Carotid Endarterectomy for Atherosclerotic Stenosis Associated with Non-bifurcating Cervical Carotid Artery: A Case Report

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We report a case of a 79-year-old man presenting with left cervical carotid artery stenosis associated with non-bifurcating cervical carotid artery, a very rare congenital anatomical variation supplying different branches of the external carotid artery directly from a common trunk without a bifurcation. We performed carotid endarterectomy for this symptomatic carotid artery atherosclerotic stenosis. Here, we discuss the treatment strategy, arteriotomy, route for flush out, and usage of a shunt devise system for this characteristic morphology. In addition, the embryological mechanism for developing this rare anatomical variation is discussed.

Keywords: non-bifurcating cervical carotid artery, carotid endarterectomy, carotid artery stenting, atherosclerotic stenosis

Introduction

Non-bifurcating cervical carotid artery is a very rare anatomical variation of the cervical carotid artery, in which the branches of the external carotid artery directly bud from the common trunk without bifurcation.1,2) Atherosclerotic stenosis is also associated with this uncommon anatomical variation. We report a case successfully treated with carotid endarterectomy (CEA) for atherosclerotic stenosis associated with non-bifurcating cervical carotid artery. Although we could find some cases reporting treatment with CEA or carotid artery stenting (CAS), we have not found any discussion regarding the details about the procedure in the literature. Given its unique morphology, a discussion about the selection of treatment, arteriotomy, routes for flush out, and usage of shunt device systems is worthy of attention. In addition, the embryological mechanism for developing this rare anatomical variation is discussed.

Case Presentation

A 79-year-old man presented three times with amaurosis fugax of the left eye; arterial stenosis in the left carotid artery was identified. Computed tomography angiography (CTA) revealed the absence of left carotid bifurcation, all branches of the external carotid artery (ECA) arose from the common trunk of the carotid artery. The distal side of the common trunk configured a loop formation at the level of the C1, the first vertebral body passing through the carotid canal as usual, which presented a normal route for the internal carotid artery (ICA) (Fig. 1A, B). This indicated the anatomical variation as non-bifurcating cervical carotid artery.

Left common carotid angiography showed a short segmental stenosis just proximal to the superior thyroid artery, and its stenosis rate according to the North American Symptomatic Carotid Endarterectomy (NASCET) was 62% at the level of the fourth cervical vertebrae C4 (Fig. 2). Furthermore, an external ultrasonography showed a hypoechoic plaque and an increased peak systolic velocity of 244 cm/s (Fig. 1C). The plaque was of high intensity in T1- and T2-weighted sagittal images using the black-blood method. These findings indicated a lipid-rich and fragile plaque. The patient’s cardiac function was acceptable for general anesthesia, and we considered this patient with symptomatic carotid artery stenosis as a candidate for surgical treatment.

We performed CEA for this carotid artery stenosis. An arteriotomy was made from about 3 cm proximal to the superior thyroid artery (STA) and to 1 cm distal to it (Fig. 3A). The mean stump pressure of ICA during the interruption of left common carotid artery was 80 mmHg, therefore we performed the procedure successfully without the use of a temporary shunt device system. The plaque had a relatively smooth surface without any subintimal hemorrhage, but the content of the plaque was macroscopically lipid-rich, fragile (Fig. 3B). We selected the STA to flush out any debris or air after decamping. The intraoperative electroencephalogram was stable during the procedure operation. Also, no vagal responses or fluctuating vital signs were identified.

Postoperative magnetic resonance imaging showed no abnormal findings, and there were no apparent neurological deficits. The postoperative course was uneventful at the 6-month follow-up, and CTA showed no restenosis of the lesion (Fig. 3C). Moreover, the pathological examination of the surgical specimen revealed typical atheroma.

Discussion

A non-bifurcating cervical carotid artery is a rare congenital anatomical variation. The overall incidence of this anatomical variation detected by magnetic resonance angiography is 0.21%.2) Embryologically, the ICA originates from the third aortic arch and the dorsal aorta, and the ECA originates from the ventral aorta, the first aortic arch, and the second aortic arch.3) Two hypotheses are discussed for the development of this anatomical variation, an agenesis of the ECA,1) and a segmental agenesis of the ICA.2,4–6)
branches of the ECA arising from the common trunk, all branches of the ECA arose from the common trunk, and normal anatomical variation of right carotid artery. B: Thin slice axial image of CTA showed normal left carotid canal (arrow), no asymmetrical findings. C: External ultrasonography showed a hypoechoic plaque and stenosis (arrow). CTA: computed tomography angiography, CCA: common carotid artery, ECA: external carotid artery, ICA: internal carotid artery, STA: superior thyroid artery, FLA: facial and lingual artery.

