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Bypass to the Intracranial Giant or Large Internal Carotid Artery Aneurysms: Superficial Temporal Artery to Middle Cerebral Artery Bypass Re-visited

Galip Zihni SANUŞ[1]
Ziya AKAR[2]
Taner TANRIVERDİ[3]
Banu TÜTÜNCÜLER[4]
Mustafa UZAN[5]
Civan IŞLAK[6]
Naci KOÇER[7]

[1,2,3,4,5] Istanbul University, Cerrahpasa Medical Faculty, Department of Neurosurgery, Istanbul, Turkey
[6,7] Istanbul University, Cerrahpasa Medical Faculty, Department of Radiology, Division of Neuroradiology, Istanbul, Turkey

ABSTRACT

OBJECTIVE: Hunterian ligation of the internal carotid artery is an acceptable treatment modality for inoperable intracranial carotid aneurysms. Despite the risk of thrombo-embolic complications, ligation together with superficial temporal artery-middle cerebral artery (STA-MCA) bypass surgery is vital in some patients. Our aim is to present our experience in five patients in whom STA-MCA bypass and balloon occlusion were performed due to inoperable intracranial carotid artery aneurysms.

METHODS: During the last five years, five patients with inoperable internal carotid artery (ICA) aneurysms were treated by STA-MCA bypass surgery followed by permanent endovascular ICA occlusion. Patients were selected for bypass surgery on the basis of failing balloon test occlusion. Patients were managed in the intensive care unit after surgical and endovascular procedures.

RESULTS: Clinical improvement was noted in all patients and no major complication during the follow-up was seen. Aneurysmal thrombosis was confirmed in all patients.

CONCLUSION: Hunterian ligation associated with bypass surgery is an effective treatment method in selected patients. The following points should be considered for a good outcome: 1) experienced surgeon for bypass surgery, 2) experienced neuroradiologist for endovascular occlusion of the parent vessel as close to the aneurysm neck as possible, and 3) judicious postoperative management by means of anticoagulation, fluid replacement, and pressure control.

KEY WORDS: Endovascular occlusion, Internal carotid artery aneurysm, STA-MCA bypass.

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INTRODUCTION

Although surgical clipping or endovascular coiling are the most commonly accepted treatment options for intracranial aneurysms, the presence of a wide neck, atheroma or calcification at the base in the case of giant or large intracranial aneurysms may preclude safe clipping or prevent adequate coil density at the aneurysm-parent vessel interface, leading to coil compaction or recanalization. Since the first extracranial-to-intracranial (EC-IC) bypass surgery for the successful treatment of complex middle cerebral artery (MCA) aneurysm (23), many authors have described EC-IC bypass for giant or large internal carotid artery (ICA) aneurysms including cavernous, petrous, high cervical and certain paraclinoid carotid aneurysms that are not amenable to surgical

Correspondence address:
Taner TANRIVERDİ
P.K: 5, 34301, Cerrahpasa,
Istanbul-Turkey
Phone: +90 212 414 34 27
Fax : +90 212 414 34 27
E-mail : tanerato2000@yahoo.com

or endovascular treatment (2, 6, 7, 11, 12, 14, 16-19, 25). On the other hand, following the report stating the failure of EC-IC bypass to reduce the risk of ischemic stroke by the EC/IC Bypass Study Group (22), there has been a decrease in the number of procedures. Recent studies have re-visited the utility of superficial temporal artery to middle cerebral artery (STA-MCA) bypass in the presence of occlusive cerebrovascular disease or complex intracranial aneurysms.

In this article, we report our STA-MCA bypass experience with five patients with large or giant intracranial ICA aneurysms that were not amenable to either clipping or endovascular coiling. We re-visited the utility of this procedure and want to present our results and discuss them under the light of the relevant literature.

PATIENTS AND METHODS

Patients

Five patients in whom STA-MCA bypass surgery was performed due to large or giant intracranial ICA aneurysms that were considered inoperable using either surgical clipping or endovascular coiling during the last five years were included in this study. Table 1 presents the summary demographic data of these five patients.

Imaging and indications for bypass surgery

All patients underwent magnetic resonance imaging (MRI) and/or computed tomographic (CT) scanning of the brain followed by cerebral angiography (CA) in conjunction with balloon test occlusion (BTO). The aneurysms in these patients were considered to be surgically unclippable depending on the findings of MRI, CT scanning or CA. The indication for bypass surgery was determined after failure of BTO, which has been defined as neurological deficits during 20-minute parent vessel occlusion and/or inadequate cerebral blood flow on the test occlusion on xenon blood flow tomography (< 30 ml/100 g/ min).

