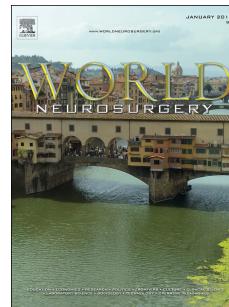


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Technical Case report: Superficial temporal artery-superior cerebellar artery bypass with anterior petrosectomy: Technical Case Report

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Key Words: anterior petrosectomy, superficial temporal artery-superior cerebellar artery (STA-SCA) anastomosis, surgical complication, bypass

Abbreviations and Acronyms

3D-CTA: 3-dimensional computed tomographic angiography

CSF: cerebrospinal fluid

DSA: digital subtraction angiography

GSPN: greater superficial petrosal nerve

ICG: indocyanine green

MRA: magnetic resonance angiography

MRI: magnetic resonance imaging

NIM: Nerve Integrity Monitoring

SPECT: single-photon emission computed tomography

STA-SCA: superficial temporal artery-superior cerebellar artery

Abstract (247 words)

Background: Superficial temporal artery (STA) -to- superior cerebellar artery (SCA) bypass is associated with a relatively high risk of surgical complications, such as hematoma and/or edema caused by temporal lobe retraction. Therefore, the right side is typically used to avoid retraction of the left temporal lobe. In this report, we present a case of left STA-SCA bypass with anterior petrosectomy to avoid retraction of dominant side temporal lobe and describe the surgical technique in detail.

Clinical Presentation: A 69-year-old man presented with gradual worsening of dysarthria and gait disturbance. MRI showed no signs of acute infarction, but digital subtraction angiography (DSA) showed severe stenosis of basilar artery and faint flow in the distal basilar artery. On 3-dimensional CT angiography (3D-CTA), posterior communicating arteries were not visualized; we could identify the left SCA, but not the right SCA. In spite of dual antiplatelet therapy, a small fresh brain stem infarct was detected 10 days after admission. To avert fatal brain stem infarction and further enlargement of the infarct, we performed left STA-SCA bypass with anterior petrosectomy to avoid retraction of the dominant side temporal lobe. Postoperative imaging revealed no new lesions such as infarction or temporal lobe contusional hematoma, and confirmed the patency of the bypass. Post-operative single-photon emission computed tomography (SPECT) demonstrated improved cerebral blood flow in the posterior circulation. The patient was transferred to another hospital for rehabilitation.

Conclusions: This method helps minimize the risk of injury to temporal lobe, especially that of the dominant side.

RUNNING TITLE: Bypass with anterior petrosectomy

Highlights:

A 69-year-old man presented with worsening of dysarthria and gait disturbance.

Despite dual antiplatelet therapy, enlargement of the infarct was detected.

We could identify the left SCA, but not the right SCA.

We performed left STA-SCA bypass with anterior petrosectomy.

This method helps minimize the risk of injury to dominant side temporal lobe.

INTRODUCTION

Although there have been no randomized trials of cerebral revascularization to treat stenoocclusive disease in the posterior circulation, various surgical methods have been used for intracranial revascularization in patients with occlusive cerebrovascular disease of vertebra-basilar arterial system. Superficial temporal artery (STA) to superior cerebellar artery (SCA) bypass is the most frequently used and often the most suitable method for both vertebral artery and distal basilar artery lesions. Several case reports of STA-SCA bypass have been published¹⁻⁶. Hopkins et al reviewed several reports of STA-SCA and found a high incidence of surgical complications associated with this technique; these include postoperative hematoma and edema caused by retraction of the temporal lobe³. Therefore, the right side is typically used in order to avoid retraction of the temporal lobe on the dominant side. In this report, we present the first case of left STA-SCA bypass with anterior petrosectomy performed to avoid retraction of the dominant side temporal lobe and describe the surgical technique in detail.

