www.surgicalneurologyint.com

ScientificScholar® Knowledge is power
Publisher of Scientific Journals

Surgical Neurology International
Editor-in-Chief: Nancy E. Epstein, MD, Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Neurovascular

Editor
Kazuhiro Hongo, MD,
Shinshu University, Matsumoto, Japan

SNI Open Access

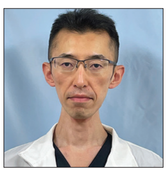
Case Report

A case of symptomatic carotid artery occlusion after aortic arch replacement treated with carotid-carotid crossover bypass

Yusuke Sakamoto[1], Kenko Maeda[2], Masaya Takemoto[2], Jungsu Choo[2], Mizuka Ikezawa[2], Ohju Fujita[2], Fumihiro Sago[2], Daiki Somiya[2], Akira Ikeda[2]

[1]Department of Neurosurgery, Nagoya Ekisaikai Hospital, [2]Department of Neurosurgery, JCHO Chukyo Hospital, Nagoya, Japan.

E-mail: *Yusuke Sakamoto - usakamoto420@gmail.com; Kenko Maeda - kenkouc200@gmail.com; Masaya Takemoto - nutake0105@gmail.com; Jungsu Choo - jonsu_the_sankakukin@yahoo.co.jp; Mizuka Ikezawa - mizuka_ike@yahoo.co.jp; Ohju Fujita - haohju.cactus@gmail.com; Fumihiro Sago - f.sagoh@gmail.com; Daiki Somiya - daiki0413somiya@gmail.com; Akira Ikeda - a.ikeda.chukyo@gmail.com



***Corresponding author:**
Yusuke Sakamoto,
Department of Neurosurgery,
Nagoya Ekisaikai Hospital,
Nagoya, Japan.

usakamoto420@gmail.com

Received : 29 April 2022
Accepted : 14 June 2022
Published : 23 June 2022

DOI
10.25259/SNI_415_2022

Quick Response Code:

ABSTRACT

Background: Symptomatic common carotid artery (CCA) occlusion is rare and its treatment remains unestablished. Although cases of subclavian-to-carotid bypass have been reported, very few cases of carotid-to-carotid crossover bypass have been reported, despite its advantages. We report a case of Riles type 1A symptomatic CCA occlusion after aortic arch replacement that was treated with carotid-to-carotid crossover bypass with favorable outcomes.

Case Description: A 65-year-old woman with a history of hypertension, hyperlipidemia, diabetes, and total arch replacement for thoracic aortic aneurysm was admitted to our hospital with a complaint of the right hemiparesis and motor aphasia. Head magnetic resonance imaging revealed a fresh infarction in the left cerebral hemisphere. Cervical computed tomography (CT) angiography revealed left CCA occlusion. Thoracic CT angiography showed severe stenosis of the left subclavian artery. SPECT showed a general decrease in blood flow in the left cerebral hemisphere. We performed a carotid-to-carotid crossover bypass with a synthetic graft that was passed through the subcutaneous tunnel. First, the right carotid artery-synthetic graft end-to-side anastomosis was performed. Subsequently, we performed synthetic graft-left CCA end-to-side anastomosis. The postoperative course was uneventful. Cervical computed tomography angiography showed perfect patency of the crossover bypass. The patient recovered almost completely and was independently performing daily activities.

Conclusion: Carotid-to-carotid crossover bypass is a durable treatment for symptomatic CCA occlusion. Further studies are needed to compare its outcomes with those of other methods and to confirm our findings with larger sample size.

Keywords: Aortic arch replacement, Common carotid artery occlusion, Crossover bypass, Stroke, Synthetic graft

