Operative nuances of an occipital artery to posterior inferior cerebellar artery bypass

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Occipital artery to posterior inferior cerebellar artery bypasses remain an important tool for cerebrovascular neurosurgeons, particularly in the management of complex aneurysms of the posterior inferior cerebellar artery requiring proximal occlusion or trapping. The procedure requires meticulous technique and attention to detail. The authors outline their technique for accomplishing this bypass emphasizing nuances for complication avoidance. (DOI: 10.3171/2009.2.FOCUS0911)

Key Words • occipital artery • posterior inferior cerebellar artery • cerebral revascularization • extracranial-intracranial bypass • low-flow bypass

Although once a commonly performed revascularization procedure for posterior circulation ischemic disease,5,9,11 endovascular techniques have largely supplanted OA to PICA bypass for this indication. However, OA-PICA bypass remains an indispensable tool in the management of complex aneurysms of the PICA that cannot be reconstructed using microsurgical clipping or coil embolization and require parent vessel occlusion or trapping.

Revascularization of the distal PICA territory can be accomplished with OA-PICA bypass, PICA-PICA side-to-side anastomosis (in situ bypass), or other less common techniques such as reimplantation of the PICA into the vertebral artery.1–4,6,7 Occipital artery-PICA bypass remains our preferred method of revascularization for the distal PICA territory, with PICA-PICA bypass reserved for those patients with an inadequate or injured OA. Occipital artery-PICA bypass involves temporary occlusion of only a single intracranial vessel and does not place both PICA vessels in jeopardy should there be bypass occlusion, a rare but nevertheless potential complication.

Successful OA-PICA bypass surgery requires thorough preoperative evaluation and planning, and precise and meticulous surgical technique. This article presents the technique of the senior author (A.S.D.) in performing OA-PICA bypasses and emphasizes strategies for complication avoidance.

Surgical Technique

Careful preoperative angiographic analysis of the caliber and course of the OA as well as the caliber and configuration of the PICA vessel and its tributaries is essential. We obtain a formal cerebral angiogram for any case that is under consideration for a bypass procedure. This should include external carotid artery injections to assess the size and course of the OA. The caliber of the OA should be at least 0.8–1 mm, while the PICA should be no smaller than the donor vessel. Anastomoses are feasible with smaller vessels, although patency and flow capacity are concerns. Preoperative angiographic assessment of the OA course will make the neurosurgeon aware of any tortuosities that may endanger a successful harvesting of the donor vessel (Video 1).

The patient is placed prone on the operating table in a Mayfield 3-point head fixator. Despite the frequency with which neurosurgeons place patients in the Mayfield, this is a crucial step that, if inappropriately performed, can make the bypass more difficult or even impossible to perform should the neurosurgeon fail to avoid the OA. The pins are placed so that the single pin is 2 cm superior and anterior to the pinna, ipsilateral to the donor OA. The paired pins are then placed contralateral to the donor OA, with the posterior pin 2 cm above the pinna. The head is maintained in a flexed position. The patient is secured with additional straps, padding, and tape to the operating table.

Abbreviations used in this paper: OA = occipital artery; PICA = posterior inferior cerebellar artery.
On the OA in the procedure. The skin incision is outlined in Fig. 1. Illustration of the skin incision, bone removal, and course of the OA in the procedure. The skin incision is outlined in dark blue. The descending limb of the incision toward the mastoid groove is made if it is necessary for the OA dissection. The bone removal is indicated in light blue for a standard OA-PICA bypass. The bone removal can be extended laterally and superiorly if a far-lateral approach will be incorporated. The OA is dissected from above the superior nuchal line down to the mastoid groove and left in continuity. Used with permission from B. Shepherd (www.shepherdvisual.com).

The skin incision is performed with the goal in mind of preserving the OA in continuity while skeletonizing it from the distal (above the superior nuchal line) to proximal (just medial to the mastoid groove) end (Fig. 1). Dissection of the OA is considerably more difficult than the dissection of the superficial temporal artery and meticulous attention to detail is a prerequisite. First, the midline avascular plane is identified. As the skin incision is extended laterally, the point at which the OA crosses the skin incision is noted. As this point is approached, a small curved hemostat is used to dissect over the OA and protect it as the incision is carried across it. The course of the artery is then followed proximally using Jamieson scissors. A generous periadventitial cuff is left along the OA. Small branches from the OA are coagulated using bipolar forceps at low current and sectioned at a distance from their origin from the OA trunk itself. Although the authors have used the microscope to perform this dissection, loupe and headlight magnification may be easier and more efficient. The OA is typically surrounded by a venous plexus and runs with the occipital nerve in a fascial sheath. A large muscular branch of the OA is often encountered proximally and should be coagulated and sectioned. This vessel can be anticipated from the preoperative angiogram and must not be confused with the main trunk itself. The OA should be dissected proximally until its entrance into the muscular bed at the mastoid groove. Through this dissection, the OA will have ample length and will follow a straight path from the mastoid groove to the site of anastomosis with the PICA.

