Bypass Revascularization Applied to the Posterior Cerebral Artery

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BACKGROUND: **The application of bypass procedures to the posterior cerebral artery (PCA) in combination with proximal clipping or trapping is a useful option for the treatment of complex posterior circulation aneurysms, especially those of the PCA. Because of its course around the midbrain through various cisterns, different approaches are required to access the PCA.**

OBJECTIVE: **The presented study analyzes a retrospective case series of bypass procedures to the PCA to investigate the relevant treatment strategies and their outcomes.**

METHODS: **Seven patients with bypass procedures to the PCA bypass were analyzed. The location of the aneurysms, approaches, site of anastomosis, bypass patency, pre- and postoperative modified Rankin Scale scores, and transient and permanent morbidity were assessed.**

RESULTS: **Analyzed patients were treated for intracranial aneurysm located on the P2 ($n = 3$) or P3 ($n = 2$) of the PCA, bilateral vertebral artery dissecting aneurysm ($n = 1$) or internal carotid artery-posterior communicating artery aneurysm ($n = 1$). The following approaches were used: anterior temporal approach ($n = 2$), anterior temporal approach combined with subtemporal approach ($n = 2$), combined transpetrosal approach ($n = 1$), posterior interhemispheric approach ($n = 1$), and posterior interhemispheric approach with subtemporal approach ($n = 1$). All bypasses were patent. Permanent morbidity occurred in 2 patients via cognitive dysfunction ($n = 1$) and hemiparesis ($n = 1$).**

CONCLUSIONS: **Bypass revascularization of the PCA territory is effective for the treatment of complex vascular lesions affecting the posterior circulation. To address the various surgical segments of the PCA, different approaches are required. Combined approaches allow access to the PCA proximal and distal from the lesion.**

INTRODUCTION

The application of bypass procedures to the posterior cerebral artery (PCA) in combination with proximal clipping or trapping is an advantageous option for the treatment of complex aneurysms of the PCA, basilar artery, and vertebral artery.[1-7] Bypass procedures with the PCA as the recipient

Key words
- Aneurysm
- Anterior temporal approach
- Bypass
- Combined transpetrosal approach
- Posterior cerebral artery
- Posterior interhemispheric approach

Abbreviations and Acronyms
ATA: Anterior temporal approach
CTA: Computed tomography angiography
EC: External carotid artery
ICA: Internal carotid artery
M2: M2 segment of the middle cerebral artery
mRS: Modified Rankin Scale
OA: Occipital artery
P1: P1 segment of the PCA
P2: P2 segment of the PCA
P3: P3 segment of the PCA
P4: P4 segment of the PCA
PCA: Posterior cerebral artery
PCoA: Posterior communicating artery
PIHA: Posterior interhemispheric approach
RAG: Radial artery graft
STA: Superficial temporal artery
SVG: Saphenous vein interposition graft
V3: V3 segment of the vertebral artery

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Citation: World Neurosurg. (2016) 96:460-472.
http://dx.doi.org/10.1016/j.wneu.2016.09.031

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

artery are challenging, however, because of its close relationship to sensitive neuroanatomical structures and a deep, narrowed surgical corridor. The semicircular course of the PCA around the upper brainstem requires different approaches to the microsurgical target regions in the interpeduncular, ambient or quadrigeminal cistern, and posterior interhemispheric fissure.[8] As such, the approaches to the PCA are varied from anterior to posterior and include the pterional approach, subtemporal approach, transpetrosal approach, and occipital interhemispheric approach.[1-6,9-12]

The presented study analyzes and describes our retrospective case series on bypass procedures to the PCA territory as well as the relevant treatment strategies and their outcomes. A particular focus is the technical description of the microsurgical approaches and bypass options.

METHODS

This study was approved by the institutional review board at the Sapporo Teishinkai Hospital. Patient consent was not required in this study. From April 2012 to January 2016, we surgically treated 7 patients with PCA bypass for the treatment of intracranial aneurysm. The location of the aneurysms, surgical approaches, site of anastomosis, recipient artery, bypass patency, pre- and postoperative modified Rankin Scale (mRS) scores, and transient and permanent morbidity were assessed.