INTRODUCTION

Compared to symptomatic internal carotid artery (ICA) occlusion, symptomatic common carotid artery (CCA) occlusion is a relatively rare disease.[1] Superficial temporal artery-middle cerebral artery (STA-MCA) bypass is a well-known and established treatment option for ICA occlusion, although the indication for surgery is controversial.[14] However, treatments for CCA occlusion are still poorly established.[7] Few cases of endovascular treatment have been reported, but this is difficult to perform in heavily calcified carotid arteries that may prevent guidewire crossing.[6] In addition, the risk of embolic complications should be considered in endovascular treatment. Some bypass treatment options, such as subclavian-to-carotid bypass, have been reported earlier. However, this bypass method requires knowledge of cervicothoracic anatomy and techniques in vascular surgery, which some neurosurgeons may not be experienced with. Further, it may also result in complications such as brachial plexus injury.[2,4,10,16] On the other hand, a few cases of carotid-to-carotid crossover bypass have been reported as an alternative to subclavian-to-carotid bypass.[9,13] Although crossover bypass is not a common treatment option for CCA occlusion, this approach has some merits and may be beneficial in some complicated cases.[5,12] In this report, we describe a case of Riles type 1A symptomatic CCA occlusion after aortic arch replacement, which was treated with carotid-to-carotid crossover bypass with favorable postoperative outcomes.[15]

CASE DESCRIPTION

The authors obtained written informed consent from the patient. No approval from the IRB was sought as this article is a case report.

The patient was a 65-year-old woman with a history of hypertension, hyperlipidemia, diabetes, atherosclerotic occlusion of the right subclavian artery and right femoral artery, and thoracic aortic aneurysm. She was admitted to our hospital with a complaint of the right hemiparesis (manual muscle testing [MMT] = 2) and motor aphasia. The Glasgow Coma Scale score was E4V3M6 on arrival. Diffusion-weighted magnetic resonance imaging (MRI) of the head showed a high-intensity zone in the left insular cortex and temporal lobe [Figure 1a]. The left ICA and MCA were not clear [Figure 1b]. The electrocardiogram showed sinus rhythm on arrival. Our neurologist started conservative therapy with heparin (10,000 U/day) and clopidogrel 75 mg/day. The symptoms of the patient improved on the day following admission; however, mild hemiparesis persisted (MMT = 4). The neurologist consulted us on day 6 about surgical treatment for the patient. Cervical and head computed tomography angiography (CTA) showed complete occlusion of the left CCA, extending from its origin to right before the carotid bifurcation. Riles type 1A occlusion was suspected. The left external carotid artery (ECA) was anastomosed with the left vertebral artery through a small branch of the occipital artery [Figure 2a]. The anterior communicating artery was well developed, although there was a small unruptured aneurysm [Figure 2b]. The left posterior communicating artery was hypoplastic [Figure 2c]. The patient had undergone surgical treatment for a thoracic aortic aneurysm with vascular replacement 7 months before at another hospital. CTA also showed severe stenosis of the left subclavian artery and intermediate stenosis of the right brachiocephalic artery [Figure 2a]. We suspected carotid artery occlusion at the anastomosed site of the synthetic vascular graft. We did not perform cerebral angiography for fear of catheter-induced synthetic graft injury of the anastomosed site. Single-photon emission computed tomography (SPECT) showed a general decrease in blood flow in the left cerebral hemisphere at rest [Figure 2d]. Acetazolamide stress SPECT was not performed in the early phase of ischemic stroke as there was a risk of recurrent stroke. On day 16, the patient experienced a second stroke. Diffusion-weighted MRI revealed high-intensity areas on the left temporal and parietal lobes [Figure 3]. The patient presented with the right hemiparesis, motor aphasia, and Gerstmann syndrome. Argatroban hydrate (30 mg/day for 2 days followed by 10 mg/day for 5 days) and aspirin (200 mg/day) were administered. On day 17, her symptoms improved, except for the persistent mild hemiparesis (MMT = 4) and Gerstmann syndrome. Despite intensive medical care, the patient had a recurrent stroke. The collateral blood flow from the hypoplastic posterior communicating artery was not viable. Furthermore, collateral blood flow from posterior circulation through occipital artery anastomosis was not considered because of severe stenosis of the left brachiocephalic artery. Therefore, the development of collateral blood flow was not possible after long-term multiple antiplatelet therapies. Furthermore, we did not expect the risk of hyperperfusion to be so high, because the blood flow of the unilateral CCA is shared with the bilateral ICA. Hence, we decided to perform surgical vascular reconstruction in the acute phase of stroke.

