the surgical microscope, from a lateral to medial direction and from a posterior to anterior direction.

The MMA was found by tracing the vessels from the dural surface medially. The MMA was dissected away from the dura until the foramen spinosum was reached extradurally. Intradurally, the sylvian and carotid cisterns were opened. After

Figure 1 The middle meningeal artery (MMA) is anastomosed end-to-side with the P2 segment of the posterior cerebral artery (PCA). The temporal lobe has been resected to improve the view of the middle cerebral artery (MCA) anastomosis.

Figure 2 Schematic illustration showing the middle meningeal artery (MMA)-to-P2 segment of the posterior cerebral artery (PCA) bypass. The arrow indicates the transposition of the MMA to perform the bypass procedure. ICA, internal carotid artery; Pcom, posterior communicating artery; BA, basilar artery; OcN, oculomotor nerve; TN, trigeminal nerve.

the temporal lobe was retracted, the interpeduncular and ambient cisterns were opened and the P2 segment of the PCA was exposed. The MMA trunk was transected just before the bifurcation of its anterior and posterior branches where it passed inside the dura over the foramen spinosum until it reached the P2 segment to which it was anastomosed end to side (Figs. 1 and 2).

The diameters of the MMA (before the exit of its anterior and posterior branches) and P2 segment and also the length of the MMA trunk, from the foramen spinosum to the bifurcation of the anterior and posterior branches, were measured with an electronic caliper.

RESULTS

The mean caliber of the MMA at the anastomosis site (before the exit of the anterior and posterior branches) was 2.1 ± 0.25 mm (range, 1.5 to 2.5 mm). The mean caliber of the P2 segment was 2.2 ± 0.2 mm (range, 2.0 to 2.4 mm). The mean length of the MMA needed to perform a bypass was 32 ± 4.1 mm (range, 28 to 36 mm). The mean length of the MMA trunk was 39.5 ± 4.4 mm (range, 35 to 44 mm). In all cadavers we were able to create a tension-free anastomosis between the MMA and P2.

DISCUSSION

Vertebrobasilar insufficiency is a common cause of central vertigo or dizziness. Several techniques are available for a posterior circulation bypass for its treatment: an occipital artery (OA)-to-posterior inferior cerebellar artery (PICA), OA-to-anterior inferior cerebellar artery (AICA), superficial temporal artery (STA)-to-superior cerebellar artery (SCA) or -to-PCA bypasses. Radial artery grafts from the VA to PICA and long venous grafts from the ECA or VA to the PCA have been used.^{1-5,7-16} The diameters of the donor (OA and STA) and recipient (PICA, AICA, or SCA) arteries are less than 2 mm, which limits their ability to provide sufficient blood flow. Procedures using the proximal PCA as the recipient and the ECA or VA as the donor vessel in the bypass are reported to be more protective.^{5,14,15} The VA is used as the proximal vessel if it is the same size as and is well connected to the other VA. If the VA is markedly dominant and the other VA is small, the ECA is used as the proximal artery.¹⁴

The use of the MMA as a donor site for bypass surgery has been described in detail. The MMA-to-MCA bypass has been used, especially when the STA has not been available as a donor artery.¹⁷⁻²⁰

We performed this anatomical study to determine whether the diameter and length of the MMA were suitable to perform an anastomosis between the MMA and P2 segment of the PCA

and to determine the feasibility of this surgery. We found that a short length of the MMA (~3 cm) was sufficient to create a bypass between the MMA and P2. The calibers of the MMA and P2 were well matched. Furthermore, the mean caliber of these arteries was more than 2 mm. Therefore, the bypass is likely to provide sufficient blood flow. Before such an anastomosis is performed, however, preoperative angiography would help to assess the diameters of the MMA and PCA to insure that they are large enough to serve as a usable bypass. The subtemporal transzygomatic approach has been found to be suitable for such a bypass procedure.

The MMA-to-P2 segment of the PCA bypass has several advantages. First, as noted, it should provide sufficient blood flow because the mean diameter of the MMA is more than 2 mm.³ Second, its patency rate may be high because it is a single, arterial-to-arterial graft. Artery-to-artery anastomoses have been reported to have patency rates as high as 90%.^{14,15} An ECA- or VA-to-P2 segment of the PCA bypass with long venous grafts have a lower patency rate (70–80%) although they provide high blood flow.^{6,16} Third, such a bypass is more simple to perform than an ECA-to-P2 bypass: no second incision or anastomosis is needed in the cervical region. Finally, in an ECA-to-P2 segment of the PCA bypass, the graft bends where it enters the cranium. However, the graft between the MMA and PCA follows an almost a straight course, which is important in creating a patent bypass. Bending and kinking diminish blood flow, and the graft may then occlude.⁶

The disadvantage of an MMA-to-P2 bypass is that the anastomosis is performed at considerable depth, unlike an STA-to-MCA bypass. To prevent cerebrospinal fluid leakage, the dura over the hole can be sealed with fibrin glue.

CONCLUSION

When an arterial-to-arterial bypass and sufficient blood flow are needed, an MMA-to-P2 segment of

the PCA bypass may be a good alternative to an ECA-to-PCA bypass using long grafts.

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