



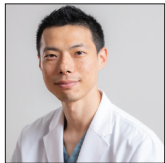
Case Report

Emergent carotid artery stenting for cervical internal carotid artery injury during carotid endarterectomy: A case report

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Received : 11 November 2020

Accepted : 04 February 2021

Published : 17 March 2021

DOI

10.25259/SNI_806_2020

Quick Response Code:



ABSTRACT

Background: Carotid endarterectomy (CEA) has been the standard preventive procedure for cerebral infarction due to cervical internal carotid artery stenosis, and internal shunt insertion during CEA is widely accepted. However, troubleshooting knowledge is essential because potentially life-threatening complications can occur. Herein, we report a case of cervical internal carotid artery injury caused by the insertion of a shunt device during CEA.

Case Description: A 78-year-old man with a history of hypertension, diabetes, and hyperuricemia developed temporary left hemiplegia. A former physician had diagnosed the patient with a transient cerebral ischemic attack. The patient's medical history was significant for the right internal carotid artery stenosis, which was severe due to a vulnerable plaque. We performed CEA to remove the plaque; however, there was active bleeding in the distal carotid artery of the cervical region after we removed the shunt tube. Hemostasis was achieved through compression using a cotton piece. Intraoperative digital subtraction angiography (DSA) revealed severe stenosis at the internal carotid artery distal to the injury site due to hematoma compression. The patient underwent urgent carotid artery stenting and had two carotid artery stents superimposed on the injury site. On DSA, extravascular pooling of contrast media decreased on postoperative day (POD) 1 and then disappeared on POD 14. The patient was discharged home without sequela on POD 21.

Conclusion: In the case of cervical internal carotid artery injury during CEA, hemostasis can be achieved by superimposing a carotid artery stent on the injury site, which is considered an acceptable troubleshooting technique.

Keywords: Carotid endarterectomy, Emergent carotid artery stenting, Iatrogenic vessel injury

INTRODUCTION

Carotid endarterectomy (CEA) has been the standard preventive procedure for cerebral infarction due to cervical internal carotid artery stenosis.^[3,4] However, CEA causes complications, such as

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cerebral ischemia, in 70% of patients.^[6] Since complications can be serious, troubleshooting knowledge is essential to avoid complications.

Herein, we report a case of vessel injury in the distal carotid artery of the cervical region caused by the insertion of a shunt device during CEA. Hence, we performed emergency carotid artery stenting (CAS), and the patient had a good outcome.

CASE DESCRIPTION

A 78-year-old man referred to our hospital had a history of hypertension, Type 2 diabetes, hyperuricemia, and chronic subdural hematoma. The patient visited a former physician due to transient ischemic attack causing paralysis on the left side. Cervical magnetic resonance angiography revealed severe stenosis of the right internal carotid artery. The patient did not experience impaired consciousness or neurologic deficits, and the coagulation/fibrinolytic testing results were not remarkable. A carotid echography revealed that the peak systolic velocity of the right internal carotid artery was 276 cm/s. The plaque was mobile with low echogenicity.

A cervical three-dimensional computed tomography angiography examination showed stenosis of the right carotid artery from C4/5 to C5/6. The stenosis rate was 71% based on the method used in the North American Symptomatic CEA Trial [Figure 1a].

Cervical magnetic resonance imaging (MRI) revealed an unstable plaque with a major axis of 20 mm showing T1 (black blood) high intensity from the right common carotid artery to the proximal internal carotid artery [Figure 1b].