PATIENT

A 65-year-old man was first admitted to our hospital in September 2012 because of dysarthria and mild right hemiparesis. Magnetic resonance imaging (MRI) and 3-dimentional-time-of flight magnetic resonance angiography (MRA) showed left pons acute infarction and mild stenosis of the basilar artery (Figure 1A-C). He was treated with antiplatelet therapy and underwent rehabilitation; at the time of discharge, he had slight right hemiparesis, but was able to walk without a cane (modified Rankin Scale score 2). He was prescribed antiplatelet and antihypertensive drugs at discharge; annual MRI and MRA examinations performed on follow-up showed no remarkable changes. In June 2016, he was re-admitted to our hospital due to gradual worsening of dysarthria and gait disturbance. MRI showed no signs of acute infarction; however, MRA revealed severe stenosis of the basilar artery (Figure 1D-F). Digital subtraction angiography (DSA) showed severe stenosis of basilar artery and faint flow in the distal basilar artery (Figure 2A-B). Three-dimensional CT angiography (3D-CTA) was performed to assess the vascular network around the distal basilar artery (Figure 2C-E). 3D-CTA showed no posterior communicating arteries; we could identify the left SCA (red arrows in Figure 2E), but not the right SCA. In spite of dual antiplatelet therapy (aspirin and cilostazol), repeat MRI performed 10 days after re-admission revealed a small fresh brain stem asymptomatic infarct (Figure 2F). ¹²³I-iodoamphetamine single-photon emission computed tomography (SPECT) revealed poor perfusion in the posterior circulation (Figure 3A-B). After a discussion with neurovascular surgeons and neuroradiologists, we

decided that the endovascular approach was not suitable because the severe stenotic lesion was long and located at elongated portion. Surgical revascularization was planned in order to prevent the distinct possibility of fatal brain stem infarction and further enlargement of the infarct. Aspirin therapy was stopped 7 days before operation. Since the right SCA was not discernible on 3D-CTA, we performed left STA-SCA bypass with anterior petrosectomy to avoid retraction of the dominant side temporal lobe in July 2016 (4 weeks after re-admission).

Surgical procedure

A lumbar catheter was inserted for intraoperative cerebrospinal fluid (CSF) drainage. Nerve Integrity Monitoring (NIM) (NIM-Response 2.0; Medtronic XOMED Inc., Jacksonville, FL, USA) was used for facial nerve monitoring (large arrow in Figure 4A). The patient was placed supine and the head of the bed was raised by approximately 20 degrees. The patient's head was secured with a Mayfield three-pin headholder with 45 degrees of contralateral head rotation and slight down-positioning of the vertex (Figure 4 A-B). The parietal branch of the STA was traced on the scalp with the use of a Doppler probe, and skin incision was made over the STA parietal branch. Approximately 10 cm of the vessel was dissected under the microscope, and the curved skin incision was then extended to the midline forehead along the hair line; subsequently, an additional skin incision was made (approximately 5 cm in length) posteriorly for anterior petrosectomy (small arrows in Figure 4A-B). The temporalis fascia and muscle were incised in the direction of the skin incision from the superior temporal line to the root of the zygoma. The temporal muscle, lateral to the linea temporalis, was dissected only up to the thin temporal fascia, and the lateral half of the subgaleal flap was elevated together with the superficial temporal fat pad in order to preserve the frontalis branches of the facial nerve. This lateral half of the flap was elevated further down to expose the zygomatic arch, zygoma, and the lateral orbital rim. Zygoma was cut with a saw and the temporal muscle was reflected further inferiorly and posteriorly together with the zygomatic arch. Craniotomy was then performed and the inferior portion of the bone flap was brought down to the base of the middle fossa, enough to expose the foramen rotundum and the foramen ovale for anterior petrosectomy. After achievement of hemostasis, CSF drain was opened and about 50 mL of CSF was drained to minimize retraction of the temporal lobe. Elevation of the dural layer over the middle fossa was started from around the foramen ovale posteriorly towards the arcuate eminence to expose the petrous apex. Using NIM-Response for greater superficial petrosal nerve (GSPN) monitoring, petrous apex was drilled away (Figure 5A-B). Temporal dural layer was incised along the undersurface of the temporal lobe, vertically up to the superior petrosal sinus (SPS); a parallel dural incision to the SPS was then made, perpendicular to the first

