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Technical Notes

Extracranial vertebral artery to middle cerebral artery bypass in therapeutic internal carotid artery occlusion for epipharyngeal carcinoma: A technical case report

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ABSTRACT

Background: Vertebral artery (VA) to middle cerebral artery (MCA) bypass is a rarely selected technique because a complex expanded dissection is required, and often, a better donor artery than VA exists. A good indication for VA-MCA bypass is the treatment of head-and-neck malignancies with the sacrifice of the internal carotid artery (ICA) or for carotid artery rupture.

Methods: A 23-year-old man with epipharyngeal carcinoma, treated by ligating the carotid artery with a VA-MCA bypass before chemoradiotherapy, was reported. Radiographic findings showed that the bone of the carotid canal was dissolved, and the right ICA was engulfed by the tumor. As epipharyngeal carcinoma is hypersensitive to radiation, in cases where the tumor rapidly disappears, ICA may dangle in the pharynx and rupture may occur. In addition, to irradiate sufficiently, the ICA may become an obstacle. Hence, we decided to perform carotid ligation with a VA-MCA bypass before radiation and chemotherapy for the primary lesion. We selected the V3 portion of the VA as the donor on the ipsilateral side, as it can supply high-flow cerebral blood flow, which is not influenced by carcinoma and less influenced by irradiation for the epipharynx.

Results: The VA-MCA bypass was completed without complications followed by endovascular occlusion of the ICA. Induction chemotherapy was initiated for the patient 2 weeks after surgery. The patient achieved a complete response following chemoradiotherapy.

Conclusion: ICA ligation with VA-MCA high-flow bypass earlier than chemoradiotherapy is useful for epipharyngeal carcinoma as it prevents carotid artery rupture and allows radical intervention.

Keywords: Carotid artery rupture, Carotid blowout syndrome, Epipharyngeal carcinoma, Skull base malignancy, Vertebral artery to middle cerebral artery bypass

INTRODUCTION

Vertebral artery to middle cerebral artery (VA-MCA) bypass is a rarely selected technique as exposing the extracranial VA takes time, and sometimes, other recipient arteries are more useful to reach MCA, such as an external carotid artery or superficial temporal artery (STA). However, the VA-MCA bypass technique can be a good alternative in cases where another recipient artery cannot be selected.[6,9,10] A good indication of VA-MCA bypass is for the treatment of head-and-neck malignancies and carotid blowout syndrome (CBS), which occurs during the treatment of these malignant tumors.[6,9]

CBS is a rare but severe complication after surgical and radiological interventions for head-and-neck cancers.[8,15] Once CBS occurs, ligation of the carotid artery is the major approach to treat this catastrophic situation. Nevertheless, carotid artery ligation has shown high mortality and ischemic complication rates due to intolerance to carotid occlusion.[2,15]

To avoid ischemic complications, carotid ligation with bypass or endovascular repair with covered stents should be considered as another option.[1,3] However, due to its urgent situation and malignant nature, the outcome is unsatisfactory.[1,13] Therefore, carotid ligation before radical neck surgery or radiological intervention for high-risk CBS patients may be a feasible alternative.

Here, we present a case of planned carotid ligation preceding the intervention for epipharyngeal carcinoma with VA-MCA bypass.

CASE PRESENTATION

This study was approved by the Institutional Review Board, and informed consent was obtained from the patient. A 23-year-old man presented with a 3-month history of progressive difficulty in swallowing and discomfort in the pharynx. The patient was diagnosed with epipharyngeal carcinoma using biopsy. The pathology report revealed nonkeratinizing nasopharyngeal carcinoma, undifferentiated type, Ki-labeling index 60–70%, and latent membrane protein-1 positive, cT4N0M0, cSTAGE IV A.

Computed tomography (CT), CT angiography (CTA), and magnetic resonance imaging (MRI) revealed a heterogeneous mass occupying the epipharyngeal region [Figure 1]. The bone of the carotid canal was dissolved and the right internal carotid artery (ICA) was engulfed by the tumor. The radiology, otorhinolaryngology, and neurosurgery departments were consulted for the case. It is well known that epipharyngeal carcinoma has an effective response to radiation[12] and chemotherapy.[14] In cases where the tumor rapidly disappears, the ICA may dangle in the pharynx, and a rupture may occur due to bacterial infection. In addition, to irradiate sufficiently, the ICA could become an obstacle.