The dissection of the OA is performed in stages corresponding to the muscle and skin flap dissection. This dissection in stages allows optimal visualization of the OA for the dissection and avoids working in a “hole.” As the suboccipital musculature is reflected from the occiput (leaving a cuff for reattachment along the superior nuchal line) and C-1, the OA is dissected progressively more proximally until the suboccipital region, occipital condyle, and arch of C-1 are exposed and the OA is completely skeletonized in continuity from above the superior nuchal line proximally to the mastoid groove.

A suboccipital craniotomy or cranietomy is performed extending from the side of interest just across midline. If a far lateral approach is required as part of the procedure, to trap or occlude a PICA aneurysm for example, additional bone is resected to expose the sigmoid sinus. The posterior third of the condyle and the arch of C-1 are removed (more laterally to the side of approach) for a far lateral transcondylar approach. Attention should be paid to any opened mastoid air cells, as the eventual passage of the OA graft through the dura prevents a watertight dural closure at the end of the surgery. Bone cement or bone wax can be used to seal the air cells to minimize the risk of a postoperative CSF leak.

Preparation of the Recipient Vessel

After the dura is exposed and meticulous hemostasis is obtained, the dura is opened in a curvilinear fashion from the midline at C-1 extending superolaterally to the top of the exposure. An additional incision is made superomedially and the dural margins are sutured to the adjacent tissue. Under the operating microscope, the medullary loop of the PICA is identified as it travels around the brainstem before coursing to the vermis and cerebellar hemisphere. Sharp dissection at high magnification is performed to free the caudal loop for performance of the anastomosis. The authors have encountered perforators to the medulla even at this distal PICA segment, and these should be preserved and the site of anastomosis adjusted accordingly. A 10-mm segment of the PICA should be prepared for the anastomosis. The contralateral PICA is visualized and dissected, allowing mobilization toward the ipsilateral PICA. This step is routinely performed to

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allow performance of a side-to-side PICA anastomosis as a second option for revascularization of the PICA territory should the neurosurgeon encounter difficulty with any step in the performance of an OA-PICA anastomosis.

A rubber background is placed under the ipsilateral PICA (Fig. 2). If there are no perforating vessels tethering this portion of the PICA, the background may be sutured to the soft tissue or dura superiorly and inferiorly to elevate the artery and isolate the segment. Suturing of the rubber background to the soft tissue was adopted from the work of Dr. Thor Sundt.

**Preparation of the Donor Vessel**

The OA, which has been left in continuity, is freed of adventitia and soft tissue under the microscope for a 10–15-mm segment at a distal portion of the OA, allowing enough graft length to comfortably perform the anastomosis. Although the artery can be freed of adventitia after it is sectioned, the turgor of the vessel when it is left in continuity usually facilitates the dissection. The dissection is performed with fine microscissors and jeweler forceps. The OA is then secured distally with a hemoclip and sectioned in an oblique fashion proximal to the clip. Excellent run-off should be obtained from the OA and a temporary aneurysm clip is applied proximally to prevent blood loss. Once both of these parameters are reached, temporary clips are applied proximally and distally on the recipient PICA. Using a sharp arachnoid knife or alternatively a 27-gauge needle, an arteriotomy is started and extended with microscissors. The lumen of the recipient vessel is irrigated with heparinized saline.

A 9-0 nylon suture (Ethicon) with a BV-100-4 needle (Ethicon) is used for the anastomosis as the muscular wall of the OA may bend the needle of the 10–0 nylon suture (Fig. 3). An interrupted suture technique is generally used and may allow future enlargement and maturation of the anastomotic site compared with a running suture technique, although a running suture technique may be substituted, particularly when both arteries are large. A stitch is placed first at the heel and toe of the donor artery, anchoring the graft to the recipient at both of these locations. The suture is placed from outside of the PICA into the lumen and exits through the OA from inside to the outside. Both anchoring sutures are tied and cut. Attention must be paid to avoid catching other portions of the recipient vessel wall. A single suture may be used multiple times and is more efficient as long it is handled appropriately. As the last few stitches are being placed, the suture may be trimmed to a suitable length but not tied to facilitate displacement of the subsequent stitch. Alternatively, the needle may be left in place between the donor and recipient wall as the next suture is placed. Eventually all sutures are tied. The OA is then rotated to expose the front wall that must be sutured. The inner lumen of the PICA is inspected to ensure accurate suturing of the back wall before beginning the front wall closure. The lumen is once again irrigated with heparinized saline. The front wall closure is then performed in a similar fashion using interrupted sutures. The lumen is filled with heparinized saline prior to completion of the final suture.

The temporary clip is removed from the distal PICA, followed by release of the temporary clip from the proximal PICA. The temporary clip is then removed from the OA. If any bleeding at the anastomotic site occurs, it will generally stop with the application of Surgicel (Johnson & Jonsson) and gentle compression using a cottonoid. Only rarely is an additional suture necessary and cau-
tion must be exercised to ensure accurate placement of the stitch. Warm, nonheparinized irrigation is also used at this point. Patency of the graft is confirmed using microDoppler, intraoperative angiography, or indocyanine green videoangiography.

