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*Case Report*

# High-flow bypass surgery using a radial artery graft for an extracranial internal carotid artery aneurysm: Case reports and literature review

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## ABSTRACT

**Background:** Extracranial carotid artery aneurysms are rare. Surgery may be difficult when vessels are tortuous and on a high cervical level. We report two patients whose tortuous extracranial internal carotid artery (ICA) aneurysm located on a high cervical level was successfully treated by ICA ligation and a high-flow bypass using a radial artery (RA) graft between the external carotid- and the middle cerebral artery.

**Case Description:** (Case 1) A 47-year-old man suffered a recurrent cerebral infarct despite medical treatment. His right extracranial ICA aneurysm measured 33 mm; it was tortuous and located at a high cervical level. We ligated the ICA after placing a high-flow bypass using an RA graft. The aneurysm was not repaired. (Case 2) A 59-year-old woman noticed pulsatile swelling on her left neck. It was due to an extracranial ICA aneurysm that was large (36 mm), tortuous, and located at a high cervical level. We performed ICA ligation after placing a high-flow bypass using an RA graft without direct aneurysmal repair. Six months after the operation she noted a pulsatile bulge on the left oropharynx. We confirmed recurrence of an aneurysm from retrograde blood flow and performed internal trapping by occluding the distal portion of the ICA aneurysm using an intravascular procedure.

**Conclusion:** ICA ligation after placing a high-flow bypass with an RA-graft is a technically demanding, but safe procedure to address extracranial ICA aneurysms that are tortuous and located at a high cervical level.

**Keywords:** Aneurysm, Bypass surgery, Extracranial internal carotid artery, Radial artery graft

## INTRODUCTION

Extracranial carotid artery aneurysms constitute fewer than 1% of all aneurysms.[2-4] Without treatment, around 50% of patients develop cerebral ischemia. While the rupture rate is low, the morbidity and mortality rates are high and aggressive treatment is recommended.[2,8,9,11-13] Even with various surgical methods, their treatment is difficult especially when the aneurysms are tortuous and located at a high cervical level.[2,7,8,11-13] We report two patients whose tortuous extracranial internal carotid artery (ICA) aneurysms at a high cervical level were successfully treated with a high-flow bypass using a radial artery (RA) graft between the external carotid artery (ECA) and the middle cerebral artery (MCA) (ECA-RA-M2 portion).

## CASE REPORT

### Case 1

This 47-year-old man had suffered left hemiparesis due to a cerebral infarct at the right MCA 9 years earlier. The diagnosis was thrombo-embolism from a right extracranial ICA aneurysm and antiplatelet treatment was started. He developed left hemiparesis and was admitted to a local hospital. Brain magnetic resonance imaging (MRI) revealed a cerebral infarct in the right MCA territory and heparinization was added. However, his paresis worsened due to progression of the infarct. On the 22$^{nd}$ day after admission, he was transferred to us. On admission, left hemiparesis (3~4/5; MMT) was observed. Brain MRI revealed a subacute cerebral infarct in the MCA territory; perfusion MRI showed hypo-perfusion of the right hemisphere [Figure 1]. Cervical MRI, computed tomography (CT) scans, and a right carotid artery angiogram showed an ICA aneurysm (33 mm) at the C2 level [Figure 2]. We considered endovascular treatment difficult due to the aneurysmal tortuosity and direct repair difficult due to its high cervical location. Therefore, we performed ICA ligation after placing a high-flow bypass using an RA graft without direct aneurysm repair.[10]

Postoperatively, there was no neurological deterioration; brain MRI showed no new cerebral infarction. Cerebral angiography confirmed right ICA occlusion and disappearance of the aneurysm [Figures 2c and d]. He was transferred to a rehabilitation hospital 26 days after the operation. At 12 months after the operation, left hemiparesis was present but he was able to walk without a cane and to pursue the activities of daily living independently. He suffered no aneurysm recurrence.

### Case 2

This 59-year-old woman had noticed pulsative swelling on the left neck 4 months earlier. She underwent cervical 3D-computed tomography-angiography; the presence of an extracranial ICA aneurysm was suspected and she was transferred to our hospital. She presented with no obvious neurological deficits. Brain MRI showed no lesion, however, perfusion MRI revealed hypo-perfusion in the left hemisphere [Figure 3]. Cervical MRI, CTA, and angiography confirmed a left extracranial ICA aneurysm (36 mm) at the C2/C3 level [Figure 3]. We considered endovascular treatment difficult due to aneurysmal tortuosity and direct repair difficult due to its location at a high cervical level. Therefore, we placed a high-flow bypass using an RA graft and ligated the ICA.[10]