ICA test occlusion

ICA test occlusion was performed under neurolept anesthesia and took 15 minutes at the normal blood pressure for the patient. All patients were monitored in terms of vital signs and a meticulous neurological evaluation was performed. The balloon was deflated if the patient tolerated ICA occlusion after hypotensive challenge or developed a gross neurological deficit. ICA test occlusions in all patients were performed by the same two specialists (C. I and N.K).

Surgical technique

We used an end-to-side STA-MCA bypass that is known to be a relatively low volume bypass in all patients. All STA-MCA bypasses were performed by the senior author (Z.A). The readers of Turkish Neurosurgery may find the detailed explanation of the STA-MCA bypass procedure in the literature (8, 9, 13); however, the authors contributing to this study want to underline some points that should be considered while performing this surgery. First of all, the patient should be positioned so that the head can be turned to align the temporal and parietal region parallel to the floor and the incision should be marked directly over the STA branches, namely the frontal and parietal branches. Secondly, the branch to be used should be dissected from the surrounding tissue in an almost bloodless manner by using jeweler's forceps. Following dissection of the appropriate branch of the STA, irrigation with heparinized saline should be performed. And thirdly, gentle manipulation should not be forgotten and a dilute solution of papaverine should be placed on the donor artery and recipient artery to mitigate vascular spasm while performing the dissection of the donor artery and preparation of recipient artery, which is the angular or posterior occipital artery in the majority of cases. All patients began to receive aspirin immediately after bypass surgery, which was supplemented with low dose warfarin after 7 days and were monitored clinically and examined daily until ICA occlusion.

Timing of ICA occlusion and post-occlusion management

Permanent ICA occlusion was performed about 10 days after STA-MCA bypass in all patients. All patients underwent post-bypass test occlusion in order to verify bypass patency angiographically and to confirm whether there was clinical adaptation to improved flow. This is especially important in lower flow (STA-MCA) bypasses and all patients passed the second test occlusion. Post-ICA occlusion management included the monitorization of the patients in intensive care unit where systemic arterial and central venous pressures were monitored and intravenous heparin was continued for at least 48 hours. After hospital discharge, warfarin was continued for 3 months after which aspirin alone was used.

RESULTS

The clinical data of the patients are presented in Table 1. We included five patients, four women and one man, with a mean age of 50.2 ± 8.4 years and with a mean follow-up of 28.6 ± 25.6 months. Three patients (Patients 1, 2, 3) had headache in early period but completely recovered at the time of hospital discharge. None of the patients showed any complication in late follow-up period. STA-MCA bypass patency was confirmed angiographically in all patients.

Illustrative case

This 55-year-old woman presented with a long history of headache and 4-month history of diplopia. Following a CT scan of the head (Figure 1A), which demonstrated an oval shaped hyperdense mass lesion near the left cavernous sinus, MRI (Figure 1B) disclosed a large left ICA aneurysm 1.5 cm in diameter. The lesion was confirmed on MR-angiography (Figure 2A) and CA that showed the aneurysm originated from the cavernous and supraclinoid segment of the left ICA (Figure 2B). Since the patient could not tolerate BTO, we decided to perform an STA-MCA bypass. The patient underwent end-to-side STA-MCA bypass in which the frontal branch of the STA was connected to the angular artery (Figure 3). The postoperative course of the patient was uneventful and permanent occlusion of the left ICA was performed 10 days after surgery. Complete resolution of the patient's headache and sixth nerve palsy was achieved. An angiogram obtained at the 7-month follow-up examination showed a patent bypass (Figure 4).

DISCUSSION

Technical developments in diagnostic tools, operating microscope, microvascular suture materials and an extensive understanding of cerebral vascular territory anatomy have allowed the development of bypass procedures. After an international randomized trial that reported STA-MCA bypass was not superior to medical therapy for t reatment of ischemic cerebral diseases (22), the number of these procedures has decreased dramatically over the years. However, it is now well-known that cerebral revascularization is an important procedure in the treatment of complex intracranial aneurysms, cranial base tumors and some occlusive diseases. STA-MCA bypasses would be helpful in cases in which major vessel occlusion is required leading to interruption of the blood flow to the distal middle cerebral vasculature, and recent cadaveric (8, 9, 20, 21) or clinical publications (2, 6, 7,