**Closure**

After the anastomosis is performed with confirmed patency, and after the aneurysm has been obliterated (if applicable), closure is performed. The dura is closed except for a portion allowing the graft to enter without constriction. A dural substitute is placed around the OA entry site through the dura. The wound is copiously irrigated. All mastoid air cells are again inspected to ensure that they are completely sealed with bone cement or bone wax. The bone flap may then be replaced, leaving a large entry site for the OA pedicle, or a cranioplasty may be performed with titanium mesh. The muscle and fascia are carefully reaproximated to the superior nuchal line and the midline muscle and ligamentum nuchae is approximated in watertight fashion with 0-0 Vicryl (Ethicon) suture. The superior dermis and subcutaneous tissue is closed with interrupted 3-0 Vicryl suture and the skin is closed with a running 4-0 nylon suture. A loose head wrap is applied. The patient is maintained on 325 mg/day of aspirin and the systolic blood pressure is maintained in the normal range in the postoperative period.

**Complications and Other Considerations**

Although one should always strive for the perfect case, it is also necessary to prepare for instances when this ideal plan doesn’t occur. Patency of the graft is confirmed using microDoppler, intraoperative angiography, or indocyanine green videoangiography.

Blood flow or thrombosis in the well-harvested vessel, to kinking or damaging the vessel during closure. Because of the risk of damage to the OA, as well as the possibility that the OA will be insufficient, it is necessary to expose the contralateral PICA to prepare for a side-to-side anastomosis. Kinking can often be avoided by ensuring that there is ample OA length to reach the anastomotic site, while damaging the vessel during closure can be avoided by paying close attention to the graft at all times during closure (which is easier said than done).

After the anastomosis is complete, we have found that intraoperative indocyanine green videoangiography is useful in detecting correctable flow limitations such as stenosis at the site of the anastomosis. We also advocate frequent use of the microDoppler after any manipulation of the graft to ensure that adequate flow persists. Intraoperative angiography is rarely used. Although some procedures are altered by the presence of subarachnoid hemorrhage, our protocol does not differ for patients who present with acute subarachnoid hemorrhage.

Unfortunately, the potential for graft failure or inadequacy persists even in the setting of a successful technical surgery. In their series of OA-PICA bypasses for ischemic disease, Sundt et al. observed graft occlusion in 6 (13.0%) of 46 patients, as well as an additional patient in whom the graft did not supply sufficient flow. Four of these occlusions occurred in patients without a preoperative disability, and the occlusions did not result in any new deficits, leading the authors to conclude that the graft occlusion was likely a result of inappropriate patient selection. However, the 2 remaining graft occlusions and the insufficient graft all resulted in patient death. Whereas OA-PICA bypass is often the preferred technique for bypassing flow to the distal PICA territories, PICA-PICA anastomosis is another viable option. Patient series examining the results of this technique are scant; however, the few that exist have reported no issues with graft patency. The procedure allows for excellent matching of vessel caliber, but graft failure or occlusion in these cases have the potential.

**Fig. 3.** Illustration of the performance of the anastomosis. A: Heel and toe sutures are placed with 9-0 nylon suture anchoring the donor vessel to the recipient. B: The back wall is closed first using interrupted sutures. The suture is placed from outside of the PICA to the inside and from inside the OA to the outside. C: The front wall is closed using interrupted sutures. Each suture is placed from the outside of the OA to the inside and from inside the PICA to the outside. Used with permission from B. Shepherd (www.shepherdvisual.com).
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for disastrous consequences by compromising bilateral PICAs. For this reason the OA-PICA bypass has been our primary treatment option in these cases, but the decision is typically left to physician preference.

Wound healing and CSF leaks are also 2 significant potential complications that must be kept in mind. A wide-based flap, taking care to spare the posterior auricular artery, is performed. Additionally, because the dura cannot be closed in a watertight fashion, meticulous multilayer closure of the muscle and fascia, as well as careful approximation of the galea and skin, is necessary to minimize the risk of CSF leakage.

Conclusions

Ischemic posterior circulation disease was a previously common indication for performance of an OA-PICA bypass. Because this indication has largely been supplanted by endovascular techniques, the frequency of OA-PICA bypass operations has decreased. However, the OA-PICA bypass remains an important technique in the armamentarium of neurosurgeons treating complex cerebrovascular disease, particularly aneurysms of the PICA that cannot be adequately reconstructed with microsurgical clipping or coil embolization and that require parent vessel occlusion or trapping. In the authors’ practice, previously coiled, or stented and coiled, PICA aneurysms that recur and are not amenable to further endovascular therapy are a growing indication for an OA-PICA bypass followed by aneurysm trapping/parent vessel occlusion. Thorough preoperative evaluation and planning and meticulous surgical technique are critical in the successful performance of this surgery.

Disclaimer

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