# Intracranial In Situ Side-to-Side Microvascular Anastomosis: Principles, Operative Technique, and Applications

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**Key words**
- Side to side anastomosis
- Intracranial bypass
- Cerebral bypass
- Cerebral revascularization
- In situ bypass
- Clipping of aneurysms
- Treatment of stenosis

**Abbreviations and Acronyms**
**ACOM**: Anterior communicating artery
**AICA**: Anterior inferior cerebellar artery
**CTA**: Computed tomographic arteriogram
**DACA**: Distal anterior cerebral artery
**DSA**: Digital subtraction angiogram
**ECA**: External carotid artery
**EC-IC**: Extracranial to intracranial
**EEG**: Electroencephalogram
**H&H**: Hunt and Hess
**IC-IC**: Intracranial to intracranial
**ICG**: Indocyanine green
**MCA**: Middle cerebral artery
**mRS**: Modified Rankin score
**PICA**: Posterior inferior cerebellar artery
**SAH**: Subarachnoid hemorrhage
**SCA**: Superior cerebellar artery
**RAG**: Radial artery graft

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OBJECTIVE: **Side-to-Side microvascular anastomosis is a revascularization technique used to create an artificial conduit between two similar adjacent vessels. This technique is used for microsurgical clipping of aneurysms, when indicated. It is important to study the angiographic results, both immediate and long term, along with the clinical outcomes and indications of the procedure.**

METHODS: **Fifteen patients who had this procedure over a fourteen-year period were reviewed for patency of bypass by intra-arterial digital subtraction angiography (DSA) and computed tomographic arteriograms (CTA) and their clinical outcomes were studied. The mean age of the study group was 53.4 years and mean angiographic follow up period was 14 months.**

RESULTS: **All surviving patients (14 patients) had patent anastomosis with good clinical outcomes. None of the patients developed a clinically manifested stroke due to the procedure, while one had a small asymptomatic infarct detected post operatively.**

CONCLUSION: **This technique is a useful and durable solution for correcting critical stenosis or complete occlusion of the vessels, while clipping intracranial aneurysms.**

## INTRODUCTION

Since the first bypass reported in 1967 by Yasargil for the treatment of cerebral ischemia, different surgical methods using various grafts have been tried and evaluated for cerebral revascularization (1, 10, 21). The concepts and techniques for bypasses have evolved over time along with their indications to get the best benefit of the risk associated with these highly technical procedures (8, 14, 17, 18, 20). In 1986, Ikeda et al. first described the microvascular side-to-side anastomosis technique (6). The idea of the technique is to create an artificial conduit for blood flow between two adjacent vessels of similar caliber. This type of in situ bypass has been commonly practiced in cardiothoracic surgery for coronary revascularization with high long-term patency rates (12). Although revascularization using a harvested graft vessel may be used for high-flow replacement in proximal vessels, local techniques of revascularization, without a graft, may be more advantageous for distally located vessels. After the initial neurosurgical case reports in the early nineties, a few case series have discussed the applications of the procedure (2, 9, 13). However, the long-term patency rate has not been well documented in cerebral vasculature. This article details the operative nuances, long-term patency, and clinical outcomes of this procedure based on consecutive series of patients treated by the senior author (LNS).

## INDICATIONS

Side-to-side microvascular anastomosis can be used electively or emergently for cerebral blood flow augmentation or replacement. This technique is chosen for flow replacement in many cases of complex aneurysms when clipping the aneurysm will result in the total occlusion of a small artery (**Figures 1A** and **1B**) or produce a critical stenosis (**Figure 1C**). In the anterior circulation, these situations can be addressed with A3-A3 anastomosis for anterior communicating artery (ACOM) aneurysms, A4-A4 anastomosis for pericallosal aneurysms, and M2-M2 or M3-M3 anastomosis for middle cerebral artery (MCA) aneurysms (8, 15, 16). In the posterior circulation, posterior inferior cerebellar artery (PICA) to PICA, anterior inferior cerebellar