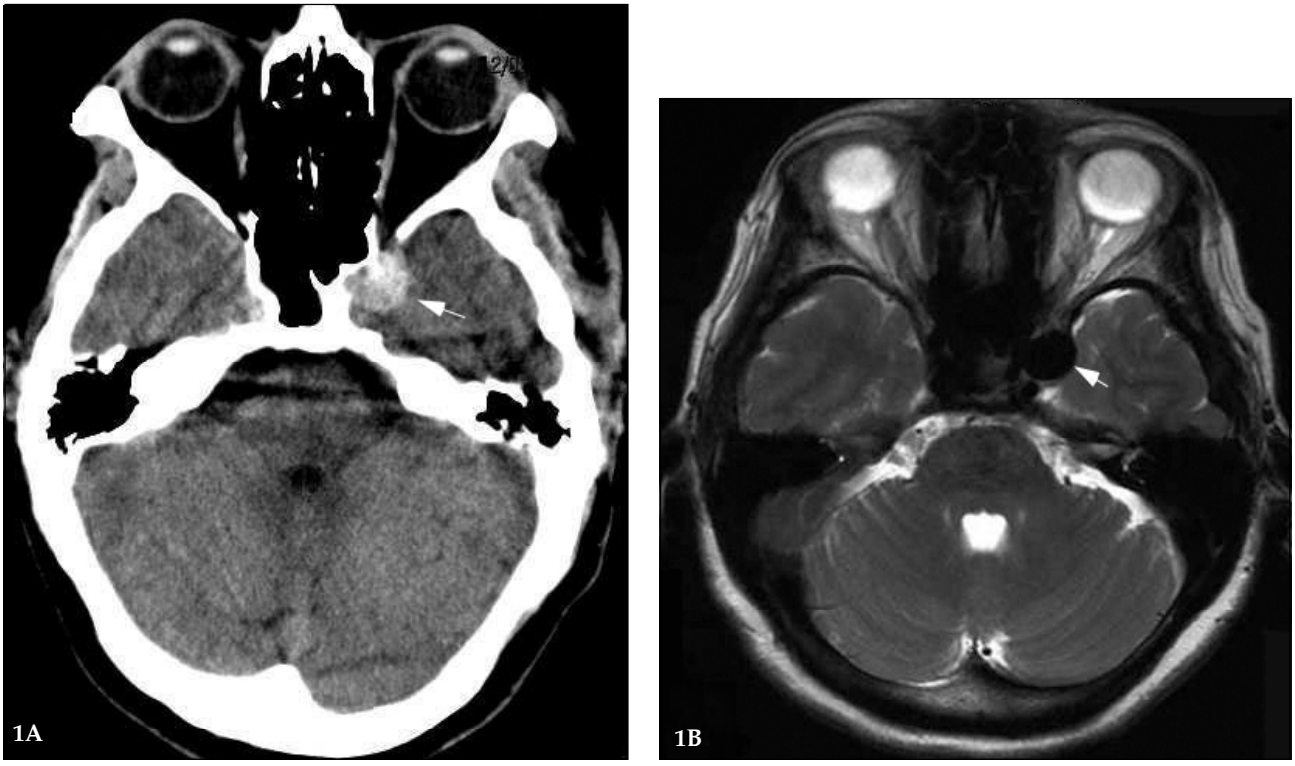

Figure 1: CT scan of the head (**A**) showing an oval shaped hyperdense mass lesion near the left cavernous sinus and MRI (**B**) disclosed a large left ICA aneurysm with 1.5 cm in diameter (arrows).

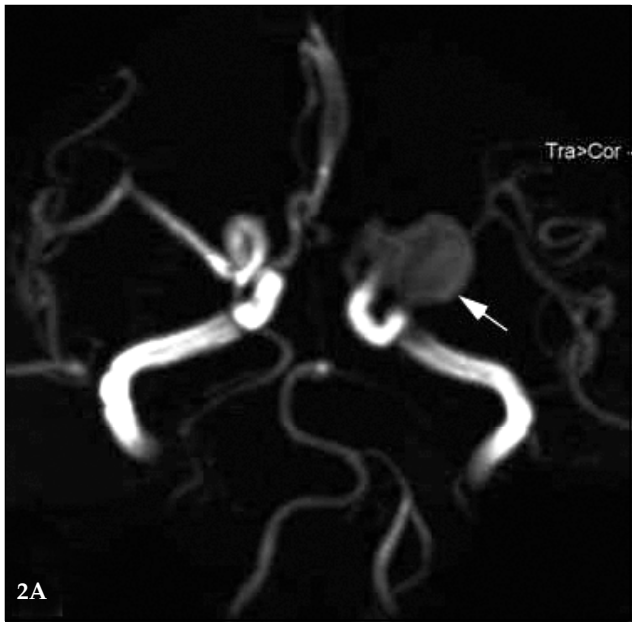

Figure 2: MR-angiography (**A**) and cerebral angiography (**B**) showed that the aneurysm originated from the cavernous and supraclinoid segment of the left internal carotid artery (arrows).