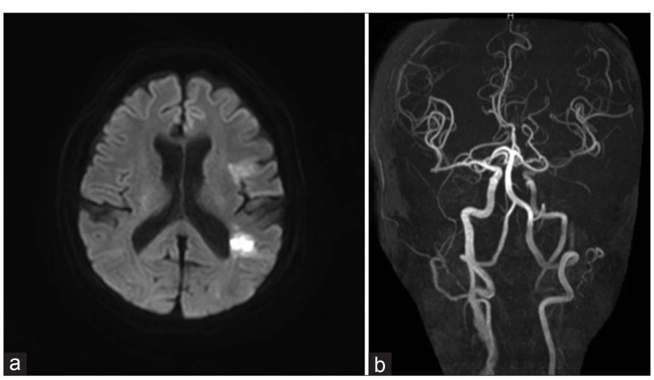


Figure 1: (a) Head magnetic resonance imaging showed a new infarction in the left insular cortex and temporal lobe. (b) Head magnetic resonance angiography (MRA). The left internal carotid artery and MCA were not clearly visible.

Surgical strategy

Due to severe stenosis of the left subclavian artery, left subclavian- or axillary-to-carotid bypass could not be

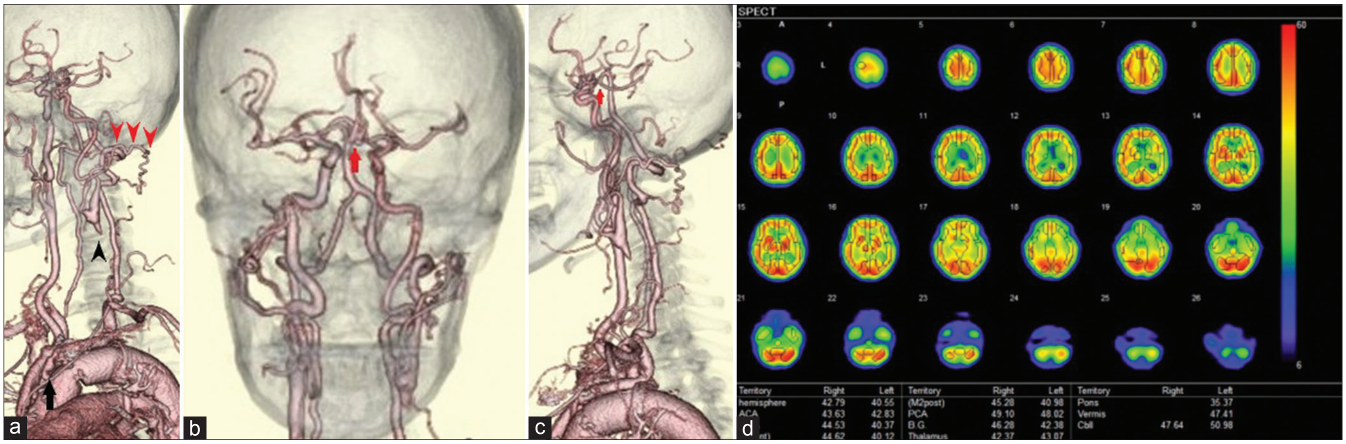


Figure 2: (a) The left cervical computed tomography angiography (CTA), left oblique view. The left common carotid artery was totally occluded from its origin to just before the carotid bifurcation (black arrowheads). Collateral anastomosis between the left occipital artery and a small branch of the left vertebral artery was detected (red arrowheads). Severe stenosis of the left subclavian artery was also observed (black arrow). (b) Head-and-neck CTA, front view. The anterior communicating artery was well developed (arrow), although there was a small unruptured aneurysm in the artery. (c) The left cervical CTA, left lateral view. The left posterior communicating artery was hypoplastic and not visible on CTA (arrow). (d) Single-photon emission computed tomography showed a general decrease in blood flow in the left cerebral hemisphere at rest.

