Internal Maxillary Artery to Upper Posterior Circulation Bypass Using a Superficial Temporal Artery Graft: Surgical Anatomy and Feasibility Assessment

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■ BACKGROUND: **Revascularization of the upper posterior circulation (UPC), including the superior cerebellar artery (SCA) and posterior cerebral artery (PCA), may be necessary as part of the surgical treatment of complex UPC aneurysms or vertebrobasilar insufficiency. The existing bypass options have relative advantages and disadvantages. However, the use of a superficial temporal artery graft (STAg) in a bypass from the internal maxillary artery (IMA) to the UPC has not been previously assessed. We studied the surgical anatomy and assessed the technical feasibility of the IMA-STAg-UPC bypass.**

■ METHODS: **Fourteen cadaver heads were studied. The STAg was harvested proximally from about 15 mm below the zygomatic arch. The IMA was exposed through the lateral triangle of the middle fossa. The IMA-STAg-UPC bypass was completed using a subtemporal approach.**

■ RESULTS: **The bypass was successfully performed in all specimens. The average length of the STAg from the donor to the recipient was 46.4 mm for the s_2 SCA, and 49.5 mm for the P_2 PCA. The average distal diameter of the STAg was 2.3 mm. More than 83% of STAgs had a diameter of ≥2 mm distally. At the point of anastomosis, the average diameter of the SCA was 1.9 mm, and the average diameter of the PCA was 3.0 mm.**

■ CONCLUSIONS: **The proposed bypass is anatomically feasible and provides a suitable caliber match between the bypass components. Our results provide the anatomic basis for clinical assessment of the bypass in tackling complex lesions of the vertebrobasilar system requiring revascularization.**

INTRODUCTION

Complex and giant aneurysms of the vertebrobasilar system are challenging lesions.[1-4] If left untreated, most of these lesions can be deadly.[3,5] Neither standard microsurgical clipping techniques nor endovascular treatment methods have been successful in tackling these lesions.[6-12] On the other hand, Hunterian ligation of the basilar artery is not a risk-free option to treat these lesions.[1,5] However, occlusion of the basilar artery proximal to the lesion combined with revascularization of the efferent branches may minimize neurologic complications and allow for a definitive treatment.[2,4,13-15] When selected carefully, patients with vertebrobasilar insufficiency (VBI) syndrome may also experience favorable surgical outcomes after revascularization of the rostral brainstem.[16-21]

Key words
- Ambient cistern
- Basilar artery
- Cerebral revascularization
- Posterior cerebral artery
- Subtemporal approach
- Superior cerebellar artery
- Vertebrobasilar insufficiency

Abbreviations and Acronyms
ATA: Anterior temporal artery
EC: Extracranial
ECA: External carotid artery
IC: Intracranial
IMA: Internal maxillary artery
PCA: Posterior cerebral artery
RAG: Radial artery graft
SCA: Superior cerebellar artery
STA: Superficial temporal artery
STAg: Superficial temporal artery graft
SVG: Saphenous vein graft
UPC: Upper posterior circulation
VBI: Vertebrobasilar insufficiency

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Revascularization of the posterior cerebral circulation is technically difficult and associated with high morbidity and mortality when associated with complex aneurysms or VBI.[4,13,17,18,22-24] The upper posterior circulation (UPC) vessels, including the superior cerebellar artery (SCA) and posterior cerebral artery (PCA), are accessible through the subtemporal approach, or pretemporal and orbitozygomatic modifications of the pterional approach.[1,18,25-28] However, because of narrow and deep surgical corridors, these approaches may not provide optimal access for completing a bypass to the UPC.[26,29]

Generally, the bypass is targeted to the segment of the PCA and/or SCA lying anterior or lateral to the mesencephalon (i.e., the P_2 or s_2 segment).[30] The superficial temporal artery (STA) has been commonly used for this purpose.[17,19,20,22,27,31] However, because the STA narrows progressively in its course, it may not provide sufficient flow to the recipient territories.[31-34] In such cases, an extracranial (EC)-intracranial (IC) bypass using an interposition graft may provide adequate flow. Interposition grafts such as the radial artery graft (RAG) or saphenous vein graft (SVG) between the external carotid artery (ECA) and SCA/PCA may be associated with caliber mismatch and complications from hyperperfusion syndrome or graft occlusion.[16,35,36]

Recently, IC-IC bypasses have gained recognition for the treatment of complex vascular lesions, including dolichoectatic vertebrobasilar aneurysms.[4,37,38] There are several reasons that make IC-IC bypasses appealing and advantageous; for example, the short distance between the donor and recipient, protection of the entire bypass by the cranial vault, and optimal caliber match between the donor and recipient. However, IC-IC bypass to the UPC complex is limited by its anatomic complexity.[37] The in situ SCA-PCA side-to-side bypass is an elegant solution,[38-41] but it is relatively difficult to perform, and sometimes, both arteries may need to be occluded to address a basilar apex disease. Furthermore, this technique does not work for VBI syndromes.