After surgery, she suffered left incomplete facial nerve palsy (House-Brackmann Grade II) due to local injury. Brain MRI showed no ischemic lesion, and confirmed patency of the high-flow bypass without blood flow from the proximal portion of the ICA. She was discharged 18 days after the operation. However, 6 months after the operation, she noted a pulsatile bulge on the left oropharynx although her facial nerve paralysis had disappeared. A cerebral angiogram from the RA graft showed that the aneurysm was fed retrogradely in the delayed phase. We trapped the aneurysm by occluding the distal portion of the ICA intravascularly [Figure 4]. Postoperatively, she had no new neurological symptoms. MRI confirmed the disappearance of blood flow in the aneurysm and she was discharged 6 days after the operation. On follow-up 6 months later she suffered no neurological symptoms; MRI confirmed gradual shrinkage of the aneurysm.

## DISCUSSION

Open repair is the gold-standard treatment for ECA aneurysms. The potential risks posed by surgery are unwanted embolization, difficulties with distal control, and injury to surrounding vital structures. The reported

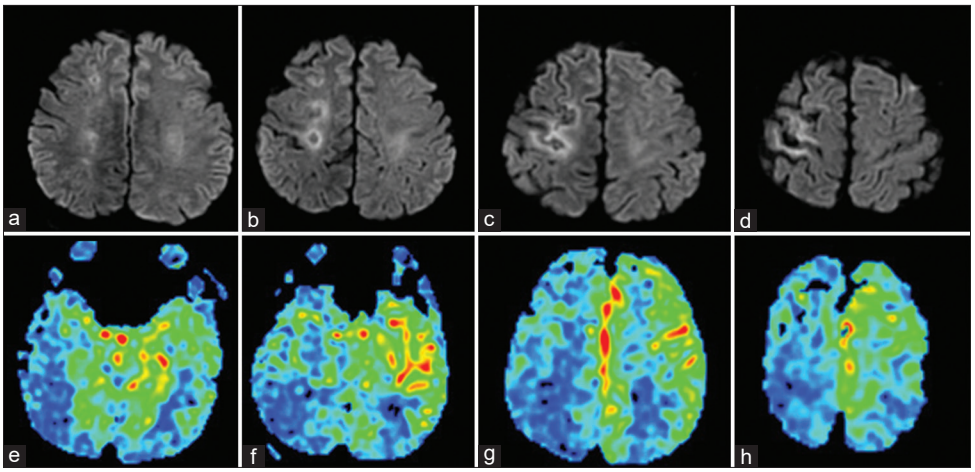


**Figure 1:** (Case 1) Brain magnetic resonance (MR) images (a-d) reveal a subacute cerebral infarct in the territory of the middle cerebral artery. Perfusion MR images (e-h) showed hypo-perfusion in the right hemisphere.


**Figure 2:** (Case 1) Cervical axial computed tomography scans (a and b) show a 33-mm extracranial carotid artery aneurysm (white arrow). The upper end of the aneurysm (a) is at the mandibular level. The left carotid artery angiogram (c, lateral view) shows an internal carotid artery (ICA) aneurysm with an irregular wall at the C2 level. (d) Postoperative angiogram confirming ICA occlusion and disappearance of the aneurysm and patency of the radial artery graft (arrowhead).

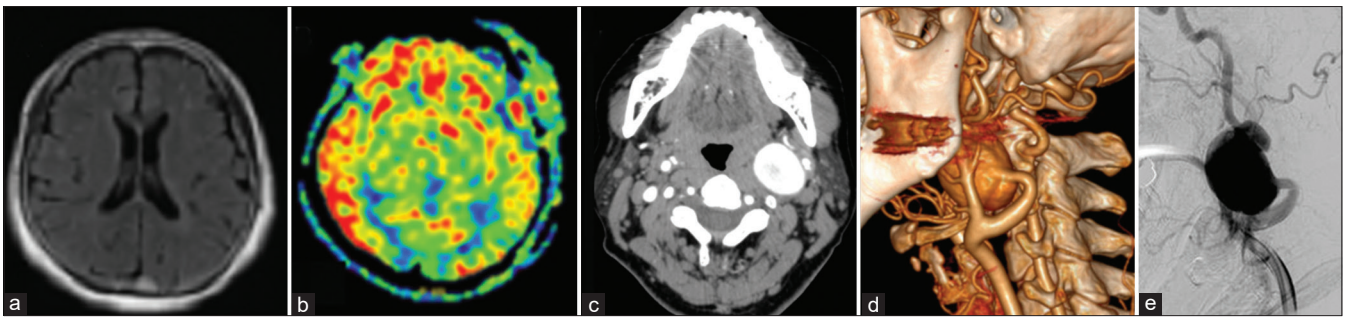


**Figure 3:** (Case 2) T2-FLAIR magnetic resonance imaging (MRI) axial image (a) shows no abnormal lesion. MRI perfusion images (b) reveal hypo-perfusion in the left cerebral hemisphere. Cervical computed tomography angiograms (c and d) and a left carotid artery angiogram (e) reveal a 36-mm left extracranial internal carotid artery aneurysm the level of C1 to C3. Part of the aneurysm is behind the mandible.

