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Technical Note

Disobliteration of an Occluded Common Carotid Artery with Patent Bifurcation via Antegrade Ring Stripping

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There is a lack of guidelines concerning common carotid artery (CCA) occlusive disease in the presence of a patent internal carotid artery (ICA). A novel surgical technique that disobliterates an occluded CCA was successfully performed in three cases. The detailed surgical steps are presented herein. After proximal division of the CCA behind the sternoclavicular junction, the occluded CCA was endarterectomized via antegrade ring stripping. After removal of the atheromatous core, the CCA was everted, and the wall remnants were cleaned under direct vision. Simultaneous eversion endarterectomy of the ICA was performed when necessary. After reversion of the CCA, it was transposed and anastomosed to the ipsilateral subclavian artery distal to the orifice of the vertebral artery. This novel technique can be used in selected cases by experienced surgeons.

Key Words: Carotid stenosis, Endarterectomy, Common carotid artery, Ring stripping, Transposition

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INTRODUCTION

Ischemic stroke is a serious disease caused by multifactorial thromboembolic events related to the cerebral vasculature. Excluding intracranial cerebral artery occlusions, the extracranial carotid and vertebral arteries have to be incriminated for the ischemic brain damage when cardiac and aortic arch sources are excluded. While there is abundant literature proving the relationship between internal carotid artery (ICA) stenosis and ischemic stroke, there is no sufficient information or guidelines concerning the coexistence of a totally or near totally occluded common carotid artery (CCA) with patent carotid bifurcation. The patterns concerning this bifurcation include both patent arteries and patent ICA or external carotid artery (ECA) only. In case of both CCA and ICA occlusion, endarterectomy is usually contraindicated.

Three patients with similar patterns of carotid arterial occlusive disease, i.e., total occlusion or high-grade stenosis of the CCA, underwent surgery in the same manner to restore the carotid bifurcation, achieve reperfusion of the common, internal, and external carotid arteries, and consequently improve the cerebral blood flow. Herein, we describe the detailed surgical techniques used in disobliterating the occluded CCA and transposing it to the ipsilateral subclavian artery with or without simultaneous ICA endarterectomy.

This study was approved by the institutional review board (IRB) of the Aretaieion University Hospital (IRB no. 213/25-02-2020).

TECHNIQUE

1) Case 1

An asymptomatic 69-year-old male patient presented with a high-grade stenosis (>80%) of the left ICA (Fig. 1). The ipsilateral CCA had a stenosis of >90% near its orifice.

2) Case 2

A 49-year-old female patient presented with dizziness and a high-grade stenosis of the left ICA. The ipsilateral CCA was totally occluded from the orifice until the carotid bifurcation.

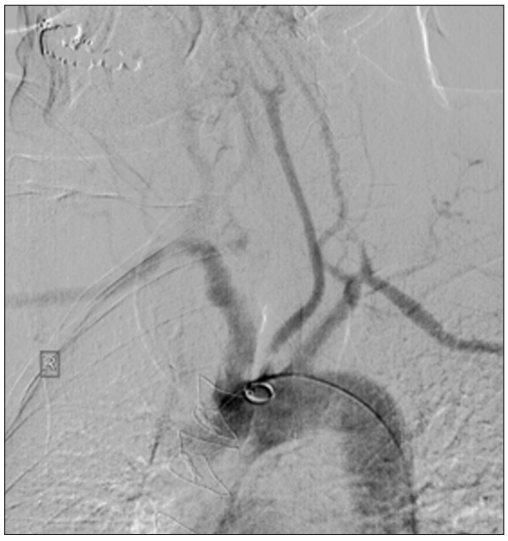

Fig. 1. Digital subtraction angiography showed a high-grade stenosis of the left internal carotid artery and an occlusion of the orifice of the left common carotid artery.

3) Case 3

A 73-year-old female patient presented with dizziness, and digital subtraction angiography (DSA) revealed a high-grade stenosis of the left CCA and ICA (Fig. 2A), total occlusion of the right CCA, and patent right carotid bifurcation. The bifurcation was perfused via collateral networks between the anterior thyroid artery and inferior thyroid artery (Fig. 2B).