Recently, we have proposed the use of a proximally harvested STA graft (STAg) for intermediate-to-high-flow bypass from the internal maxillary artery (IMA) to the middle cerebral artery (MCA) territory.[42,43] We used a harvesting technique for the IMA through the lateral triangle of the middle fossa previously reported by our team, to decrease the graft length and maximize the caliber match between the graft and the MCA.[42,44] Inspired by the promising features of the IMA-STAg-MCA bypass, we conducted the present anatomic study to 1) assess the feasibility of IMA-UPC bypass using an STAg and 2) assess the caliber match and graft length to help predict long-term graft viability.

METHODS

Fourteen cadaveric heads (28 sides) were prepared for surgical simulation using our protocol, including a customized embalming formula.[45] This novel embalming formula enables realistic brain retraction, making cadaveric surgical simulation similar to real surgery. Each head was placed in a 3-pin freedom clamp (Mizuho America, Union City, California, USA) in the lateral position. The vertex was slightly tilted toward the floor. A temporal craniotomy was completed flush with the middle fossa floor.

Harvest of a Proximal STAg

The skin incision was designed to allow both harvest of the STA and a subtemporal craniotomy. Starting 1 cm anterior to the tragus, the incision ascended and curved posteriorly above the pinna. Just behind the pinna, the incision tuned superiorly and anteriorly to reach the midline behind the hairline.

Because the STA diameter tapers rapidly as it ascends in the scalp, we used our technique for harvesting a more proximal STAg, which provides a better length and diameter for the graft.[46] This method includes subcutaneous dissection in the galeal plane, below the level of the zygomatic arch and down to the capsule of the parotid gland. At this level, a galeal septum marks the border between the STA posteriorly, and the most posterior twig of the frontal division of the facial nerve, anteriorly (**Figure 1**). Staying behind this septum enables efficient harvesting of a larger-diameter STAg and provides protection for the facial nerve. As a result, the STAg was harvested as proximal as possible (about 15 mm below the level of the zygomatic arch), and the larger post-bifurcation STA branch was used when needed.

Exposure and Harvest of the IMA

The IMA was exposed using our previously reported middle fossa craniectomy through the lateral triangle.[44] After elevation of the temporal dura from the middle fossa floor, the lateral triangle of the middle fossa was identified lateral to the foramina of spinosum and ovale, between the sphenosquamosal and petrosquamosal sutures, staying anterior to a coronal plane passing through the anterior root of the zygomatic arch to avoid violation of the temporomandibular joint. Drilling this triangle exposed the infratemporal fossa just above the lateral pterygoid muscle. Partial resection of the muscle allowed exposure and isolation of the IMA medial to the buccal nerve. The artery was then clipped permanently just before its transition to the pterygopalatine fossa anteriorly. A temporary aneurysm clip was

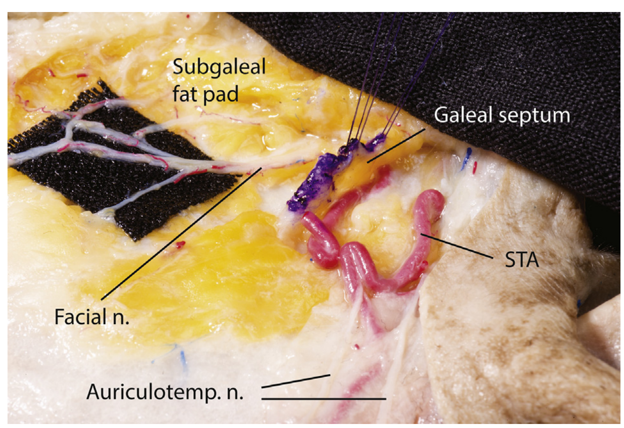

Figure 1. Cadaveric dissection showing the galeal septum between the superficial temporal artery (STA) and the most posterior twig for the frontal branch of the facial nerve (n.). This galeal septum protects the facial nerve and dissects the infrazygomatic part of the facial nerve. Dissection should be performed using microscopic magnification and started on the posterior aspect of the superficial temporal artery.