Preoperative balloon test occlusion (BTO) revealed 35% decrease in ICA pressure compared with preocclusion ICA pressure. We decided to perform ICA ligation using a V3- radial artery graft (RAG)-MCA bypass in anticipation of radiation and chemotherapy for the primary lesion. We selected the V3 portion of the VA as the donor on the ipsilateral side, as it can supply high-flow cerebral blood flow not influenced by carcinoma and is less influenced by irradiation of the epipharynx.

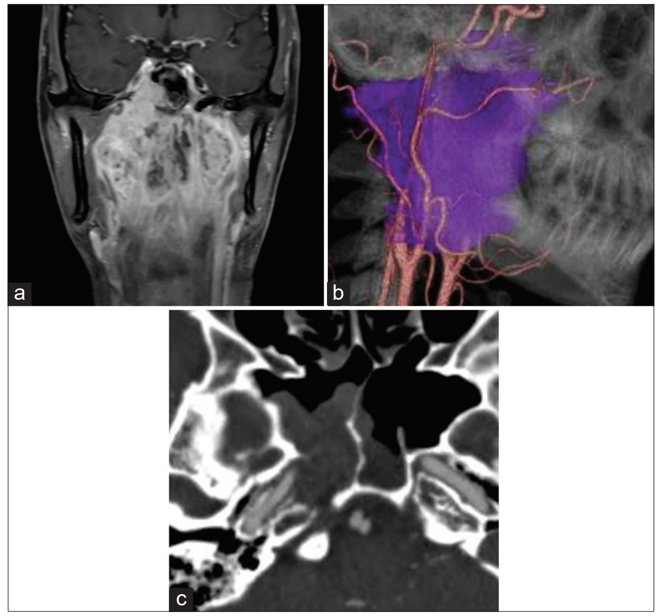


Figure 1: Preoperative images of the case. (a) Coronal gadolinium-enhanced T1-weighted magnetic resonance imaging shows that the tumor envelops the epipharyngeal region to the sphenoid sinus and the skull base. (b) Lateral view of fusion image between computed tomography angiography and tumor (purple color) reconstructions. Tumor engulfs the right side internal and external carotid arteries. (c) Computed tomography angiography reveals that the tumor envelopes the sphenoid sinus and the right side carotid canal. The bony structure of the carotid canal is dissolved by the tumor.

Surgical technique

Supplementary video shows the detailed step-by-step procedures [Video 1]. Before surgery, 100 mg of aspirin was administered 1 week in advance, since endovascular ICA occlusion was planned. The patient was positioned in a supine-lateral position with the right side up by a pillow under his right shoulder. The right forearm was placed laterally to harvest the RAG. The skin incision was designed, as shown in [Figure 2a]. The frontotemporal skin incision was designed from just above the STA parietal branch to the midline of the hair. To join this skin incision, an additional curved incision along the lateral process of the C2 vertebra was added. This last incision aimed to dissect the suboccipital muscles in a layer-by-layer manner and expose the V3 segment of the VA, making a graft route above the mastoid body and temporal bone.

First, the parietal branch of the STA was harvested from just below the skin incision, and the frontotemporal skin flap was elevated in a two-layer manner. The frontal branch of the STA was harvested from the skin flap. An additional skin incision was made to join this frontotemporal skin incision. The galea and occipital muscles were dissected to belong to the skin flap. To do this, the sternocleidomastoid (SCM) muscle and occipital muscle were exposed first [Figure 2b],

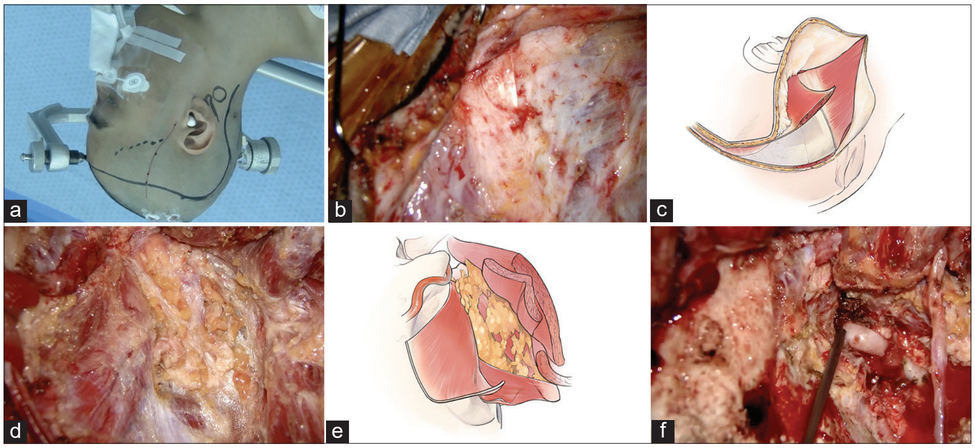
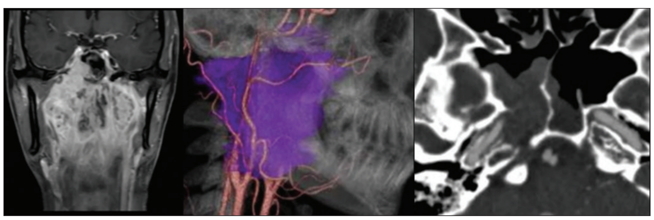


