The superficial temporal artery trunk as a donor vessel in cerebral revascularization: benefits and pitfalls

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Object. The superficial temporal artery (STA) is the mainstay of donor vessels for extracranial–intracranial bypass in cerebral revascularization. However, the typically used STA anterior or posterior branch is not always adequate in its flow-carrying capacity. In this report the authors describe the use of the STA trunk at the level of the zygoma as an alternative donor and highlight the benefits and pitfalls of this revascularization option.

Methods. The authors reviewed the cases of 4 patients in whom the STA trunk was used as a donor site for anastomosis of a short interposition vein graft. The graft was implanted into the middle cerebral artery to trap a carotid aneurysm in 2 patients, and the posterior cerebral artery for verteobasilar insufficiency in the other 2. Discrepancies in size between the interposition vein and STA trunk were compensated for by a beveled end-to-end anastomosis or by implanting the STA trunk into the vein graft in an end-to-side fashion.

Results. Intraoperative flow measurements confirmed the significantly higher flow-carrying capacity of the STA trunk (54–100 ml/minute) compared with its branches (10–28 ml/minute). The STA trunk interposition graft has several advantages compared with an interposition graft to the cervical carotid, including a shorter graft and no need for a neck incision. However, in the setting of ruptured aneurysm trapping, with the risk of subsequent vasospasm, it is a poor conduit for endovascular therapies.

Conclusions. The STA trunk is a valuable donor option for cerebral revascularization, but should be avoided in the setting of subarachnoid hemorrhage. (DOI: 10.3171/FOC/2008/24/2/E7)

KEY WORDS • blood flow • bypass surgery • cerebral revascularization • superficial temporal artery

Operative Technique

The general technique for STA dissection has been described previously.5,12 Whenever possible a single skin incision incorporating the STA origin and the trajectory of the anterior or posterior branch of the distal STA as an in situ arterial graft. The standard STA-MCA bypass is the workhorse of cerebral revascularization and has been used in the management of cerebrovascular occlusive diseases and complex aneurysms.1,3,13,14,18 However, the distal STA is not always an adequate source of flow, especially for hemispheric revascularization, necessitating the use of long interposition vein or arterial grafts, typically to the cervical carotid artery. In the present study we provide an update on an alternative strategy; the use of the STA trunk as a donor vessel, with a short vein interposition graft, in 4 cases. The benefits and pitfalls of this alternative revascularization strategy are illustrated and discussed.
If the flow in the trunk is deemed adequate, a short inter-
position vein graft is used. After the distal anastomosis to
the intracranial recipient vessel, the proximal anastomosis
is then created to the stump of the STA trunk. A discrep-
ancy in size between the vein (generally 3–4 mm in diameter)
and the STA trunk (generally 1.5–2.5 mm) can be compen-
sated in either of 2 ways: 1) the STA can be fishmouthed
widely to perform a beveled end-to-end anastomosis (Fig.
2 left) or 2) the STA can be fishmouthed and implanted
end-to-side into the proximal aspect of the ligated vein
graft (Fig. 2 right). The proximal anastomosis can be per-
formed in a leisurely manner because there is no temporary
cerebral ischemia, as may be associated with using a graft
from the cervical carotid artery.

Case Reports

Case 1

This 58-year-old man presented with symptoms of ver-
tebrobasilar insufficiency. Magnetic resonance imaging
of the brain demonstrated posterior fossa infarcts. The patient
received a diagnosis of severe intracranial-dominant left
vertebral artery stenosis. In anticipation of angioplasty and
stenting, the patient was started on aspirin and Plavix, but a
significant hemorrhagic conversion of a cerebellar stroke
developed, prompting discontinuation of the antiplatelet
therapies. This precipitated occlusion of the intracranial
stenosis, with subsequent fluctuating symptoms dependent
on blood pressure. He was therefore taken to the operating
room for posterior circulation revascularization with a PCA
bypass. The distal STA branch was too short to reach the P2
segment, so the STA was cut proximally above the zygoma
and demonstrated a cut flow rate of 54 ml/minute. An inter-
position vein graft was performed between the STA and
PCA (P2 segment). Final bypass flow rate was 45 ml/
minute. The patient was discharged to an acute rehabilita-
tion facility, and was doing well with a palpable bypass at
3 months.