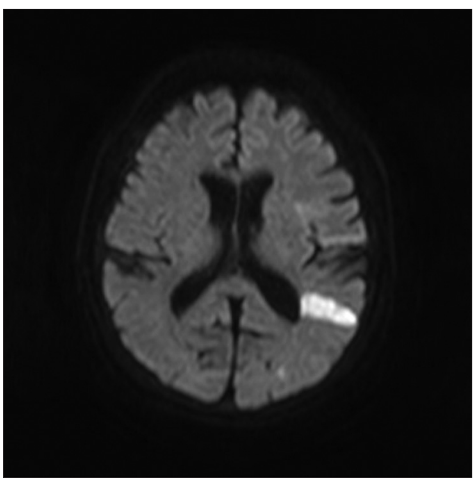


Figure 3: Diffusion-weighted magnetic resonance imaging on day 16 showed the emergence of high-intensity areas on the left temporal and parietal lobes, which indicated a second stroke.

performed. We consulted our endovascular surgeon regarding the risk of performing transcatheter angioplasty. There was a fear of catheter-induced suture injury of the aorta synthetic graft, which could be catastrophic if performed on this patient. Furthermore, we wished to avoid a complicated two-stage vascular reconstruction, which would involve subclavian to carotid bypass following subclavian angioplasty, to reduce invasiveness. Although we considered a bonnet bypass, the left STA was too thin to allow sufficient blood flow. In addition, the patient had unruptured aneurysms in the right MCA and anterior communicating artery. We avoided the bonnet bypass in case surgical clipping would be needed for aneurysms in the future. The right CCA with intermediate stenosis was the only choice for the donor site. The patient had a history of arteriosclerotic occlusion of the femoral artery and right subclavian artery and had undergone vascular reconstruction. We were not certain of the condition of the radial artery graft. Therefore, we decided to perform a carotid-to-carotid crossover bypass with a synthetic vascular graft.

Surgery

On day 25, vascular reconstructive surgery was performed. Dual antiplatelet therapy (aspirin 200 mg/day and clopidogrel 75 mg/day) was administered until 7 days before the surgery and continued with a single antiplatelet drug (aspirin 200 mg/day) until surgery. The patient was placed in a supine position under general anesthesia. The somatosensory evoked potential (SEP), motor evoked potential (MEP), and near-infrared spectroscope (NIRS) were monitored. First, the neck was rotated to the left side at approximately 30°. A linear skin incision along the sternocleidomastoid muscle (SCM) was made to expose the right CCA. After exposing 3 cm of the right CCA, we began the contralateral procedure. The neck was rotated to the right side at approximately 30°, and a linear skin incision was made along the left SCM. We then exposed the left CCA, ECA, and ICA. Indocyanine green showed a stump of an isolated CCA. The length of the stump was approximately 10 mm. Based on the length of the stump and the diameter of the CCA, we chose a 6 mm Gore-Tex® Stretch vascular graft and CV-7 Gore-Tex suture® (W.L. Gore and Associates, Inc., Medical Product Division, Flagstaff, AZ, USA). We created a subcutaneous tunnel with a shunt passer and passed it through a synthetic graft. Before clamping, edaravone 30 mg, methylprednisolone (125 mg), phenytoin (250 mg), and 20% mannitol (300 ml) were administered for cerebral protection. Heparin 4000 U was also infused. We then clamped the right CCA and made a linear vascular incision with a spits scalpel and dilated the arteriotomy with an aortic puncher. Since the orifice of the carotid artery was very small, the carotid shunt, which may have interrupted the back wall suture, was not used. We then performed right carotid artery-synthetic graft end-to-side anastomosis with a running suture [Figure 4a]. Debris and air were flushed out through the synthetic graft. After completing the anastomosis, we clamped the synthetic graft and released the right CCA. The total clamp time of the right carotid artery was 21 min 52 s. After adjusting the length of the synthetic graft, we clamped the left ICA and ECA with a titanium aneurysm clip. In addition, we clamped the proximal end of the left CCA. We made a linear vascular incision with a spits scalpel, dilated the arteriotomy with an aortic puncher, and performed the synthetic graft-left CCA end-to-side anastomosis in the same way as were done for the right side [Figure 4b]. Unlike in a typical carotid endarterectomy, we did not flush debris and air to the ECA due to fear of causing embolization. Therefore, we started anastomosis from the heel to the toe of the orifice on both the front and back wall using double-armed suture thread. Before ligating the back and front wall suture threads, we declapmed the external and internal carotid arteries to flush the debris and air through the toe of the vascular orifice [Figures 4c and d]. After flushing the debris and air, we ligated the anastomosis and released the left ECA, ICA, and CCA. The total clamp time was 21 min and 38 s. After declamping, good pulsation of the synthetic graft was observed [Figures 4e and f]. There was no remarkable change in SEP, MEP, and NIRS during surgery. The postoperative course of the patient was uneventful. No additional neurological symptoms were observed. Careful blood pressure control was performed to avoid hyperperfusion syndrome. Postoperative MRI showed no additional infarction. Head-and-neck CTA showed perfect patency of the crossover bypass [Figure 5a]. The postoperative SPECT (postoperative day 14) did not show a remarkable improvement in cerebral blood flow [Figure 5b]. The symptoms of the patient improved, but mild acalculia and alexia persisted. The patient had asymptomatic intermediate stenosis of the right proximal brachiocephalic artery; hence, we consulted a vascular interventional radiologist. Careful observation with single antiplatelet medication therapy (aspirin 100 mg/day) was recommended. The patient was discharged to a rehabilitation hospital. During the follow-up period at the outpatient clinic, the patient was able to independently perform daily activities, and cervical MRA showed perfect patency of the synthetic graft.