Figure 2: Intraoperative findings. (a) Right skin incision design. The frontotemporal skin incision is designed from just above the superficial temporal artery parietal branch to the hair's midline. To join this skin incision, an additional curved one along the lateral process of the C2 vertebra is added. (b) The sternocleidomastoid and occipital muscles are exposed. (c) The occipital muscle is elevated as it belongs to the skin flap by detaching it from the superior nuchal line. (d and e) The suboccipital triangle is exposed. (f) The V3 portion of the vertebral artery is exposed.



Video 1: Surgical technique of the V3-middle cerebral artery bypass.

and insertion of those muscles had to be exposed. Then, the occipital muscle was elevated as belonging to the skin flap by detaching it from the superior nuchal line [Figure 2c]. Thus, the occipital muscle is a skin flap. As the occipital muscle belongs to the skin flap, the SCM, splenius capitis, and semispinalis capitis muscles, which are inserted on the superior nuchal line, can be tightly attached to the occipital muscle during the closure. Consequently, the muscle-tendon can be attached to minimize muscle atrophy. Suboccipital muscle dissection was then performed layer by layer. With a layer-by-layer dissection, the occipital artery was dissected but preserved as blood flow from the skin must be preserved as much as possible. This would help in postoperative wound healing and tolerance of irradiation to the skin. After exposing the suboccipital muscle triangle [Figures 2d and e], the V3 segment of the VA was exposed [Figure 2f].

Subsequently, a frontotemporal craniotomy was performed. By distal Sylvian fissure dissection, the M1 to M3 portion of the MCA was fully exposed [Figure 3a]. The STA-MCA bypass was performed before M2-RAG anastomosis [Figure 3b]. The STA-MCA bypass is performed to ensure flow in case the V3-RAG- MCA bypass becomes occluded after ICA ligation, in addition to providing pressure monitoring through the other branch of the STA. Once the STA-MCA bypass was performed, the M2-RAG anastomosis was performed in an end-to-side manner [Figure 3c]. After completion of the anastomosis, pressure monitoring was performed through the other branch of the STA. Heparin saline was then administered at the contralateral end of the RAG, which distended the graft. The graft route was determined by adjusting the contralateral end of the RAG to the V3 segment of the VA, and the mastoid and temporal bones were drilled just below the graft route to avoid compression of the graft and shorten the graft route [Figure 3d]. An end-to-side V3-RAG anastomosis was then performed [Figure 3e]. To anastomose the V3 segment, the linear arteriotomy is not feasible as the arterial wall of the VA is quite thick and stiff. Consequently, using a vascular punch, a wider arterial hole is required. The M2 segment of the MCA was temporarily occluded, and the V3-RAG-M2 bypass was opened. Using Doppler, indocyanine green video angiography, and pressure monitoring, graft patency, and flow were identified [Figures 3f and g].

Postoperative course

The patient was conscious, with no neurological deficit. CTA showed good patency of the V3-RAG-MCA and STA-MCA bypasses. The ICA was occluded using endovascular coiling the day after systemic heparinization [Figure 4]. Postprocedural CT and MRI revealed no infarction or hemorrhage. The postoperative course was uneventful, and the patient was transferred to the ear, nose, and throat center to receive radiation and chemotherapy 2 weeks after surgery with an mRS of 0. The patient underwent chemotherapy and radiotherapy followed by induction chemotherapy. The patient achieved a complete response after chemoradiotherapy 6 months after surgery.