Case 2

This 42-year-old man with a prior history of hyperten-
sion and smoking presented to an outside institution with
crescendo transient ischemic attacks that progressed to
slurred speech, lethargy, and obtundation, at which time
he was transferred to our institution. Magnetic resonance
imaging and angiography of the brain demonstrated an oc-
ccluded basilar artery, with minimal retrograde flow into the
basilar tip. Angiography demonstrated a fetal right PCA
origin and no evident angiographic filling into the top of the
basilar. As a final resort, the patient underwent surgery for
posterior circulation flow augmentation. The STA was dis-
sected for ~10 cm; the STA cut flow rate was 10 ml/minute
and was deemed inadequate for flow augmentation. The
STA was truncated 2 cm above the zygoma, and the rate
improved to 60 ml/minute. An STA-PCA bypass using an
interposition vein graft was constructed. The flow rate in
the bypass graft segment after anastomosis was 60
ml/minute. The graft was patent on angiography 3 weeks
postoperatively. However, unfortunately, the patient died of
systemic sepsis from pneumonia 1 month later.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Diagnosis</th>
<th>Bypass Type</th>
<th>Distal STA Cut Flow</th>
<th>Proximal STA Cut Flow</th>
<th>Bypass Flow Measurement</th>
</tr>
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<tr>
<td>1*</td>
<td>ischemia</td>
<td>STA-PCA</td>
<td>—</td>
<td>54 ml/min</td>
<td>45 ml/min</td>
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<tr>
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<td>basilar occlusion</td>
<td>STA-PCA</td>
<td>10 ml/min</td>
<td>60 ml/min</td>
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<td>ICA aneurysm</td>
<td>STA-MCA</td>
<td>28 ml/min</td>
<td>100 ml/min</td>
<td>85 ml/min</td>
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<tr>
<td>4</td>
<td>ICA aneurysm</td>
<td>STA-MCA</td>
<td>10 ml/min</td>
<td>89 ml/min</td>
<td>95 ml/min</td>
</tr>
</tbody>
</table>

* The distal STA flow was not measured in this patient because it was a short segment.
Case 3

This 44-year-old woman was admitted with a 1-week history of severe headache. A head computed tomography scan showed focal hyperdensity over the right carotid terminus region. Further workup with cerebral angiography showed a dissecting pseudoaneurysm involving the right supraclinoid ICA, which extended into the origin of the ACA. The patient underwent surgery for trapping of the aneurysm with a bypass to the MCA. At the time of surgery, there was fusiform expansion and discoloration of the ICA, but the aneurysm was unruptured. Flow rates were measured intraoperatively in the M\(_2\) branches, the sum of which was 81 ml/minute. The STA was dissected and the cut flow rate was measured to be only 28 ml/minute. Therefore the STA branch was felt to be inadequate for revascularization, and was cut at its proximal stump; repeated cut flow measurement through the STA trunk demonstrated 100 ml/minute. This was considered to be sufficient to replace the MCA. An autologous saphenous vein graft was used as an interposition graft, and an STA trunk-vein-M\(_2\) bypass was performed. Blood flow in the bypass following anastomosis and trapping measured 85 ml/minute, almost identical to the recipient bed. The patient did well neurologically and has a patent bypass on angiography 6 months postoperatively.
This 50-year-old woman presented with a Grade III SAH. Her initial angiogram demonstrated a ruptured 15-mm-long left posterior communicating artery region aneurysm with a dysplastic fusiform ICA dilation, in addition to a smaller 5-mm left anterior choroidal artery aneurysm (Fig. 3A). The patient underwent craniotomy for surgical trapping of the fusiform ICA segment and aneurysm. During temporary ICA occlusion distal to the aneurysm, minimal collateral flow was present across the anterior communicating artery, based on intraoperative flow measurement of the M1 branch (fall from 70 ml/minute to 5 ml/minute with temporary clipping). The STA branch was dissected free for 8 cm, and the cut flow rate was only 10 ml/minute. An interposition venous graft was used between the proximal STA trunk and the M1 segment. Flow measurement in the bypass was 95 ml/minute after aneurysm trapping, and Day 5 postoperative angiography confirmed good bypass filling and obliteration of the aneurysms (Fig. 3B). The patient initially recovered well, but on postoperative Day 7 (Fig. 3C), right hemiparesis and speech difficulty developed due to a severe intracranial vasospasm. The patient underwent multiple cerebral angiograms and intraarterial verapamil infusions through the bypass. The endovascular therapy was limited by the easy and severe spasmogenicity of the STA in response to cannulation for intraarterial injections. Furthermore, access for angioplasty could not be obtained due to the size and spasmogenicity of the proximal STA. The patient suffered patchy areas of stroke in the left hemisphere. She was discharged to a rehabilitation facility. The bypass was palpable at her 3-month follow-up office visit.