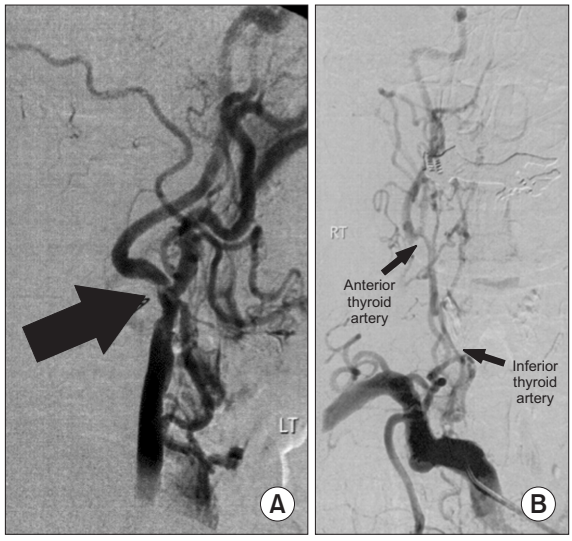

Fig. 2. (A) Digital subtraction angiography (DSA) of the neck and brain revealed a high-grade stenosis of the left common carotid artery (CCA) (arrow). (B) DSA of the neck and brain revealed a total occlusion of the right CCA and a patent carotid bifurcation (arrows). The collateral networks between the anterior thyroid artery and inferior thyroid artery were prominent to supply blood flow to both the internal carotid artery and external carotid artery.

Table 1. Demographics and the lesion characteristics of the patients

Case no.	Age (y)/sex	Risk factors	Symptom	Imaging	CCA occlusion	Ipsilateral ICA stenosis	Contralateral ICA stenosis
1	69/male	Hyperlipidemia, smoking, DM, CABG	No	DUS, DSA	Left >90% at orifice	Left >80%	No
2	49/female	Hypertension, hyperlipidemia, smoking, DM	Dizziness	DUS, CTA	Left, 100%	Left >50%	Right >50%
3	73/female	Hypertension, hyperlipidemia, smoking, DM	Dizziness	DUS, DSA	Right, 100%	No	Left >80%

CCA, common carotid artery; ICA, internal carotid artery; DM, diabetes melitus; CABG, coronary artery bypass graft; DUS, duplex ultrasonography; DSA, digital subtraction angiography; CTA, computed tomography angiography.

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The demographic data, risk factors, symptoms, and examination findings of the patients with CCA occlusion (CCAO) and those with ipsilateral and contralateral ICA stenoses are described in Table 1.

All three patients underwent surgery under general endotracheal anesthesia. Through an oblique neck incision with a lateral horizontal extension parallel to the clavicle, both the subclavian and carotid arteries were exposed. A single intravenous dose of 5,000 IU heparin was injected before clamping. The CCA was divided low behind the sternum, and the proximal stump was ligated using silk 2.0 and polypropylene 4-0 crossing sutures. Eversion endarterectomy of the ICA was only performed in case 1. In cases 2 and 3, the bifurcation was divided horizontally, and eversion endarterectomy was performed in both the ICA and ECA. Antegrade ring stripping from the proximal end of the CCA to the bifurcation was performed, and the atheromatous core of the CCA was removed (Fig. 3). The entire CCA was everted through the horizontal incision, and the inner wall was totally exposed and cleared thoroughly of the remnants. After reversion of the CCA, the distal end was anastomosed (closure of the horizontal incision) to the ICA and ECA (Fig. 4). In cases 1 and 2, the left proximal CCA was transposed behind the sternocleidomastoid muscle and anastomosed to the subclavian artery distal to the origin of the left vertebral artery. Postoperative DSA showed a patent CCA without stenotic lesions. In case 3, the right CCA was too short to transpose it behind the muscle and anastomose it to the subclavian artery without tension despite the proximal division of the CCA. Therefore, a short 6-mm expanded polytetrafluoroethylene interposition graft was used to bridge the subclavian artery and the proximal end of the disobliterated CCA.