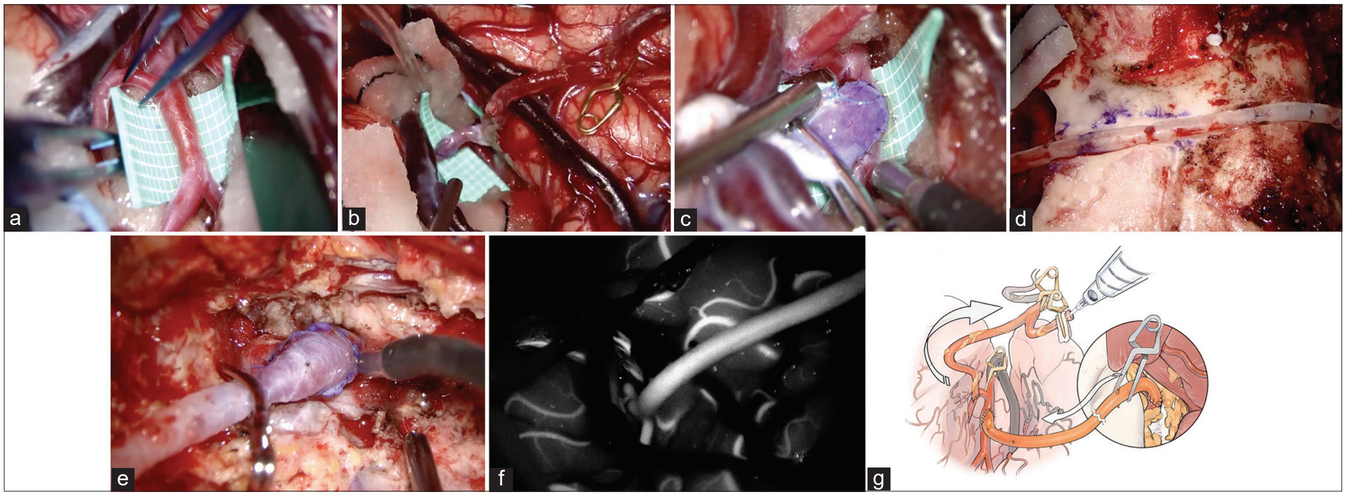


Figure 3: Intraoperative findings of the V3-radial artery graft -M2 bypass. (a) Superior trunk of the M2 is considered as a recipient artery once Sylvian fissure dissection is complete. (b) At first, superficial temporal artery to the M3 portion of the middle cerebral artery (MCA) bypass is performed. (c) The M2 portion of the MCA to RAG anastomosis is performed. (d) The mastoid and the temporal bones are drilled just below the graft route not to compress the graft and make the graft route shorter. (e) V3 to RAG anastomosis is performed. (f) Indocyanine green video angiography demonstrates good filling of the V3-RAG-M2 bypass. (g) Schematic image of the pressure monitoring.

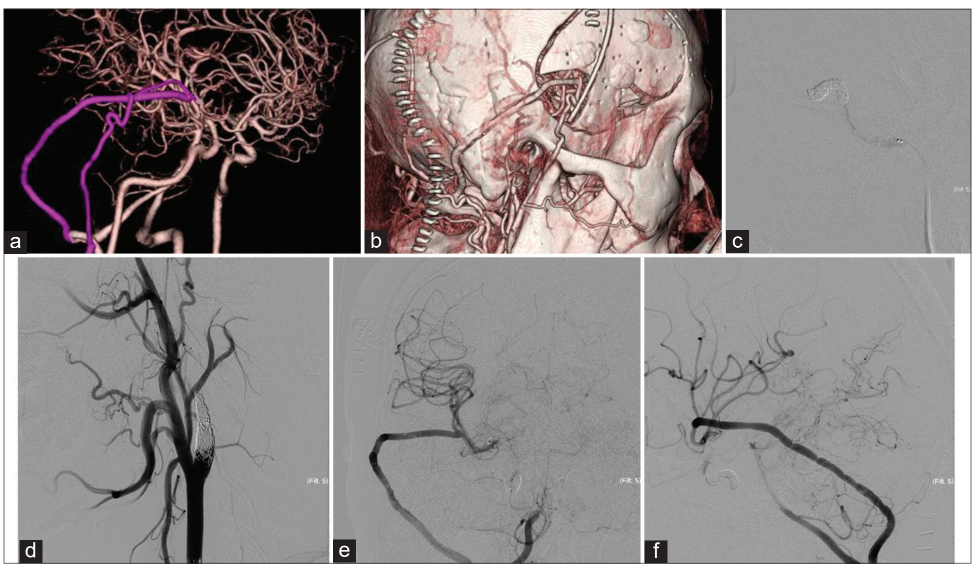


Figure 4: Postoperative courses. (a and b) The reconstruction of the computed tomography angiography in lateral view reveals good filling of the V3-radial artery graft (RAG)-M2 and superficial temporal artery -middle cerebral artery bypass. The internal carotid artery is not occluded at this time. (c) The cavernous portion of the internal carotid artery (ICA) is occluded by coil, lateral view of angiography image. (d) The cervical ICA is occluded, oblique view of angiography image. (e and f) Anterior to the posterior and lateral view of the digital subtraction angiography after ICA occlusion shows good filling of the V3-RAG-M2 bypass.