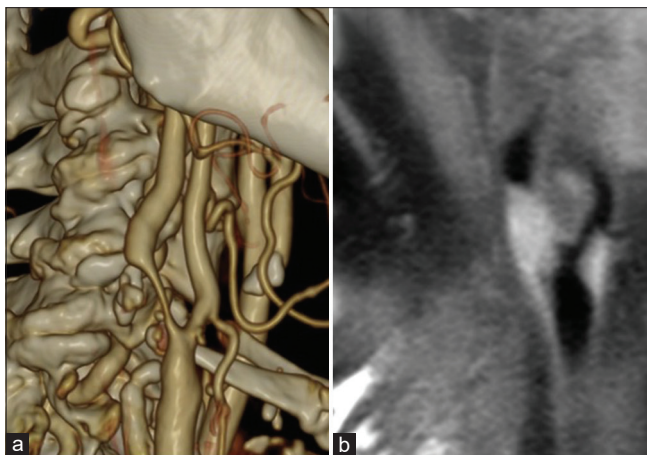


Figure 1: Preoperative image. (a) Cervical three-dimensional computed tomography angiography: stenosis of the right carotid artery occurred from C4/5 to C5/6, and the stenosis rate was 71% based on the method used in the North American Symptomatic Carotid Endarterectomy Trial, (b) cervical magnetic resonance imaging: examination revealed an unstable plaque with a major axis of 20 mm showing T1 (black blood) high intensity from the right common carotid artery to the proximal internal carotid artery.

The patient had severe symptomatic stenosis of the right internal carotid artery, which was an indication for revascularization. We planned to perform CEA because the plaque was vulnerable, and the patient did not present with high-risk factors for the procedure. Clopidogrel 75 mg/day was initiated at the time of onset but was discontinued 5 days before surgery.

We performed CEA in a hybrid operating room. The Furui's double-balloon shunt system (Muranaka Medical Instruments, Osaka, Japan) was used, and balloons in both the common carotid artery side and the internal carotid artery side were injected with 0.5 mL of air. Then, we removed the plaque and sutured the carotid artery. An intraoperative digital subtraction angiography (DSA) revealed extravascular pooling of contrast media in the distal carotid artery of the cervical region, indicating vessel injury. The internal carotid artery, distal to the injury site, presented with severe stenosis due to hematoma compression [Figure 2a]. Since the injury site was distal to the operative field, vessel repair through direct surgery was challenging to perform. Hemostasis was achieved in the operative field. Therefore, we urgently performed CAS to repair the injured vessel and to facilitate dilation of iatrogenic internal carotid artery stenosis. We explained to the family that CAS for hemorrhagic lesions is an off-label treatment, and they provided informed consent for the procedure. Aspirin 200 mg and clopidogrel 300 mg were administered through the nasogastric tube before the procedure.

Since we performed CEA in the hybrid operating room, immediately after the end of CEA, we also performed DSA with the transfemoral technique on the same bed. A right common carotid angiography revealed extravasation of the right internal carotid artery at the injury site, and contrast medium pooled in the extravascular space. The internal carotid artery, distal to the injury site, had severe stenosis and blood flow delay in the right middle cerebral artery. The right anterior cerebral artery could not be visualized [Figure 2b].

The Carotid WALLSTENT (Boston Scientific, Natick, MA, USA) measuring 8 × 29 mm was placed to cover the distal stenosis and the injury site. Although stenosis improved, blood flow delay from the injury site to the hematoma cavity remained. Hence, the Carotid WALLSTENT, measuring 10 × 31 mm, was placed and overlapped. Then, leakage of contrast medium from the injury site decreased [Figure 2c]. We did not superimpose the third stent considering the high risk of thrombosis. On the right common carotid angiography after CAS, blood flow delay in the right middle cerebral artery improved, and the right anterior cerebral artery could be visualized [Figure 2d].