incision (blue line in Figure 5B). Then, SPS was ligated and tentorium was cut down to the tentorium incisura (blue dotted line in Figure 5B), whilst taking care not to injure the fourth nerve (arrow in Figure 5C). After dissection of the arachnoid membrane around the ambient cistern, the left SCA was identified in its lateral circum-mesencephalic portion (Figure 5C). We performed indocyanine green (ICG) video angiography and it showed antegrade flow of left SCA. The artery was gently elevated by placing a small piece of Gelform underneath the vessel. A green silicone rubber was placed on top of the Gelform (underneath the vessel) to isolate the segment of the artery to be used. The distal portion of the STA was transected and its proximal portion clipped. The vessel was irrigated thoroughly with heparinized saline. The STA was carefully cleaned of all adventitial tissue, and a fish-mouth stoma was made at the distal end of the STA. The blue dye was applied onto the surface of the cut ends of the donor and recipient vessels to enable clear visualization⁷. After stay sutures were placed at the distal end of the STA, the vessel was brought down to the area of the SCA. After clamping of the SCA, longitudinal arteriotomy was performed on the SCA equal to the length prepared on the STA. With the aid of the long bayonet microinstruments, an end to side anastomosis was completed with interrupted twelve 10-0 nylon sutures (Figure 5D). Each needle was left in place keeping the surface of both cut ends in good position until the next needle was placed, akin to the use of a pin to fasten pieces of cloth together while sewing⁸. After removal of the temporary clips, the bypass patency was confirmed by ICG video angiography. In this operation, it is theoretically difficult to achieve perfect watertight closure of the dura, since the STA traverses the temporal dural defect, which was covered by temporal muscle with fibrin glue. Furthermore, the bony defect was filled with pieces of fat tissue obtained from the abdomen. Cranioplasty was performed with titanium plates, and the wound was closed.

Post-operative course

He developed no additional neurological deficit after operation. Postoperative MRI revealed no new lesion such as infarction or temporal lobe contusional hematoma (Figure 6A-F). MRA (Figure 7A) and 3D-CTA (Figure 7B-D) confirmed the patency of the bypass (red arrows in Fig.7A-D). Post-operative SPECT (Figure 3C-D) demonstrated improved cerebral blood flow in the posterior circulation, as compared to that observed on pre-operative SPECT (Figure 3A-B). Subsequently, the patient was transferred to another hospital for further rehabilitation on POD 27. The patient was found to be well after 18 months of operation; this was confirmed by a telephone interview

DISCUSSION

Here, we present a rare case of deep bypass surgery with anterior petrosectomy. To the best of our knowledge, this is the first report of left STA-SCA anastomosis with anterior petrosectomy performed to reduce the risk of damage to the dominant side temporal lobe.

The anterior petrosal approach, which has been referred to as ‘an extension of the middle fossa approach’, originally described by Bochenek and Kukwa in 1975⁹, was initially applied to lower basilar aneurysms by Kawase in 1985¹⁰. Subsequently, this ‘Kawase’s approach’ through the middle fossa has been used to address cranial base lesions of the petroclival region, mainly for petroclival meningiomas¹¹ and brainstem cavernomas¹². However, a few reports have described the use of anterior petrosal approach for complex posterior circulation aneurysms^{13, 14}.

As mentioned earlier, the complications of hematoma and/or edema caused by temporal lobe retraction after STA-SCA bypass are not uncommon³. To minimize the extent of temporal lobe retraction, some neurovascular surgeons^{5, 6} have used the following surgical technique: positioning of head in a vertex-down position to make the temporal base perpendicular, and the temporal bone is extensively nibbled away down to the floor of the middle cranial fossa. Furthermore, veins are thereby preserved, and a large piece of Gelfoam is laid down on both sides of the operative field in the temporal base. Use of these methods was found to successfully avert postoperative swelling, edema, or hematoma of the temporal lobe. In spite of these surgical improvements, the right side is typically used to avoid retraction of the temporal lobe on the dominant side. Indeed, STA-SCA bypass through a subtemporal approach is possible and is associated with a lower risk of retraction of the dominant temporal lobe; however, the approach is technically challenging and requires high-level of microsurgical skills. Therefore, we were reluctant to perform left STA-SCA bypass through the subtemporal approach, and decided to achieve left STA-SCA with anterior petrosectomy to avoid retraction of the dominant side temporal lobe. As shown in Fig.4D-E, anterior petrosectomy allowed for a wide operative field without temporal retraction, especially on the temporal base side, and this made anastomosis easier. This approach also makes it possible to perform STA-PCA with anterior petrosectomy and external carotid artery-posterior cerebral artery bypass for treatment of basilar trunk aneurysm, as reported by Terasaka et al.¹⁴ Disadvantages of this approach include the possibility of facial nerve injury and hearing impairment, CSF leakage, and extension of the operating time.