In the postoperative period, all patients were adminis-

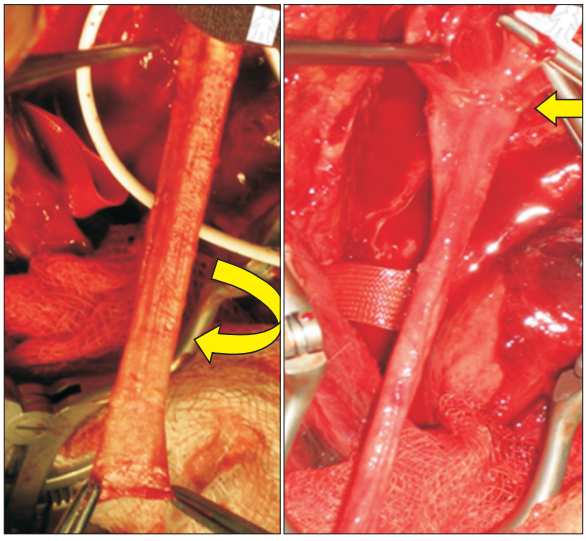

Fig. 4. After division of the proximal and distal common carotid artery (CCA), the entire CCA was everted (curved arrow), and the inner wall was cleared thoroughly via endarterectomy. After reversion of the CCA, reimplantation was performed. The straight arrow shows the distal anastomosis (suturing of the anterior carotid wall) to the internal and external carotid arteries.

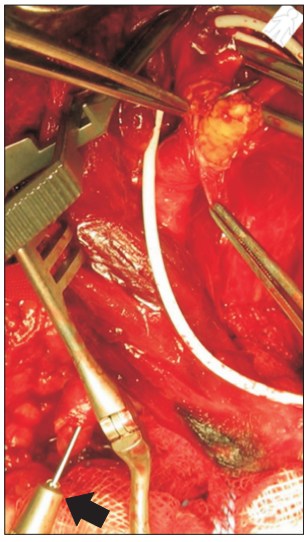

Fig. 3. Antegrade ring stripping (arrow) from the proximal end of the common carotid artery was performed. The tip of the ring stripper was exposed via arteriotomy at the carotid bifurcation on the right upper corner.

Fig. 5. Postoperative digital subtraction angiography showed patent left common carotid artery (CCA) and internal carotid artery after endarterectomy, transposition, and end-to-side anastomosis of the left CCA to the subclavian artery distal to the left vertebral artery.

tered with 100 mg acetylsalicylic acid once daily. No ipsilateral neurologic complication nor stroke developed; they had a smooth postoperative course without any other complications and were discharged on the second postoperative day. Carotid color duplex ultrasonography (DUS) at 1, 6, and 12 months of follow-up showed no stenosis of the CCA or ICA. DSA in cases 1 and 2 respectively performed 2 and 4 years later confirmed no stenotic lesion in the CCA and ICA (Fig. 5).

DISCUSSION

Over the past few decades, the majority of studies have focused on stenosis of the ICA, which is the most common site of stenosis; the CCA is the second most common site for extracranial carotid artery stenosis [1,2]. CCAO is a relatively rare condition with an incidence of approximately 1% to 4% in patients with symptomatic cerebral vascular disease [2]. Other studies have reported a prevalence ranging from 1% to 5% in patients with stroke [3-5]. Because of the various clinical presentations of CCAO from asymptomatic to severe cerebrovascular events, asymptomatic cases are diagnosed accidentally, and the veritable incidence of CCAO is unknown.

Two patients in our series had steno-occlusion of the CCA and/or stenosis of the ICA with dizziness, and the other patient was completely asymptomatic. The natural history and optimal treatment for CCAO are still uncertain and controversial because of the rarity of the cases ever reported [6]. Some authors reported that CCAO occurred more often in the left CCA and in men [2,4], which can be explained by the differences in hemodynamics and arterial length and by the direct assault of aortic plaques to origin of the left CCA [6]. Other authors reported no difference and an equal distribution between the right and left sides based on a large ultrasonographic database [3]. Bilateral CCAO is rarely reported in atherosclerosis but mostly in Takayasu arteritis [7]. A higher prevalence of Takayasu arteritis was reported in Asian populations. Rarer causes include post irradiation arteriopathy, dissection of the aortic arch and CCA, aortic arch aneurysm, fibromuscular dysplasia, hypercoagulability, and craniocervical injury [5,8]. The cause of CCAO in this series seemed to be atherosclerosis because all three patients were heavy smokers and had risk factors of atherosclerosis, such as hyperlipidemia, hypertension, and diabetes.