Pre- and Postoperative Evaluation

Pre- and postoperative radiographic evaluation were performed by computed tomography angiography (CTA) and magnetic resonance imaging, which were performed before the operation, immediately after operation, before discharge, 3–6 months after operation, 1 year after operation, and then at annual follow-up. The patency of the bypass and new ischemic lesions also were assessed.

The preoperative balloon test occlusion is not performed routinely because balloon test occlusion is not reliable for PCA territory even if the leptomeningeal collateral flow is sufficient.[13] Hence, in cases of fusiform aneurysm and patients not suitable for neck clipping, parent artery occlusion with bypass were selected.

Perioperative Care, Graft Selection, and Suturing Technique

Before performing bypass surgery, we routinely administer 100 mg of oral aspirin the day before surgery and continue doing so daily after surgery. If the perforating artery is seen to arise close to the occlusion site in the intraoperative findings, the administration of aspirin continues for an extended period of time. Otherwise, the aspirin regimen concludes within 2 weeks. An anticoagulant agent routinely is not administered peri- or intraoperatively.

Graft selection is dependent on the donor caliber, recipient artery caliber, and surgical approach. For the anterior temporal, subtemporal, and transpetrosal approaches, we select the frontal branch of the superficial temporal artery (STA) as the donor artery. For the posterior interhemispheric approach, we choose the occipital artery (OA) as the donor artery. Sometimes, however, the caliber of the donor artery is small compared with the recipient artery or the length is insufficient. In such cases, we opt for an interpositional graft.

In short, the anastomosis is performed in an end-to-side fashion. The cuff of the donor artery is cut in a fish-mouth shape. The cuffs between the recipient and donor vessels are opposed in an everted fashion to ensure that both endothelial layers are attached together and encourage reliable patency of the anastomosis. This method reduces the likelihood of a thromboembolic source forming and makes suturing safer and more accurate during the anastomotic procedure. The suturing is performed in an interrupted fashion, because the chance of donor artery growth after surgery is increased if there is demand for cerebral blood flow.

Nomenclature and Definitions

The PCA can be subdivided into 4 anatomic segments. The P1 segment of the PCA (P1) segment extends from the tip of the basilar artery to the junction of the posterior communicating artery (PCoA) and runs through the interpeduncular cistern. The P2 segment extends from the PCoA to the dorsal aspect of the midbrain. The P2 segment can be further subdivided into anterior (P2A) and posterior (P2P) segments. The P2A originates at the PCoA and courses around the cerebral peduncle to enter the proximal portion of the ambient cistern. The P2P begins at the posterior margin of the cerebral peduncle and runs along the posterolateral midbrain within the ambient cistern. The P3 segment extends from the lateral aspect of the quadrigeminal cistern at the origin of the posterior temporal artery to the anterior limit of the calcarine fissure. The P4 segment consists of the terminal cortical branches of the PCA, downstream of the offshooting parieto-occipital and calcarine arteries.

RESULTS

PCA Bypasses

In total, 7 patients with PCA bypasses were reviewed (Table 1). The underlying pathologies were P2 aneurysm ($n = 3$), P2 and P3 aneurysm ($n = 1$), P3 fusiform aneurysm ($n = 1$), bilateral vertebral artery dissecting aneurysm ($n = 1$), and internal carotid artery (ICA)-PCoA aneurysm ($n = 1$). The following approaches were used: anterior temporal approach (ATA, $n = 2$), ATA combined with a subtemporal approach ($n = 2$), combined transpetrosal approach ($n = 1$), posterior interhemispheric approach (PIHA, $n = 1$), and PIHA with subtemporal approach ($n = 1$).

All PCA bypasses were patent during follow-up periods, which ranged from 3 to 48 months. The postoperative transient morbidity included 2 cases (28.6%) of transient oculomotor palsy after ATA, 1 case (14.3%) of transient unispacial neglect, and 1 case (14.3%) of aphasia after PIHA. An asymptomatic thalamic infarction appeared postoperatively in 1 case (14.3%). Permanent morbidity included cognitive function disturbance due to infarction of the anterior thalamoperforating arteries ($n = 1$, 14.3%) and mild right hemiparesis due to thalamic infarction ($n = 1$, 14.3%). Infarctions were observed only in perforating zones from the affected segment due to intraluminal thrombosis and not in the revascularized distal PCA territory. Permanent morbidity occurred in 28.6% without mortality 0%, and the patency of all bypasses was 100%.