A few reports have described STA-SCA¹⁵ or STA-PCA¹⁶ anastomosis performed via trans-sylvian approach. However, deep bypass though trans-sylvian approach requires very high skills. Furthermore, this approach may not be feasible in some cases; Takeuchi et al reported some limitations of this approach in case of PCA

that are not readily apparent on preoperative imaging studies¹⁶.

CONCLUSIONS

We present a rare case of STA-SCA bypass surgery with anterior petrosectomy. This method helps minimize the risk of injury to temporal lobe, especially that of the dominant side.

Figure Legends

FIGURE 1. Magnetic resonance imaging (MRI) and 3D-time-of flight magnetic resonance angiography (MRA) at first admission (upper panel; **A-C**) and at readmission (lower panel; **D-F**). **A, D**, diffusion-weighted images (DWI); **B, E**, T2-weighted images (T2); **C, F**, MRA.

MRI and MRA performed at first admission shows left pons acute infarction and mild stenosis of the basilar artery (Figure 1A-C). MRI performed on re-admission (due to gradual worsen of dysarthria and gait disturbance) shows no signs of acute infarction; however, MRA shows severe stenosis of the basilar artery (Figure 1D-F).

FIGURE 2. Radiological investigations performed 10 days after re-admission. **A**, Right vertebral angiography lateral view; **B**, Right vertebral angiography anterior view; **C**, 3-dimensional CT angiography (3D-CTA) anterior view; **D, E**, 3D-CTA anteroinferior view; **F**, diffusion-weighted image (DWI).

Digital subtraction angiography shows severe stenosis of basilar artery and faint flow in the distal basilar artery (Figure 2A-B). 3D-CTA images illustrate the vascular network around the distal basilar artery (Figure 2C-E); posterior communicating arteries and right SCA are not visible, while left SCA is clearly seen (red arrows in Figure 2E). MRI performed 10 days after re-admission shows a small fresh brain stem infarct (Figure 2F).

FIGURE 3. ^{123}I -iodoamphetamine single-photon emission computed tomography (SPECT) pre-operation (upper panel; **A, B**) and post-operation (lower panel; **C, D**). **A, C**, posterior fossa; and **B, D**, cerebral hemisphere.

Pre-operative SPECT shows poor perfusion in the posterior circulation (Figure 3A-B). Post-operative SPECT (Figure 3C-D) shows improved cerebral blood flow in the posterior circulation.

FIGURE 4. Intraoperative photographs showing the patients' position and skin incision.

Skin incision was made as indicated by arrows in Figure 4A-B. Large arrow in Figure 4A shows nerve integrity monitoring (NIM).

FIGURE 5. Intraoperative microscopic photographs.

After petrous apex was drilled away (black dotted line Figure 4A-B), after temporal dural layer was incised

along the blue line shown in Figure 5B, superior petrosal sinus (SPS) was ligated, and tentorium was cut down to the tentorium incisura (blue dotted line in Figure 5B). After dissection of the arachnoid membrane around the ambient cistern, the left SCA and fourth nerve was identified in its lateral circum-mesencephalic portion (Figure 5C), An end-to-side anastomosis was completed with interrupted twelve 10-0 nylon sutures with the aid of long bayonet microinstruments (Figure 5D).

FIGURE 6. Fluid attenuated inversion recovery (FLAIR) image (upper panel; **A-C**) and DWI (lower panel; **D-F**) after bypass surgery.

Postoperative MRI shows no new lesion.

FIGURE 7. A, Magnetic resonance angiography (MRA); **B-D**, 3-dimensional CT angiography (3D-CTA) (**B**, lateral view; **C-D**, superior view)

MRA and 3D-CTA confirmed the patency of the bypass (red arrows in Fig.6A-D; arrow head indicates the site of anastomosis).