DISCUSSION

Common carotid artery occlusion (CCAO) is a rare disease and its treatment strategies are still not established. However, many bypass treatment options have been reported earlier.[4] Surgical treatment is recommended for Riles type 1A occlusion, but the treatment strategy depends on the anatomy and vascular condition of the patient.[7,15] However, subclavian-to-carotid bypass, one of the treatment options for CCAO, requires experience with cervicothoracic anatomy that most neurosurgeons do not possess and presents certain complications such as brachial plexus injury.[8] In our case, the patient had undergone total aortic arch replacement. Since the subclavian artery had severe stenosis, it was not used as

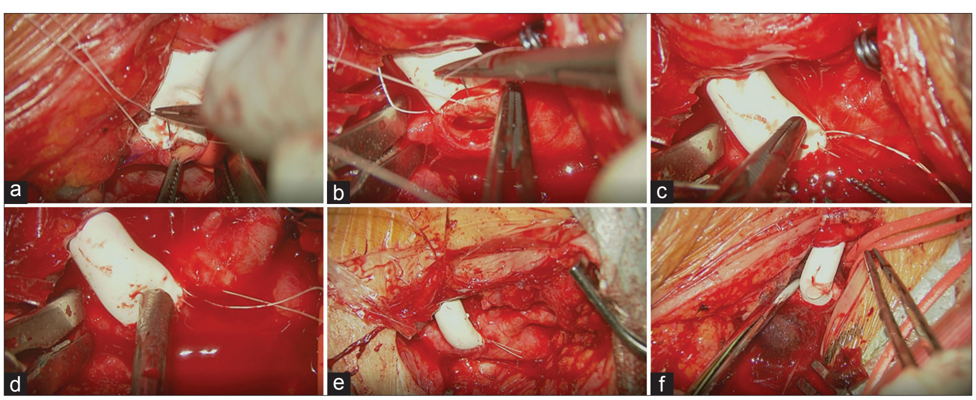


Figure 4: (a) The right common carotid artery was exposed and an end-to-side anastomosis with the synthetic graft was performed. (b) The left common carotid artery was exposed, and an end-to-side anastomosis with the synthetic graft was performed. Note that a double-armed suture thread was used, and a staying suture was only made on the heel (proximal side) of the orifice. (c) Before completing the ligation of the double-armed thread, the left internal carotid artery (ICA) was temporarily released to flush the air and debris. Note that the bubble of air was flushed from the toe (distal side) of the orifice of the synthetic graft anastomosed site with retrograde blood flow from the left ICA. (d) The left external carotid artery was temporarily released to flush the air and debris through the toe of the orifice. (e) Completed anastomosis of the right common carotid artery and synthetic graft. (f) Completed anastomosis of the left common carotid artery and synthetic graft.

