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Endarterectomy of the Totally & Subtotally Occluded Carotid Artery Facilitates the Surgery of the Stenosed Contralateral Side

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MU, OAS and UA designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors MU, MEF, EZ, GBG, EG, MOB, DMO and OAS acted in data collection and interpretation. Authors MU, MEF, EZ, GBG, EG, MOB, DMO, FNTC and MB managed the literature searches and contributed in manuscript writing. Authors MU, GP, UA and ED performed revisions and critical review of the paper. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Purpose: Patients with one side total/subtotal occlusion and contralateral side critical stenosis are high risk candidates for carotid interventions for the stenosed carotid side. We present our

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experiences with carotid endarterectomy of the stenosed side after revascularization of the occluded side.

Methods: Between March 2010 and September 2013, 85 carotid endarterectomies were performed in seventy-four patients. Among the patients, 6 had one side total/subtotal occlusion and contralateral side ≥ 70% carotid stenosis. Patients received revascularization for the occluded side first followed by of the endarterectomy of the contralateral stenosed part.

Results: Four patients had cerebrovascular symptoms ipsilateral to the occluded side. Operations were performed with local anesthesia. Endarterectomy priority was given to the occluded side which was followed by the endarterectomy of the contralateral side after 17.2±4.6 days. No neurologic deficit occured during the surgeries and shunt was not required. Mortality did not occur and patients are followed a mean of 18.4±6.3 months event free.

Conclusion: Endarterectomy of the stenosed carotid artery contralateral to the totally/subtotally occluded side is challenging and carries high risk. The treatment of the occluded side first facilitates the endarterectomy of the contralateral carotid stenosis.

Keywords: Carotid artery disease; endarterectomy; chronic total occlusion.

1. INTRODUCTION

Carotid artery stenosis is an important health problem among the aging population and contributes with significant mortality and morbidity. Despite advances, surgical treatment of the atherosclerotic carotid disease is still the best option and currently reserved for symptomatic patients and stenosis above certain limits [1-4].

Patients with total carotid occlusion may rarely be symptomatic and undergo safe surgical revascularization. Patients with one sided carotid artery occlusion are usually asymptomatic and intervention for the occluded carotid artery side is generally not required. On the other hand, since atherosclerosis is a systemic multivessel disease, many subjects with one side total occlusion may posses certain degree of carotid lesion on the contralateral side and under such circumstances treatment of the stenosed side is a challenge [5,6].

In the manuscript containing case series we present our experience and treatment strategy in patients with one side total/subtotal carotid occlusion and contralateral side carotid stenosis requiring treatment.

2. PATIENTS AND METHODS

Patients whom underwent carotid endarterectomy between March 2010 and January 2016 were analyzed retrospectively. Inclusion criteria was one side total/subtotal occlusion with contralateral side severe stenosis (≥ 70% stenosis) (Figs. 1-1, 1-2, 1-3). Except in one patient, all the operations were performed with local anesthesia by the same surgeon. The operations were fashioned in different surgical sessions except the patient whom underwent surgery with general anesthesia. These patients received endarterectomy for the occluded side first, followed by revascularization of the contralateral stenosed side.

Patients who received bilateral carotid endarterectomies with general anesthesia at the same surgical session and those who had bilateral internal carotid artery total occlusion were excluded from the study population. Other exclusion criteria was one side total occlusion without evidence of a patent lumen until intracranial segment of the artery.

Patients demographics are presented on Table 1. Doppler ultrasonography, magnetic resonance and computerized tomography angiography were used for the diagnosis and extent of the disease. All patients were consulted with cardiology and coronary angiography and stent implantation were performed when needed. Patients were prescribed aspirin (100 mg/day) and atorvastatin (20 mg/day) as soon as they were diagnosed.

3. SURGICAL TECHNIQUE

The operations were performed with infiltration anesthesia with 50% mixture of prilocaine hydrochloride and bupivacaine hydrochloride local injection. If the patient complained of pain or discomfort, repeated doses were injected until the maximum dose. A standard incision parallel to the sternocleidomastoid muscle was performed and common carotid artery (CCA), internal carotid artery (ICA), and external carotid artery (ECA) were prepared and dissected. After

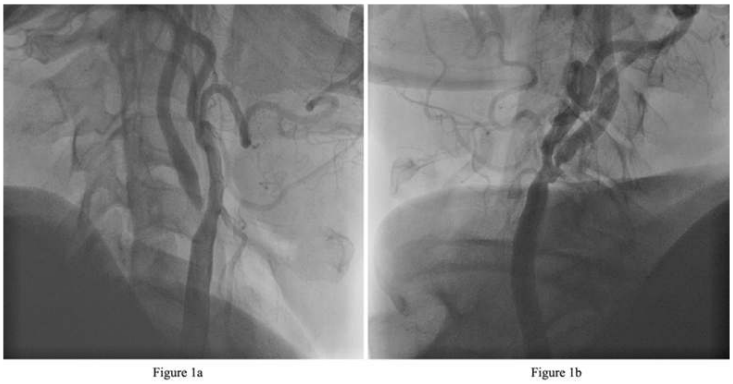

Fig. 1-1. Preoperative angiography views of one of the patients
a. *The right carotid side – Subtotal occlusion*
b. *The left carotid side – Severe stenosis*

systemic 5000 IU of heparin injection, the arteries were clamped. The consciousness and the neurologic status of the patient were evaluated with his or her response to verbal stimuli and ability to move contralateral side hand and foot for at least three minutes prior to arteriotomy. In case of neurologic disturbance, endarterectomy was performed with insertion of a shunt. The carotid endarterectomy and patchplasty were performed as usual fashion (Fig. 2a-b).