According to the “segmental identity” hypothesis proposed by Lasjaunias, the ICA consists of seven segments, each of which is located between the embryonic artery and their remnants. This anatomical variation would be formed by the agenesis of the proximal part of segment 1 of the ICA, using the proatlantal artery as a collateral pathway (Fig. 4).6,7) This hypothesis is based on the following facts: the main trunk runs along the original trace of the ECA, a similar run and variation of the branches of ECA, and coexistence of the arterial stump formation.6,8) In our case, we further identified the absence of the left carotid bifurcation and all branches of the ECA arising from the common trunk, all branches of ECA and the order of the branches were preserved. We also identified loop formation at C1 level and continuation of the common trunk as the ICA that entered the carotid canal as usual. Thereby, these findings imply that it was reasonable that the anatomical variation in our case is formed by the agenesis of the proximal part of ICA, and not an agenesis of the ECA.

The surgical plaque specimen in our case was pathologically typical atheroma like other reported three cases. The mechanism
of carotid artery stenosis with non-bifurcating cervical carotid artery is supposed to be the same with that of normal carotid artery. There is no difference in the pathological features of carotid plaque between normal vasculature and non-bifurcating cervical carotid artery. Sasaki et al. speculated that carotid plaques in the patients with non-bifurcating cervical carotid artery would be formed as a result of the histological differences in the site with the carotid sinus including baroreceptors and other local factors.6) Three cases were treated by CEA,9,10) and one case by CAS6) in the above-mentioned reviews (Table 1). Sasaki et al. reported a successful treatment by CAS with a balloon protection in the middle meningeal artery for a dangerous anastomosis between the ophthalmic artery and the middle meningeal artery.6) Intraoperative embolization is a major complication for CEA. Ogasawara et al. reported new postoperative ischemic lesions could be identified in 17.2% patients with CEA.11) Therefore, when performing the reflow of the clamped trunk at the CEA, in all cases it is important to adequately consider the handling of debris or air, or to select the artery for flushing out. As in our case, in previous reports of non-bifurcating cervical carotid artery the location of the stenosis was frequently observed adjacent to the STA,1,6,9,10) and the STA could be selected as a route for flush out. However in cases with this anatomical variation, there is some disparity concerning arteriotomy or the route for flushing out the extent of the stenosis.

It is still controversial as to whether to routinely use the shunt device system for CEA.12) When using a shunt device system for this anatomical variation, due to the frequent coexistence with the arterial stump or the loop formation of the main trunk and several branches, we should consider the difficulty of inserting the shunt tube or the possibility of an eventual malfunction of the shunt system. In our case, had the shunt system not performed properly, we also considered the possibility of simply performing the CEA without the support of the shunt device system, based on the evidence of the sustained mean stump pressure or the expected sufficient cross flow determined from the preoperative study.

As for surgical treatment for atherosclerotic stenosis of the carotid artery, we have two options: CEA and CAS.13–15) At the same time, CAS, with the important advancement of the devices, has become more widely used. The proximal control device at the CAS for atherosclerotic stenosis associated with non-bifurcating cervical carotid artery may find it difficult to regurgitate the flow of the distal trunk along the separate branches and the stenosis region. Furthermore, a single distal protection device also may be unable to protect every embolic stroke,6) and may require an appropriate placement determined by the loop formation. For atherosclerotic stenosis associated with a non-bifurcating cervical carotid artery, therefore, we have to meticulously evaluate the treatment approach alongside the pattern of branches or the stenosis region.

Conflicts of Interest Disclosure
The authors declare that they have no conflicts of interest. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

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| Author | Age, Sex | Symptom | Location of stenosis | Treatment | Perioperative stroke | Postoperative stroke |
|--------|----------|---------|----------------------|-----------|---------------------|----------------------|
| Franklin et al., 1988 | 43, M | asymptomatic | proximal to STA | CEA | not described | not described |
| Lambiase et al., 1991 | 76, M | confusion | proximal to STA | CEA | not described | not described |
| Rodriguez et al., 2002 | 66, M | asymptomatic | proximal to STA, and around FLA and IMA | CEA | none | none |
| Sasaki et al., 2013 | 68, M | amaurosis fugax | proximal to STA | CAS | none | none |
| Present case | 79, M | amaurosis fugax | proximal to STA | CEA | none | none |

CAS: carotid artery stenting, CEA: carotid endarterectomy, FLA: facial and lingual artery, IMA: internal maxillary artery, STA: superior thyroid artery.
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