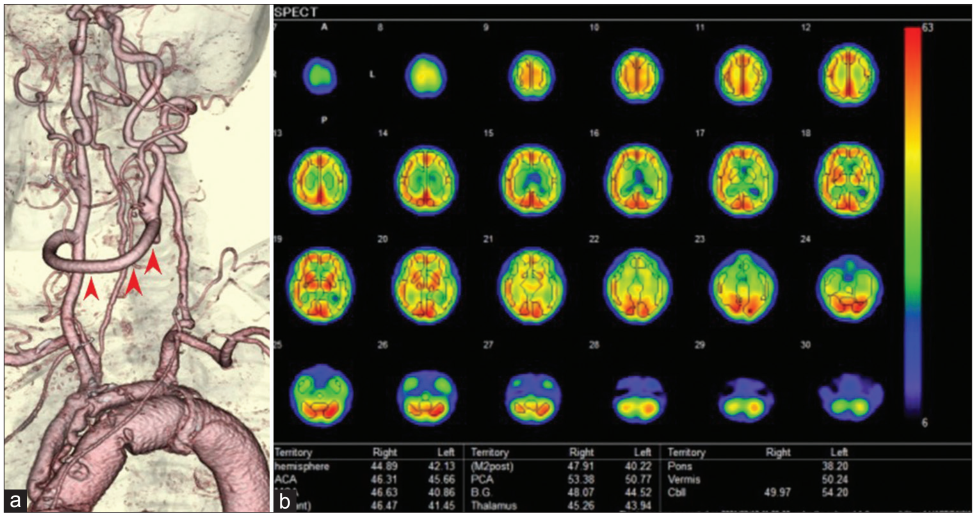


Figure 5: (a) Postoperative computed tomography angiography, left oblique view. The crossover bypass was perfectly patent (arrowheads). (b) Postoperative single-photon emission computed tomography showed a slight increase in blood flow in the left cerebral hemisphere at rest.

an inflow vessel.[11] In fact, the patient's left vertebral artery was so robust that a left V3-radial artery graft-left M2 bypass might have been a potential treatment option; however, because of the severe stenosis in the left subclavian artery, there was uncertainty regarding sufficient blood supply. Therefore, we had to select a carotid-to-carotid crossover bypass. Some cases of carotid-to-carotid crossover bypass have been reported with favorable outcomes.[3,13] Crossover bypass has a few advantages over subclavian-to-carotid bypass.[9] First, the procedure of crossover bypass is familiar to most neurosurgeons who are experienced with carotid endarterectomy, unlike subclavian-to-carotid bypass. Second, the complication rate of crossover bypass is lower than that of subclavian-to-carotid bypass.[8]

However, carotid-to-carotid crossover bypass possesses certain risks as well. First, bilateral cervical surgery may cause bilateral laryngeal nerve injury, resulting in dysphagia and airway constriction. Second, insufficiency of blood supply to the affected side or steal phenomenon of the unaffected side may arise. Until the surgery is completed, it remains uncertain whether the unilateral carotid artery can supply the bilateral hemisphere with sufficient blood flow. Our postoperative SPECT showed no remarkable change in cerebral blood flow as per our preoperative expectation; however, the patient recovered well and had no recurrent infarction after bypass surgery. Given that the blood flow of the unilateral CCA is shared with the bilateral ICA, one of the problems of crossover bypass is the uncertainty of blood supply. Third, the normal carotid artery must be clamped during anastomosis, as it may cause ischemic stroke in the unaffected hemisphere. Conversely, the ECA on the unaffected side is an ideal inflow vessel to avoid ischemic complication in the unaffected hemisphere. Unfortunately, in our case, the position of the right carotid bifurcation was so high that we found it difficult to expose the ECA for anastomosis. Therefore, we had to choose the right CCA as an inflow vessel despite the potential risk for ischemic complications.

Recently, endovascular treatment and hybrid procedures have been reported.[9] These treatments could be potential options for CCAO. However, our patient had a history of aortic arch replacement, and catheterization in the synthetic graft was avoided due to the possibility of vascular and graft injury.

Therefore, we performed a crossover bypass that had a favorable outcome for this patient. Indeed, this approach has risks of complications and uncertainty of blood supply, but it also has some advantages over other treatment options. Hence, carotid-to-carotid crossover bypass can be considered a treatment option for patients with CCA occlusion.