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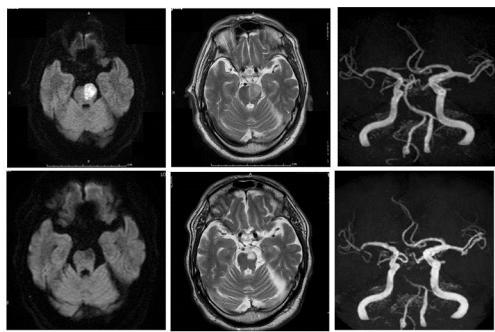


Figure 1 A|B|C
D|E|F

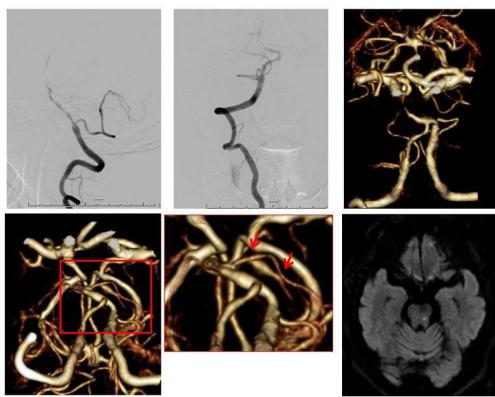


Figure 2 A|B|C
D|E|F

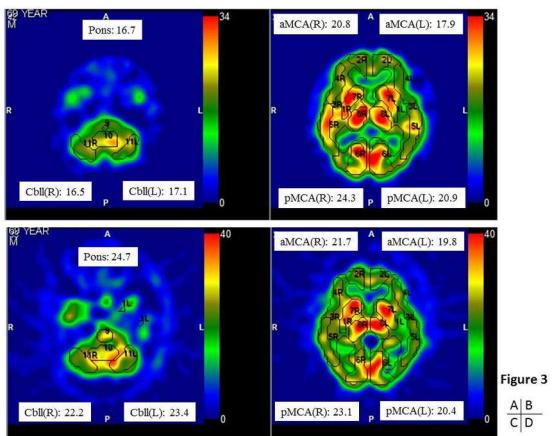




Figure 4 A | B

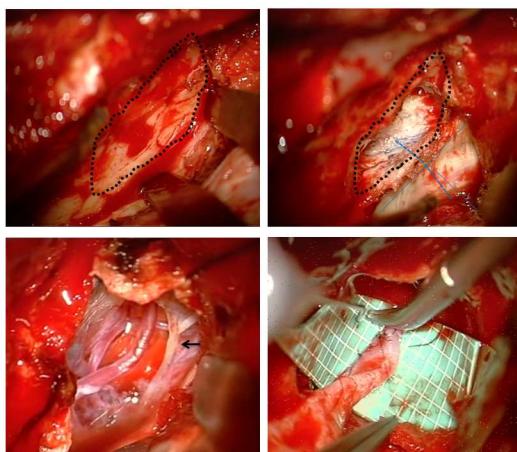


Figure 5

A | B
C | D

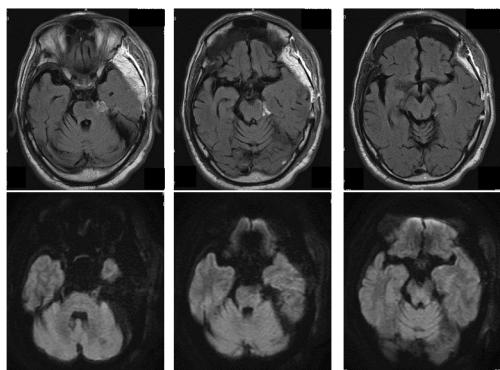


Figure 6 A | B | C
D | E | F

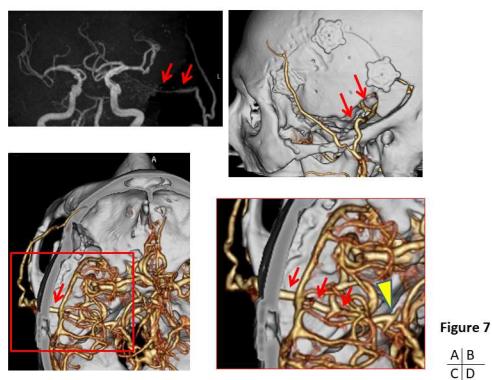


Figure 7

A | B
C | D