DISCUSSION

Indication for carotid ligation with bypass before intervention for the primary lesion

Although the planned bypass for the present case was completed without complications and with the shortest time to induction chemotherapy, the indication for bypass should be carefully analyzed. Although radical neck dissection using carotid artery sacrifice with bypass for advanced skull base malignancies has been reported previously, to the best of our knowledge, this is the first report where bypass surgery was performed for epipharyngeal carcinoma. Kalani *et al*.[7] reported 18 cases of skull base malignancies resected using sacrificing ICA combined with low-flow bypass. The bypass-related complication rate was 16.7%. They concluded that despite maximum surgical intervention, the patient's survival was dismal, with significant complications. Sacrificing ICA with bypass may be considered for low-grade malignant tumors in rare cases. We agree with this conclusion, and the indication should be discussed considering its pathology and expected prognosis. In this regard, due to the difficulty of radical resection and high sensitivity to radiotherapy, the standard treatment for epipharyngeal carcinoma is chemotherapy and radiotherapy. Even if the clinical stage is IV, the 5-year survival rate for epipharyngeal carcinoma is more than 50%. Thus, if there are any advantages to sacrificing the ICA for epipharyngeal carcinoma, carotid ligation with bypass should be aggressively considered. The advantage of sacrificing the ICA must be balanced with the complications and invasiveness of bypass surgery.

Risk of carotid artery rupture

The incidence of CBS in major head-and-neck oncological surgeries is reported between 3% and 4.5%.[2,8] The predisposing factor for CBS is preoperative radiotherapy and increases the rate to 4.5–21.1%.[2] In general, the previous radiotherapy has been administered to 80–90% of patients with CBS. There have also been reports of CBS after radiation therapy without surgical dissection.[4] Considering the hypersensitivity of epipharyngeal carcinoma for radiotherapy and the vascular toxicity of the irradiation itself, carotid canal engulfment could be a good indication for ICA sacrifice before irradiation.

In addition, postradiation ICA stenosis or occlusion occurs.[5] Thus, if long-term survival can be predicted, ICA sacrifice with bypass may help in future ischemic complications.

Bypass indication and selection of donor artery

In patients with malignant tumors of the head and neck, the selection of the ipsilateral external carotid artery as a donor artery is challenging due to its malignant nature and as it would be irradiated before or after surgery. However, contralateral STA or ipsilateral extracranial V3 can be selected. One option is a bonnet STA-interpositional graft-MCA low-flow bypass using the contralateral STA as a donor for advanced skull base malignant tumors. Kalani *et al*.[7] reported 10 cases of a bonnet bypass group, one had a stroke, and another had bypass occlusion. Hadeishi *et al*.[6] first reported a V3-RAG-MCA high-flow bypass for patients with CBS. The V3 segment of the VA was selected as the donor due to BTO intolerance, the ipsilateral external carotid artery became infected, and the STA collapsed. The indications for bypass, graft size selection, and high-flow and low-flow bypass should be determined by objective BTO findings and donor artery condition in each patient.

Although BTO identifies patients at risk of immediate ischemia caused by occlusion, its sensitivity is controversial.[11] Ischemic complications should not occur due to the failure of BTO. Hence, for neck and head malignancies, the V3 segment of the VA is considered as a good donor that can achieve a high-flow bypass and is less influenced by radiation and tumors.

Limitation of this study

This is a technically successful bypass surgery case report. The prognosis of this patient and the effectiveness of the bypass are still unknown. The validity of ICA ligation with V3-MCA bypass before treating malignant tumors of the head and neck was carefully discussed by correcting more cases.

CONCLUSION

ICA ligation with VA-MCA high-flow bypass before chemoradiotherapy for epipharyngeal carcinoma is useful as it prevents carotid artery rupture and allows radical intervention. Careful indications should be considered.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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