If CCAO occurs, perfusion of the ipsilateral cerebral hemisphere is provided through collateral circulation: first, intracranially through the circle of Willis via the anterior and posterior communicating arteries and second, in a retrograde manner. The extracranial collateral vessels fill the ECA and maintain the flow in the ICA. The extracranial collateral flow originates from the ipsilateral subclavian artery via the costocervical or thyrocervical trunks and the vertebral artery and, to a minor degree, from the contralateral ECA through the superior thyroid and lingual, facial, and occipital branches [9,10]. In case 3, DSA revealed that the right carotid bifurcation had collateral circulation from the anterior thyroid artery through the middle thyroid artery perfusion from the aortic arch (Fig. 4).

There have been three classifications of CCAO in the literature since 1983. Riles et al. [8] mentioned that thromboendarterectomy or bypass may be performed as long as either the ECA or ICA is patent, although they preferred to revascularize a patent ICA. In case of multiple vessel occlusions, flow restoration into the ECA is covetable even if the ICA is thrombosed. If both the distal vessels are thrombosed, reconstruction is possible only if the ICA or ECA are successfully reopened by thrombectomy. Although late thrombectomy of the ICA has its advantages, this procedure is either not possible frequently or is associated with a high risk of morbidity and mortality [8].

Another simpler classification was suggested by Valdueza et al. [11] based on the patency of the distal vessels. Type I occlusion is a complete occlusion of both the CCA and ICA, while type II occlusion indicates patent distal arteries. In type II occlusion, the ischemic events are caused by artery-to-artery emboli, and the ICA is supplied by collaterals via extracranial branches through the ECA with retrograde flow.

Parthenis et al. [3] proposed a modified classification of CCAO according to the hemodynamics, clinical presentation, and distal vessel patency by performing color DUS. Type I was subgrouped according to the flow direction between the ECA and the ICA. The authors suggested that the use of the modified CCAO classification may help clarify the outcome of this rare entity and emphasized that among the developed collateral circulations, only the flow direction in the ophthalmic artery may be of clinical value.

CCAO can either be immediately disastrous or clinically silent. When symptomatic, it is similar to ICA occlusion including amaurosis fugax, vertigo attacks, transient ischemic attacks, limb-shaking events in the presence of hemodynamic compromise, or major strokes [1,12,13]. The diagnostic imaging studies that may be used include non-invasive DUS, computed tomography angiography (CTA), and magnetic resonance angiography (MRA); these are replacing DSA in daily clinical practice [5]. However, DSA remains the gold standard for accurate diagnosis of CCAO because it also offers valuable information concerning the brain arterial supply and in particular the status of the circle of Willis. The limitations of DSA in CCAO include its inva-

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siveness, the inadequate concentrations of contrast media, the variable collateral circulations, the minimal flow in the distal branches, and the poor delayed images [3]. Saba et al. [14] reported that DUS is often physically limited due to the inability to assess the deep ostial origin of the CCA in approximately 5% of patients. CTA and MRA are noninvasive diagnostic tests with a sensitivity and specificity of >97% for detection of CCAO [14].

Unlike for the ICA disease, there are no definite treatment guidelines for CCAO, and data regarding the role of medical therapy are sporadic. The literature regarding the treatment strategies for CCAO is restricted and consists only of case reports and small series. The risk of ipsilateral ischemic stroke in patients with symptomatic carotid occlusion ranges from 2% to 7% per year, even with the best medical therapy. The risk may be higher, i.e., up to 30% per year, in patients with hemodynamic impairment as demonstrated by increased oxygen extraction fraction on positron emission tomography or reduced cerebrovascular reserve on acetazolamide-challenged single-photon computed tomography. Medical management of extracranial atherosclerotic lesions is well established in appropriate settings for both stenosis and occlusion [1].

The plaque characteristics and length of the occlusion of the CCA, ICA, and/or ECA may guide the choice of technique employed. Chronic occlusions, which are often heavily calcified, and those that traverse the entire length of the CCA may be better treated with extra-anatomic bypass procedures rather than endarterectomy. Short occlusions with a soft thrombus in the distal CCA may be treated with local endarterectomy via the neck approach without the need for sternotomy. However, CCA lesions are often accompanied by high-degree stenosis of the ipsilateral ICA, as in our cases, and a more complicated surgery is then needed. Endovascular and hybrid techniques for managing CCAO are still being tested but may gain more popularity in the future when more specific devices are developed or when their availability and user experience expand [15].

