Interdisciplinary Prevention and Management of Wound-Related Complications in Extracranial-to-Intracranial Bypass Surgery

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Extracranial-to-intracranial (EC-IC) bypass surgery may be necessary in patients with moyamoya disease and other ischemic conditions. However, there is a potential risk of wound-related complications in some cases. In this study, we report our approach to the prevention of wound-related complications in EC-IC bypass. Technical considerations and pitfalls of surgery are also discussed. This study included 89 patients with ischemic-onset moyamoya disease and atherosclerotic disease who underwent 108 superficial temporal artery (STA)—to—middle cerebral artery bypass procedures. Our study emphasized 3 major features. First, 3-dimensional simulation imaging was used to confirm STA anatomy. Second, the STA was meticulously dissected on the epigaleal layer to protect the galeal layer. Third, scalp skin ischemia was taken into consideration at each step until skin closure. There was no neurologic morbidity or mortality in this series. There were 2 cases of major wound-related complications requiring plastic surgical intervention, and 4 cases of minor complications that were treated conservatively. In major complication cases, the scalp defect was treated with pedicle flap reconstruction. In EC-IC bypass surgery, interdisciplinary management involving neurosurgery, plastic surgery, and radiology should reduce wound-related complications and achieve safe surgery.

INTRODUCTION

Extracranial-to-intracranial (EC-IC) bypass surgery is widely performed for moyamoya disease, ischemic cerebrovascular disease, and cerebral aneurysms or skull base tumors that are considered difficult to treat. The most common indication for EC-IC bypass surgery is symptomatic moyamoya disease. Many studies have verified the effectiveness of EC-IC bypass surgery for the prevention of ischemic events in moyamoya disease.[1-6] Furthermore, as EC-IC bypass surgery can reduce the rebleeding risk in adults with hemorrhagic moyamoya disease,[7] it is considered the treatment of choice. A recommendation of EC-IC bypass surgery for symptomatic atherosclerotic disease of the internal carotid or middle cerebral arteries is not common because of the results of an international randomized trial by an EC-IC bypass study group in 1985; in addition, the Carotid Occlusion Surgery Study concluded that EC-IC bypass surgery did not provide any overall benefit for patients.[8,9] However, the procedure is still performed, and the justification for this is based on other small series that highlight the effectiveness of EC-IC bypass surgery.[10]

Critical complications of EC-IC bypass surgery include graft occlusion, postoperative hyperperfusion, and intracranial hemorrhage, and outcomes have been reported.[11] However, wound-related complications, including scalp ulceration and necrosis, are also significant in patients who undergo EC-IC bypass surgery.[12-14] The risk of wound-related complications in EC-IC bypass surgery is caused by the decrease of superficial temporal artery (STA) blood flow to the skin. Therefore, wound-related complications can develop even in indirect anastomosis that

Key words
- Complication
- EC-IC bypass
- Ischemia
- Moyamoya disease

Abbreviations and Acronyms
3D: Three-dimensional
CT: Computed tomography
CTA: Computed tomography angiography
EC-IC: Extracranial-to-intracranial
MCA: Middle cerebral artery
STA: Superficial temporal artery

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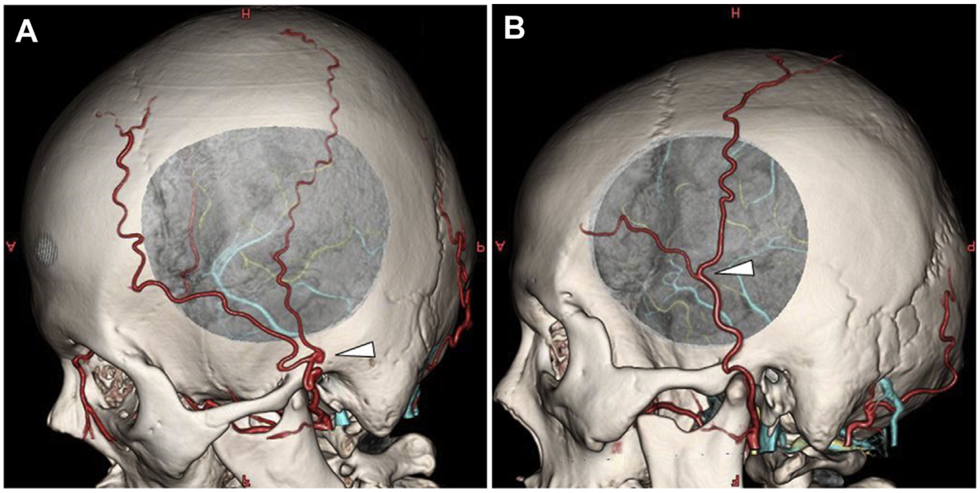