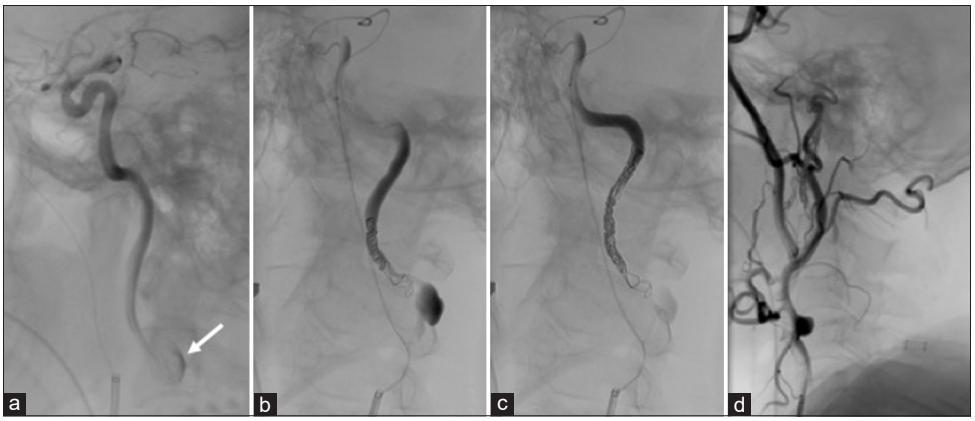


**Figure 4:** (Case 2) Retrograde angiogram from the top of the left internal carotid artery (ICA) through the radial artery graft shows the aneurysm remnant (white arrow) (a). After the ICA was occluded by coil-embolization the aneurysm disappeared (b, c, d).

postoperative mortality rate was 2.2–6.0%, morbidity due to neurological complications was 5.5–10% and included fatal stroke.[2,11] The risk for iatrogenic cranial nerve injury is 2.2–44% and particularly high when the aneurysm is located at a high cervical level.[2,7,11-13] Therefore, the addition of reconstruction to the basic strategy is recommended when the aneurysm can be approached easily, and repair should not be attempted when there is strong adhesion to surrounding tissues or when the aneurysm is at a high cervical level.[6] The aneurysms of our patients were on a high cervical level; this rendered exposure of the distal neck difficult and we considered incomplete direct aneurysmal repair dangerous. Therefore, we performed ICA ligation and placed a high-flow bypass using an RA graft without direct local aneurysm repair. The treatment outcomes were good, suggesting that our strategy is a viable treatment option in some cases. We anastomosed from the ECA to an intracranial vessel; the common and external carotid arteries must be healthy for this approach to work.

As RA grafts are usually placed at a layer shallower than the parallel-running ECA in the cervical region, it is difficult to address extracranial ICA aneurysms with RA grafts. Preoperative images confirmed that in our patients, the aneurysms were not located at sites where an RA graft would normally be placed. This point must be confirmed on preoperative images before our treatment strategy can be implemented. In both of our patients, our approach was successful without serious postoperative sequelae.

Some extracranial carotid artery aneurysms can be addressed endovascularly.[1,5,9,13] As exposure of the aneurysmal neck, even of aneurysms at a high cervical level, is not necessary, cranial nerve injury is avoidable.[4,7,9,11,13] However, endovascular procedures are not risk-free. Stroke, aneurysmal rupture, and blood vessel damage have been reported[1,9] after endovascular stenting of ECA aneurysms; 4.1% of patients died, 1.8% suffered a stroke, 6.3% a late stroke, and in 1% the carotid artery ruptured.[9] The treatment of highly tortuous or kinked carotid artery aneurysms is difficult.[1,5,7,13] Because our patients presented with severe aneurysmal tortuosity, we ruled out endovascular treatment. Advances in technology and instrumentation and the accumulation of information are needed to increase the number of patients whose aneurysms can be treated endovascularly.

## CONCLUSION

Our patients with tortuous extracranial carotid artery aneurysms that were located on a high cervical level were successfully treated by ICA ligation and the placement of a high-flow bypass using a RA-graft.

### Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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