Successful revascularization is dependent on the state of the distal branches. However, establishing patency of the ICA and ECA is essential prior to an intervention. It is obvious that the best case scenario is when the bifurcation and its branches are both open. When the ICA is totally occluded, and there is indication for revascularization of this hemisphere, the arterial supply is directed to the ipsilateral ECA, and when both the ICA and the ECA are occluded, a bypass to the ipsilateral middle cerebral artery can be performed in limited cases. The surgical interventions include endarterectomy, transposition, or bypass procedures. Bypass surgeries are usually performed with a synthetic ringed graft, such as subclavian-CCA, carotid-carotid, subclavian-ICA, subclavian-ECA, axillary-CCA, or ascending aortic bifurcation-CCA and innominate or arch-carotid bypasses [6]. Martin et al. [16] reported a case series of eight surgically treated CCAOs, performing bypass with the saphenous vein to the carotid bifurcation, ICA, or ECA with no perioperative strokes, occlusions, or deaths. Pintér et al. [17] reported a case treated with eversion carotid bifurcation endarterectomy, retrograde ring-stripper CCA endarterectomy, and stenting of the residual stenosis in the disobliterated artery. Sharma et al. [18] reported three cases of thrombotic CCAO associated with acute ischemic stroke due to tandem occlusion of the intracranial arteries. After intravenous thrombolytic therapy, early marked neurologic improvement was achieved in two cases. Collice et al. [19] reported reconstructive micro neurosurgical techniques for cerebral revascularization in four patients with total occlusions of the CCA and the ICA, performing retrograde thromboendarterectomy, followed by subclavian-ECA and superficial temporal artery-middle cerebral artery bypasses.

Transposition procedures have the merit of avoiding the use of a prosthetic graft and achieving resultant good long-term patency. Complications during transposition, such as vocal cord palsy or Horner syndrome due to medial retraction on the vagus nerve or sympathetic trunks, are very rare and temporary. The long-term patency rate for carotid transposition is excellent when performed by surgeons with experience [20].

The detailed surgical techniques of disobliteration of CCAO have been described above. We believe that proximal division of the CCA at the origin and antegrade ring stripping are safer than retrograde stripping with or without stenting. When the CCA ostium is involved, retrograde stripping is too risky and may cause dissection, perforation, or thrombosis. However, antegrade ring stripping of the CCA does not ensure thorough clearance of tissue remnants of the endarterectomized CCA. Therefore, we created an additional horizontal incision at the bifurcation, reversed the CCA, and cleared the remnant debris under direct vision. The CCA was then reversed to the normal position and transposed to the ipsilateral subclavian artery. These surgical procedures can be easily executed by experienced surgeons, with the obvious advantage of restoring blood supply without compromising the other carotid artery and also, avoiding the use of a long synthetic graft; thus, preventing the risk of infection, kinking, or graft deterioration. The patency of the endarterectomized CCA was excellent in our series.

It is a decision dilemma whether to conduct surgery when CCAO accompanies a patent bifurcation, especially in asymptomatic patients. For ICA steno-occlusion, worldwide accepted criteria exist; however, for CCAO, there are

no guidelines in case of an ipsilateral patent ICA. However, when a CCAO is accompanied by an ipsilateral internal carotid stenosis, endarterectomy of the ICA is performed along with CCAO revascularization. The clinical outcomes of asymptomatic patients with CCAO and patent carotid bifurcation are still unclear, and the traditional interventions recommended for symptomatic patients still yield questionable benefits for asymptomatic patients. Although such interventions prevent neurologic events and resolve cerebrovascular insufficiency, they are also associated with important rates of complications, i.e., 6.6% to 11.1% [6].

CONCLUSION

We presented three successful cases of disobliteration of CCAO with patent bifurcation. This novel technique may help manage some selected cases, while avoiding the risk of using a synthetic graft with minimal complications. The advantages and disadvantages of this procedure should be confirmed in further large-scale studies with long-term follow-ups.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHOR CONTRIBUTIONS

Concept and design: TK. Analysis and interpetation: TK, PC. Writing the article: TK, PC. Critical revision of the article: TK. Final approval of the article: TK, PC. Obtained funding: none. Overall responsibility: TK, PC.

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