Postoperatively, the patient continually received conservative management, including strict blood pressure control, under

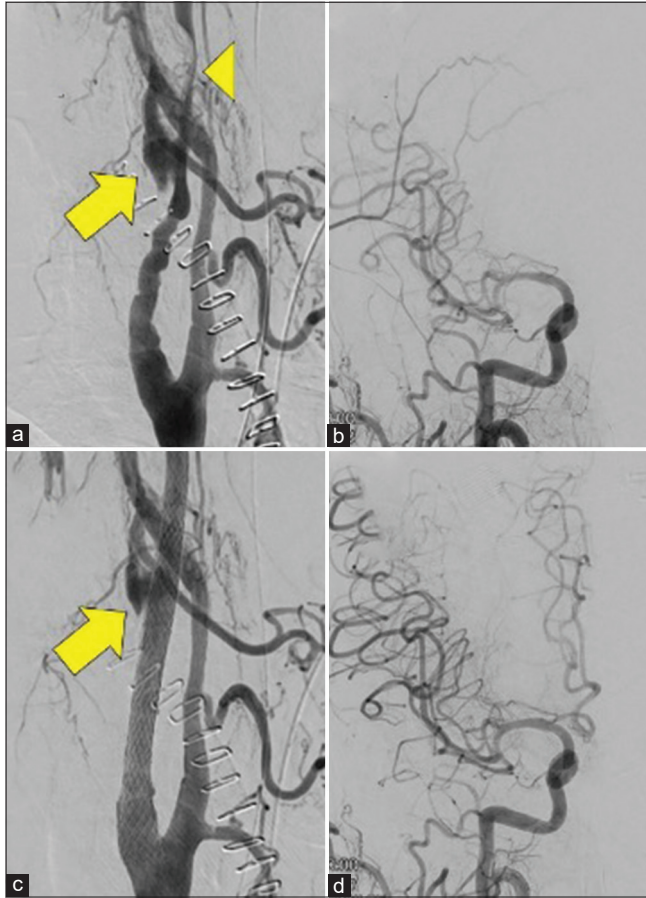


Figure 2: Right common carotid angiography before and after carotid artery stenting (CAS). (a) Cervical angiography before CAS. Contrast media leaked from the injury site of the internal carotid artery (arrow), and the internal carotid artery distal to the injury point was severely stenotic due to hematoma compression (head arrow), (b) head angiography before CAS. Blood flow in the right middle cerebral artery was delayed, and the right anterior cerebral artery could not be visualized, (c) cervical angiography after CAS. The leakage of the contrast medium from the injury site decreased (arrow), (d) head angiography after CAS. Blood flow delay in the right middle cerebral artery improved, and the right anterior cerebral artery could be visualized.

general anesthesia with intubation. Then, aspirin 100 mg and clopidogrel 75 mg were continuously administered. On DSA, extravascular pooling was further reduced at the end of CAS on postoperative day (POD) 1 [Figure 3]. Cervical computed tomography scan images were obtained on POD 2 (without contrast), 3 (with contrast), and 6 (without contrast). However, there was no increased blood mass [Figures 4a-c].

The patient was extubated on POD 6. He presented with hoarseness and right miosis due to Horner's syndrome, that is, lower cranial nerve symptoms. However, both spontaneously disappeared overtime. Therefore, hematoma decompression was considered effective. A head MRI on POD 13 revealed no new cerebral infarction or intracranial

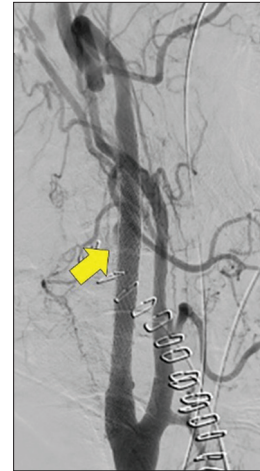


Figure 3: Right common carotid arteriography on postoperative day 1. The arrow indicates the point where the contrast media leaked due to injury. Contrast media continued to leak from the injury point. However, it decreased.

hemorrhage. On DSA, the extravascular pooling of contrast media in the injury site disappeared on POD 14 [Figure 5]. He was discharged to home without sequela on POD 21.