Figure 3: Postoperative CT showing no lesion related to bypass surgery (arrows).

Figure 4: Angiogram obtained at 7-month follow-up examination showed patent STA-MCA bypass (arrow heads).

12, 14, 24, 25) have indicated a strong rationale for re-examining the bypass procedures. Improvements in cerebral blood flow measurement techniques (3, 10) and temporary BTO (14) have also made it possible to decide which patients may benefit from the procedure for certain indications such as complex intracranial aneurysms and planned vessel sacrifice. Certain types of bypass procedures have therefore been developed and several vein and arterial grafts have been used successfully in selected patients.

STA-MCA anastomosis is the most commonly performed procedure in the anterior circulation. STA-MCA bypass is considered as low volume bypass depending on their flow volume since both donor and recipient arteries have a small diameter. This type of bypass is commonly used for an area where large volumes of blood are not necessary. Some modifications increasing blood volume have been introduced and performed successfully for cases where a large blood volume is necessary (1, 11). The extensive anatomical knowledge related to EC and IC vasculature is important for a successful bypass. Kawashima et al. have described cerebral vascularization in the anterior (8) and posterior circulation (9) extensively and discussed bypass procedures depending on the anatomical variations. In addition, microsurgical anatomy of MCA and its angiographic correlations that should be considered while performing STA-MCA bypasses have been well presented by Tanriover, et al (20). The anatomical variations of the sylvian fissure and the vessels coursing on it are also very important in STA-MCA bypass surgery since the neurosurgeon should choose the most suitable vessel for anastomosis (21).

When we compare our results with a rather small number of patients with the relevant literature, we found consistent findings that led us to state that STA-MCA anastomosis may be useful in carefully selected patients together with the aid of neuroradiology including CT and/or MRI, CA and most importantly BTO.

Despite the advancements in every aspect of diagnostic tools, surgical methods and equipments used in surgery, STA-MCA bypasses are not innocent since this type of surgery has potential pitfalls and complications. Graft occlusion, subgaleal hematoma, scalp necrosis and post-operative intracranial hemorrhage are some of the complications that may be seen after bypass surgery (10). However, many authors have underlined that meticulous effort should be spent not to damage donor or recipient artery during dissection, which in turn reduces the risk of graft or of anastomosis occlusion, in order to achieve a short-and long-term patent anastomosis. This is one of the most important reasons why such surgery should be performed by experienced surgeons. Scalp problems can be prevented by limited lateral dissection of the STA and adequate hemostasis. Limited cortical dissection and preservation of veins have been said to prevent or decrease intracranial hemorrhage.

Other major complications are due to occlusion of the major vessels and include cerebral ischemia and infarction (5). Thrombo-embolism is also another cause of cerebral ischemia (4). It is clear that the management of intracranial large or giant complex ICA aneurysms poses a unique neurosurgical challenge. The therapeutic modalities include Hunterian ligation or balloon occlusion of the proximal vessel. The rationale of the Hunterian ligation is based on the concept that diminished intralesional pressure promotes thrombosis (15). Although the role of cerebral vascularization together with major vessel occlusion is controversial, there are cases where revascularization that is vital and selecting the correct cases is therefore crucial. In such cases, one has to perform BTO to identify the patients with inadequate cerebral vascularization and to perform bypass in all patients who are planned to undergo proximal arterial occlusion. Thrombo-embolic complications are of course imminent after these procedures and require careful management following bypasses and balloon occlusions. Although the risk of intracranial hemorrhage has tempered their use, perioperative anticoagulation and/or antiplatelet therapy reduce thrombo-embolism and ischemic complications (2, 6, 13). We, did not encounter any ischemic complication during follow-up in this small series but one should not forget that we might have encountered the complications mentioned above if we had had a larger patient series. Despite complications, endovascular ICA balloon occlusion has several discrete advantages; it keeps the patient fully anticoagulated and has the ability to occlude the vessel close to the aneurysms, thus reducing the likelihood of stump emboli (2).

CONCLUSION

STA-MCA bypass associated with parent vessel occlusion is an appropriate option in selected patients with complex intracranial ICA aneurysms that are nor amenable to either surgical clipping or endovascular coiling and long-term success is possible if performed by experienced hands, . Preoperative careful review of the angiogram of the cases is vital in order to select the appropriate site of cerebral anastomosis. Preoperative radiological evaluations, surgical techniques performed by

experienced neurosurgeons, temporary and permanent occlusions performed by experienced neuroradiologists and postoperative management may predict the outcome and may decrease the complications seen after the procedures.

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