Figure 1. Preoperative planning imaging using 3-dimensional (3D) computed tomography angiography (CTA). In each case, the dominance of the superficial temporal artery (STA) branch and the location of the STA bifurcation (*arrows*) is different. 3D CTA shows the position of the STA bifurcation: (**A**) low bifurcation and (**B**) high bifurcation.

involves simple dissection of the STA.[15] As a relatively high incidence of wound-related complications has been reported in previous series,[12,14,16] we retrospectively evaluated our outcomes for EC-IC bypass surgery. We discuss technical tips and strategies for prevention and management of these complications. We also report a literature review.

MATERIALS AND METHODS

Patients

This study was approved by the Ethics Committee of Sapporo Medical University Hospital. All patients provided informed consent before participating. Between June 2009 and December 2017, 89 patients (37 men and 52 women) underwent 108 superficial temporal artery (STA)—to—middle cerebral artery (MCA) bypass procedures in our department. The median (interquartile range) age at the time of surgery was 49.0 years (30.0—64.8) ranging from 2 to 84 years. Moyamoya disease or quasi-moyamoya disease was diagnosed in 40 patients; 28 patients had ischemic cerebrovascular disease, and 21 patients had cerebral aneurysms. Bypass surgery was performed for symptomatic or pediatric moyamoya disease. In patients with atherosclerotic disease, bypass surgery was performed on those with a crescendo transient ischemic attack or hemodynamic compromise, as diagnosed with resting-state N-isopropyl (^{123}I)-p-iodoamphetamine single-photon emission computed tomography and an acetazolamide challenge test.

Preoperative Simulation Imaging

Computed tomography (CT) angiography (CTA) was performed using multidetector row CT (Aquilion ONE; Toshiba Medical Systems Corporation, Tokyo, Japan). The 3-dimensional (3D) CTA scanning parameters, the protocol for contrast material injection, and the postprocessing technique have been described previously.[17] The information was transferred to a workstation (Ziostation 2; Ziosoft, Tokyo, Japan), and 3D multicolored images were produced. Volume rendering, maximum intensity projection, and surgical simulation imaging were applied as a postprocessing technique to aid evaluation. Cortical surface and STA imaging was performed for bypass surgery planning. Specifically, the dominance of the STA branch, the location of the STA bifurcation, and anatomic variation of the STA were assessed. Next, the traveling pathway and the angle of STA branching were assessed.

Based on these data, an appropriate dissection range could be simulated. In single-bypass cases, the frontal branch could be preserved when the STA bifurcation is located near the zygomatic arch (**Figure 1A**). However, the frontal branch should be cut at the distal bifurcation when the STA bifurcation is more rostral (**Figure 1B**). In double-bypass cases, a wide subgaleal dissection range should be used when the STA bifurcation is located near the zygomatic arch.

Surgical Methods

We performed craniotomy around the anterior Sylvian fissure according to institutional policy.[17] In this method, the prefrontal, precentral, and central arteries should be selected as recipients for direct bypass. Our surgical strategy emphasizes 2 points. First, the STA was meticulously dissected on the epigaleal layer to protect the galeal layer. Second, skin ischemia should be considered at each step until skin closure. Our technique for scalp dissection and management of scalp soft tissue is as follows.

Dissection of the STA and Scalp Soft Tissue. The STA was meticulously harvested along the parietal branch under a surgical microscope. The dissection line was set along the arterial