DISCUSSION

Inserting a shunt intraoperatively to prevent cerebral ischemia during CEA is widely accepted.^[18,20] However, there are also risks of complications, such as thromboembolic events and technical errors. Sundt *et al.* have shown that 0.5% of patients present with neurological deficits due to microembolism caused by shunt insertion.^[18] Moreover, there are some reports on internal carotid artery dissection due to shunt insertion.^[19,20] However, it is debatable whether routine shunting or elective shunting can prevent complications. A previous report revealed no significant difference in terms of mortality and morbidity.^[16]

In this case, the internal carotid injury site is more distal than the operative field, and it is easy to think of injury due to the physical stimulation of the shunt balloon. The volume of air used in balloon shunting is usually ≤ 0.3 mL, but we used 0.5 mL of air. Hence, overinflation cannot be denied. The shunt balloon device was moved due to surgery in the shunt system during plaque removal, and the balloon physically damaged the blood vessel.

There have been few reports on internal carotid artery injury due to shunt insertion. However, there is only one case on, which was reported by Illuminati *et al.* In that case, immediately after shunt insertion, the internal carotid artery was injured and bled.^[9] By inserting the shunt into the distal area and inflating the balloon, hemostasis was achieved temporarily. They repaired the injury site by patching the greater saphenous vein. Moreover, the injury site was

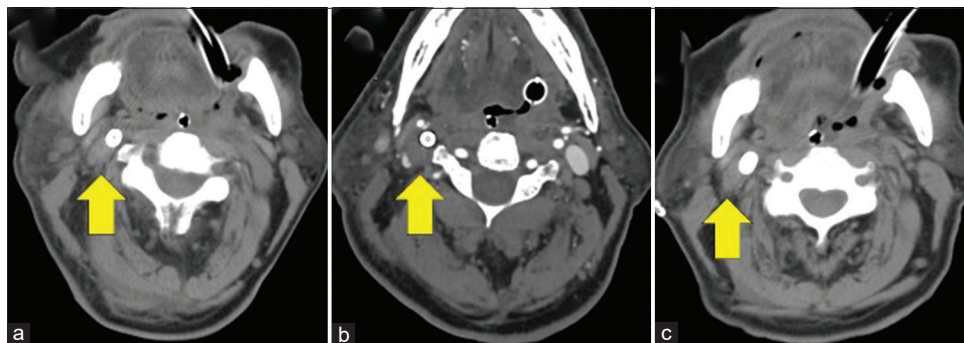


Figure 4: Postoperative cervical computed tomography. Increased blood mass was not observed. The arrow indicates the blood mass. (a) Postoperative day (POD) 2 (without contrast), (b) POD 3 (with contrast), (c) POD 6 (without contrast).

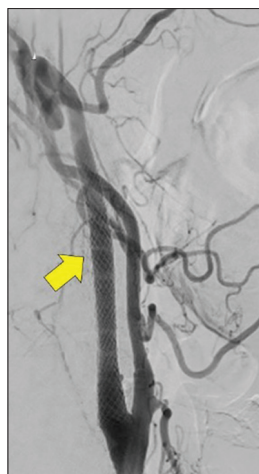


Figure 5: Right common carotid arteriography on postoperative day 14. The arrow indicates the point where the contrast media leaked due to injury as shown in Figure 3. Contrast media leakage from the injury point disappeared.

proximal, and the vessel could be repaired by patching. However, in our case, the injury site was distal, and a direct procedure was challenging to perform. Hence, we performed endovascular treatment.

Some studies have shown that using a covered stent or a flow diverter stent for internal carotid artery injury had good outcomes. Arai *et al.* revealed that hemostasis was achieved by placing a covered stent for massive hemorrhage due to carotid artery erosion in esophageal cancer.^[1] Giorgianni *et al.* reported that hemostasis was obtained by placing a flow diverter stent for internal carotid artery injury during transnasal endoscopic pituitary surgery.^[7] However, these stents are not clinically indicated for cervical internal carotid artery injuries, and they are challenging to arrange according to professionals in some facilities. Although CAS is not clinically indicated, we used a carotid artery stent for emergency evacuation with consideration of hemostasis due to its flow diverting effect.