### Discussion

Cerebral revascularization using a short interposition vein graft from the STA trunk has been reported in the past.1,16 In 1983 Little et al.11 reported the largest experience published to date, with 19 bypass procedures using the STA trunk as a donor vessel; their early patency rate was 90%. The authors proposed that this procedure might be useful as a primary means of cerebral revascularization or as an alternative approach when the distal STA branch cannot be used because of its small size, the severity of arteriosclerotic changes, or damage during its dissection. The use of the STA trunk was also described by Spetzler and colleagues10 in creating the “bonnet” bypass. This technique entails the use of the contralateral STA trunk as a donor for an interposition radial artery graft to the MCA in cases of skull base tumors with limited access to ipsilateral donor vessels.10–12 The use of the STA trunk has been described for trapping and revascularization of a giant ACA aneurysm, with STA→A2 arterial interposition graft and subsequent A2→A1 side-to-side bypass.9 Cases of saphenous vein or radial artery interposition grafting between the donor STA trunk and recipient ACA have also been reported for revascularization in cerebrovascular occlusive disease.9,17

The premise underlying the use of the STA trunk relates to Poiseuille’s law and flow dynamics, the physical law concerning the laminar flow [Q] of an incompressible uniform viscous liquid through a cylindrical tube. As such, the law is applicable to the corporeal circulation. The equation relevant to Poiseuille’s law is as follows: 

\[
Q = \frac{(\pi r^4 P)}{8\eta L}
\]

Where \( r \) represents the internal radius of the blood vessel, \( P \) the pressure at the vessel end, \( \eta \) the dynamic blood viscosity, and \( L \) the total length of the tube in that direction. Poiseuille’s law relates the flow rate to the pressure, viscosity, vessel radius, and length. Because flow is related to the radius raised to the fourth power, a minimal change in the radius of a vessel will have an exponential impact on the rate of blood flow. Additionally the length of the vessel conduit will impact blood flow inversely. Compared to the typical STA branch, the STA trunk is significantly shorter and generally of larger diameter than the distal branch. Based on flow dynamics principles, therefore, the STA trunk would be expected to have a significantly higher flow capacity than its branches. This principle is well demonstrated in our cases, in which intraoperative cut flow measurements showed an increase in flows from the 10–28 ml/minute range to the 60–100 ml/minute range in the 3 cases in which both the STA branch and trunk were measured.

Flow rates in the STA branch can vary widely as a result of a combination of factors including not only diameter and length, but also the presence of arteriosclerosis within the STA segment itself. The STA is prone to progressive intimal thickening and alteration of the elastic lamina.10 The presence of atherosclerosis within the STA branch or trunk can lead to decrease in the flow within that segment, thus rendering it unsuitable for use. Therefore, direct intraoperative measurement of the cut flow rate is an important step in determining the actual flow-carrying capacity of the STA and establishing adequacy of the donor vessel.

There are several advantages to use of the STA trunk as a donor compared to the cervical carotid artery (external or common). Use of the STA trunk allows the use of a short interposition graft (approximately 6–8 cm) compared to the significantly longer graft (18–20 cm) required for a vein or arterial graft in the cervical region. It is well-accepted that a shorter interposition graft is desirable for graft longevity and patency.5,15 The use of the STA trunk can avoid the need for a neck incision and dissection, and also reduce the size of the incision and the length of time for harvesting of the shorter vein or arterial graft. In addition, occlusion of the STA trunk for the purpose of Anastomosis poses no risk of cerebral ischemia, whereas cases requiring bypass to the common carotid rather than the external carotid artery (such as in a high bifurcation) would have the potential for ischemia during temporary clipping.

There are pitfalls to use of the STA trunk, however. This is well-illustrated in 1 of our cases (Case 4), in which the STA trunk with an interposition vein graft was adequate to replace the flow at the time of aneurysm trapping. However, once an intracranial vasospasm developed in the patient as a consequence of SAH, the choice of donor vessel limited the extent and efficacy of endovascular interventions. The STA is too small to provide a conduit for a microcatheter for balloon angioplasty, and even cannulation for injection of intraarterial vasorelaxants can induce vasospasm easily in the STA itself, exacerbating cerebral ischemia by reducing flow in the bypass. Consequently, for ruptured aneurysms, a large-caliber interposition vein graft

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from the cervical carotid artery (external or common) would be a more appropriate choice; the vein can be cannulated with microcatheters for intraarterial injections and used as a conduit for balloon angioplasty, as needed if vasospasm develops.

Conclusions

The STA trunk is a valuable donor option to consider for use in surgical cerebral revascularization, but should be avoided in the setting of SAH.

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