CONCLUSION

Carotid-to-carotid bypass is a durable treatment option for symptomatic CCAO and has advantages over other treatment options. Further studies are needed to better establish its safety and efficacy.

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.

REFERENCES

1. Belczak S, Mulatti GC, Abrão SR, da Silva ES, Aun R, Puech-Leão P, *et al*. Common carotid artery occlusion: A single-center experience in 40 cases. Int J Angiol 2016;25:39-43.
2. Belkin M, Mackey WC, Pessin MS, Caplan LR, O'Donnell TF. Common carotid artery occlusion with patent internal and external carotid arteries: Diagnosis and surgical management. J Vasc Surg 1993;17:1019-27; discussion 1027-18.
3. Chen C, Ye Z, Luo L, Guo Y, Chang Y, Ning X, *et al*. Carotid-carotid artery crossover bypass with a synthetic vascular graft for symptomatic Type 1A common carotid artery occlusion. World Neurosurg 2018;111:e286-93.
4. Hecht N, Wessels L, Fekonja L, von Weitzel-Mudersbach P, Vajkoczy P. Bypass strategies for common carotidartery occlusion. Acta Neurochir (Wien) 2019;161:1993-2002.
5. Hiu T, Kitagawa N, Suyama K, Nagata I. Progressing Takayasu arteritis successfully treated by common carotid-internal carotid crossover bypass grafting: Technical case report. Neurosurgery 2008;62:E1178-9; discussion E1179.
6. Hsu JC, Tsai HL. Endovascular recanalization of common carotid artery Total occlusion: Two case reports andliterature review. CVIR Endovasc 2020;3:6.
7. Klonaris C, Kouvelos GN, Kafeza M, Koutsoumpelis A, Katsargyris A, Tsigris C. Common carotid artery occlusion treatment: Revealing a gap in the current guidelines. Eur J Vasc Endovascularsurg 2013;46:291-8.
8. Law MM, Colburn MD, Moore WS, Quiñones-Baldrich WJ, Machleder HI, Gelabert HA. Carotid-subclavian bypass for brachiocephalic occlusive disease. Choice of conduit and long-term follow-up. Stroke 1995;26:1565-71.
9. Li ZY, Chen C, Ling C, He HY, Luo L, Li H, *et al*. Surgical procedures including carotid-carotid crossover bypass and ring-stripping hybrid operation for Rile's Type 1A common carotid artery occlusion: An experience of 6cases. Ann Transl Med 2020;8:439.
10. Martin RS 3rd, Edwards WH, Mulherin JL Jr., Edwards WH Jr. Surgical treatment of common carotid arteryocclusion. Am J Surg 1993;165:302-6.
11. Matsuda Y, Koyama T. Evaluation of revascularization after total arch replacement in common carotid arteryocclusion. World J Clin Cases 2018;6:6-10.
12. Morofuji Y, Matsunaga Y, Izumo T. Carotid-carotid bypass for a carotid artery aneurysm. World Neurosurg 2020;138:7-8.
13. Ozsvath KJ, Roddy SP, Darling RC 3rd, Byrne J, Kreienberg PB, Choi D, *et al*. Carotid-carotid crossoverbypass: Is it a durable procedure? J Vasc Surg 2003;37:582-5.
14. Powers WJ, Clarke WR, Grubb RL Jr., Videen TO, Adams HP Jr., Derdeyn CP, *et al*. Extracranial-intracranial bypass surgery for stroke prevention in hemodynamic cerebral ischemia: The carotid occlusion surgery study randomized trial. JAMA 2011;306:1983-92.
15. Riles TS, Imparato AM, Posner MP, Eikelboom BC. Common carotid occlusion. Assessment of the distalvessels. Ann Surg 1984;199:363-6.
16. Sullivan TM. Subclavian-carotid bypass to an isolated carotid bifurcation: A retrospective analysis. Ann Vasc Surg 1996;10:283-9.

How to cite this article: Sakamoto Y, Maeda K, Takemoto M, Choo J, Ikezawa M, Fujita O, *et al*. A case of symptomatic carotid artery occlusion after aortic arch replacement treated with carotid-carotid crossover bypass. Surg Neurol Int 2022;13:273.