Hagihara *et al.* showed that carotid artery stent placement for internal carotid artery injury prevented stroke in two

cases.^[8] However, no studies show that CAS was used as a troubleshooting technique for internal carotid artery injury caused by the placement of a shunt device during CEA.

The flow diverting effect of the low wall coverage stent is controversial.^[11,14] Liu *et al.* reported that the Neuroform (Boston Scientific Corp., Fremont, CA) or Enterprise stent (Codman Neurovascular, Miami, FL) was placed in the neck of a small unruptured aneurysm, and the aneurysm size decreased due to the flow diverting effect.^[13] Regarding the flow diverting effect of a carotid artery stent, Kuramoto *et al.* reported a case of complete occlusion 12 months after the placement of the WALLSTENT for an aneurysm in the narrow neck of the common carotid artery.^[10] Furthermore, Assali *et al.* reported a case in which only the WALLSTENT was placed in a traumatic pseudoaneurysm of the internal carotid artery; there was complete occlusion after only 10 min.^[2]

The Japanese government has approved the use of carotid stents, such as the closed-cell type WALLSTENT, open-cell type Precise (Cardinal Health Inc., Dublin, Ireland), and Protégé (Medtronic, Dublin, Ireland). The coverage ratios are 21.4% for the closed-cell type WALLSTENT, 19.4% for the open-cell type Precise, and 17.6% for the Protégé stent.^[15,23] Li *et al.* reported that the coverage ratios of the intracranial stent are 9.5% for the Neuroform stent and 8.2% for the Enterprise stent.^[5,12,17] The carotid stents have a higher coverage ratio than intracranial stents, and they can have a stronger flow diverting effect. Theoretically, the WALLSTENT has the highest flow diverting effect among carotid stents considering its coverage ratio.

The coverage ratio of Pipeline (Medtronic, Dublin, Ireland), which is a flow diverter stent, is approximately 30%.^[22] The coverage ratio of the nonflow diverter stent is lower than that of the flow diverter stent. However, the flow diverting effect may be enhanced further by superimposing it. The coverage ratio of LVIS (Terumo Corporation, Tokyo, Japan) is about 23%. However, Wang *et al.* reported that when LVIS was superimposed,

it exhibited a flow diverting effect more than that of Pipeline.^[21] In our case, superimposing the WALLSTENT enhanced the flow diverting effect.

There are some technical points of caution when a stent is placed in the carotid artery immediately after CEA. First, it was expected that hemostasis would be difficult with the placement of only one stent, and the distal position of the stent was determined assuming superposition from the beginning. Second, administration of antiplatelet drugs is controversial, but we thought that it would be better to administer them because of the possibility of stent superposition. Third, at the time of lesion crossing, multiple working angles created by three-dimensional rotational angiography were used to ensure crossing the true lumen safely.

Troubleshooting techniques for vessel injury during CEA include using covered stents and flow diverter stents. However, their availability is low in emergency settings. If such devices are difficult to obtain, an emergency procedure that can achieve hemostasis by superimposing carotid artery stents is worth trying.

CONCLUSION

In this case, CAS was performed urgently for a cervical internal carotid artery injury during CEA with a favorable outcome. Hemostasis can be achieved by superimposing a carotid artery stent on the injury site, which is considered an acceptable troubleshooting technique.

Acknowledgments

The authors would like to thank Enago (www.enago.jp) for the English language review.

Declaration of patient consent

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

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Takahashi T, Ikeda G, Igarashi H, Konishi T, Araki K, Hara K, *et al.* Emergent carotid artery stenting for cervical internal carotid artery injury during carotid endarterectomy: A case report. *Surg Neurol Int* 2021;12:109.