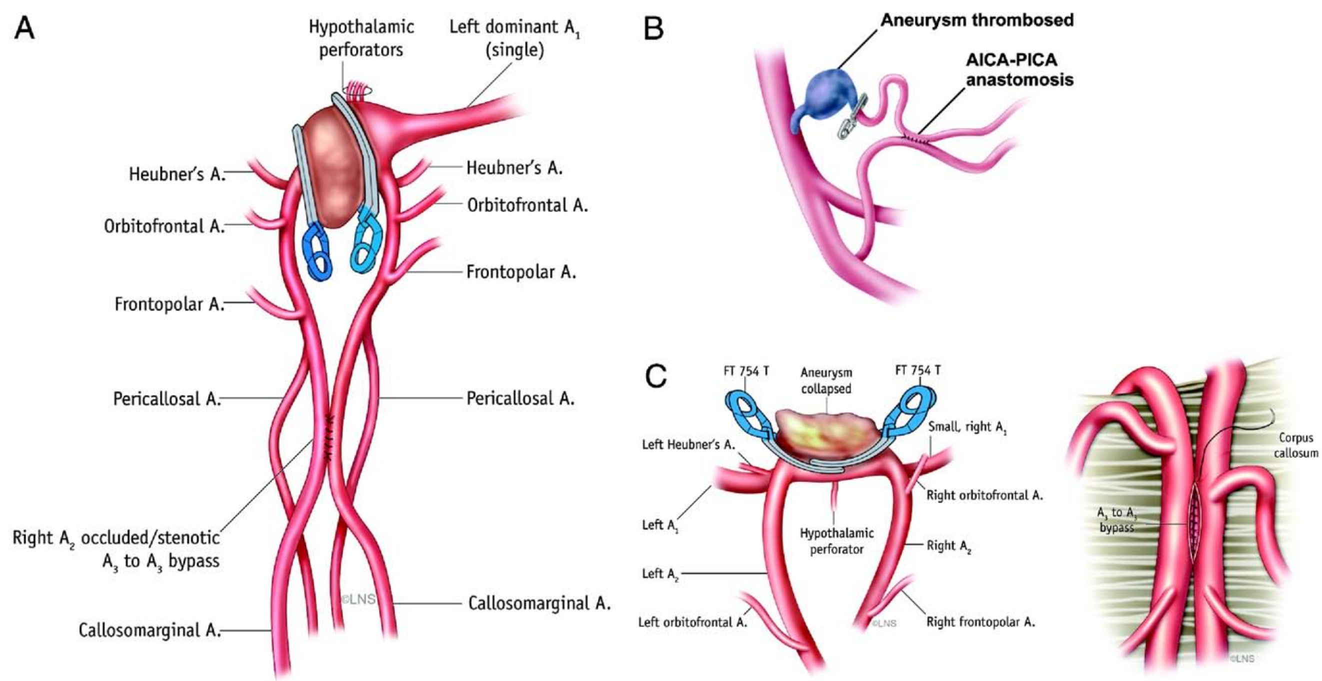


**Figure 1.** Demonstrating techniques to clip complex anterior communicating artery (ACOM) aneurysms with side-to-side anastomosis. **A,** Clipping of ACOM aneurysm with side-to-side anastomosis between pericallosal vessels to maintain distal flow, after occlusion of one of the vessels arising from the aneurysm. **C,** Stenosis and decreased blood flow due to clipping of ACOM aneurysm, managed with a distal side-to-side anastomosis of A3 vessels. **B,** Showing an anterior inferior cerebellar artery (AICA) to posterior inferior cerebellar artery (PICA) anastomosis following AICA occlusion resulting from clipping of the aneurysm. Illustrations copyright Laligam N. Sekhar, M.D.

artery (AICA) to PICA, and superior cerebellar artery (SCA) to PICA anastomosis can be used to treat aneurysms involving the origins of PICA, AICA, or SCA (**Figure 1B**) (4) . This anastomotic technique also becomes useful emergently when there is inadvertent vascular injury during an operation or trauma or occlusion of a planned extracranial bypass graft.

This technique can also be used appropriately as an adjunct to other revascularization procedures (case illustration 1). For complex aneurysms with multiple branches arising from it, more than one branch may have to be to be sacrificed e.g., both branches of MCA or A3. In such cases, a side-to-side anastomosis between the vessels with an end to side extra-intracranial bypass proximally feeding one of the two branches can be performed. (**Figures 1A** and **3F**)

The best indication for this technique is to revascularize a third- or fourth-order artery such as the A2-4, M2-3, P2-3, SCA, or PICA, when it is occluded by the treatment of the aneurysm or is significantly narrowed by clipping (50% or more diameter reduction). To perform this bypass, a neighboring artery must be available that is similar in size, and such that it can be approximated for 3 to 4 mm in parallel without tension. Alternatives to this technique are re-implantation, a short interposition graft to the recipient vessel from the adjoining vessel, and an extracranial to intracranial (EC-IC) bypass using the superficial temporal artery, occipital artery, or a radial artery graft.

## PATIENTS AND METHODS

Patients who underwent revascularization procedures for surgical clipping of aneurysms were identified from an IRB-approved prospective cerebrovascular registry at the University of Washington. From January 2005 to February 2009, a total of 81 patients had undergone various types of revascularization procedures for clipping of aneurysms, which included both high- and low-flow bypasses. Thirteen patients who underwent side-to-side anastomosis with or without other bypasses were identified from this cohort. Two patients who underwent this procedure between 1988 and 2003 were also included to form this study group of 15 patients. There were 11 women and 4 men in the age range of 28 to 71 with an average age of 53.6 years. Medical charts, arteriograms, anesthesiology records, and radiology records were reviewed retrospectively for all of these patients. Clinical outcome was determined at the last clinical follow-up visit using the modified Rankin score (mRS), and the graft patency was assessed with computed tomographic arteriograms (CTAs) and digital subtraction angiograms (DSAs). Of the total 15 patients who underwent this anastomosis, 8 had presented with subarachnoid hemorrhage (SAH). Seven patients with unruptured aneurysms had symptoms such as headache, ataxia, or double vision. All patients received standard preoperative and postoperative care. The last author (LNS) performed all operative procedures.

## OPERATIVE TECHNIQUE

The procedure is performed under a surgical microscope. The selected vessels can be of equal or slightly unequal caliber. Anastomosis should be performed between parts of the