The occluded side was prioritized followed by the surgery of the contralateral side in all patients.

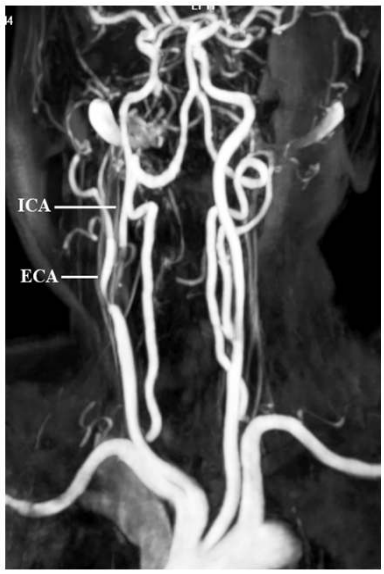

Fig. 1-2. Preoperative MR angiography views of one of the patients (*ICA, internal carotid artery; ECA, external carotid artery*)

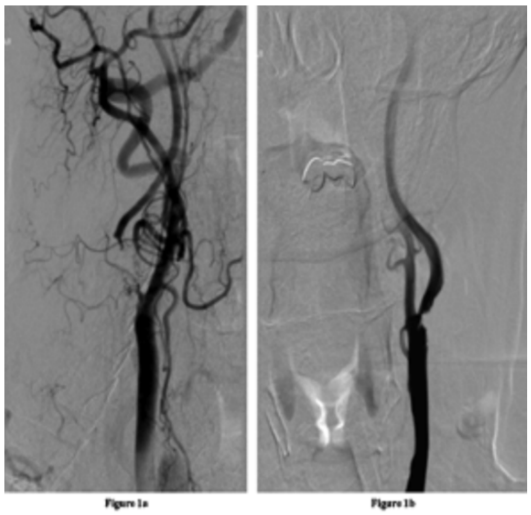

Fig. 1-3. Preoperative angiography views of one of the patients
a. The right carotid side – Total occlusion
b. The left carotid side – Severe stenosis

4. RESULTS

The study analyzed six patients; there were five males and one female. Age ranged between 52 and 84 years. All patients had history of smoking (five active, one past). Five patients were hypertensive, two were diabetic and three had hyperlipidemia requiring medication.

The history given of the patient with bilateral carotid occlusion was obtained from the the family and indicated acute collaps at home before he was admitted to the clinic unconscious and entubated. His diagnostic work up indicated bilateral internal carotid artery occlusions with

thrombus material at acute/subacute stage. After the consent of the family, bilateral carotid embolectomies and thromboendarterectomies were performed with general anesthesia. Right side was operated first. After both embolectomies backflow could be obtained and adequate inflow was maintained. He was able to open both eyes; however, was paraplegic and unresponsive to verbal stimuli or improvement in language after the operation. The patient could not be weaned off the mechanical ventilator and was lost due to a malignant arrhythmia on the 42nd postoperative day.

Among the patients whom were included to the study, four were symptomatic. One patient complained of headache and amourosis fugax. Orthostatic transient ischemic attack and visual disturbances were observed in another patient. Two patients had amaurosis fugax. The contralateral side carotid artery stenosis ranged between 75-95%. None of the patients complained of symptoms related with the stenosed internal carotid artery side. There was cervical recanalization at various segments of the internal carotid artery beyond the totally/subtotally occluded part in all cases. The left internal carotid artery was occluded in four patients and the right side in two. Coronary angiogprahy was performed in two male patients which revealed non-critical left anterior descending artery in one patient and circumflex and left anterior descending coronary artery lesions in the other case (Table 1). Endarterectomy priority was given to the occluded side which was followed by the endarterectomy of the contralateral carotid artery after 17.2±4.6 days depending on the degree of stenosis and symptom status of the patients. No neurologic disturbance occured neither during the surgery of the occluded segment nor the stenosed contralateral side; hence, carotid shunt was not required. Cross clamp times were 29.3±8.7 minutes and 27.9±13.4 minutes during the occluded side and contralateral stenosed side, respectively. Stroke or mortality did not occur except the patient with bilateral carotid occlusions; and the patient with bilateral carotid occlusions died. Minor neurologic deficit confined to the nerves of platysma and hypoglossal nerve occured in 3 patients which resolved spontaneously. The patients were followed a mean of 18.4±6.3 months event free. Control computerized tomography angiography was performed at the end of the first year showed stenosis free bilateral internal carotid arteries in all patients (Fig. 3).

5. DISCUSSION

Carotid endarterectomy is still the gold standard and mostly performed therapy for the treatment of the atherosclerotic carotid artery disease [1-4] since it was first applied by Eastcott et al. [7] in 1954 [7,8]. It is usually reserved for symptomatic patients with ≥60% internal carotid artery stenosis and asymptomatic patients with ≥70% internal carotid artery stenosis. The efficacy of the method has been proven in different randomized clinical trials [9-12].

Figure 2a Figure 2b

Fig. 2. a. Perioperative view of the occluded internal carotid artery b. Excised thromboembolic material

Table 1. Demographic data of the patients

Patient	Age	Sex (m/f)	Smoking	HT, DM, HL	IHD	Stenosis & Side	Symptoms
1	52	m	+	HL	+	Left occluded, Right 85%	Headache, Amourosis fugax
2	61	m	+	HT, DM	-	Left occluded, Right 95%	Orthostatic transient ischemic attack, Visual disturbances
3	73	m	+	HT, HL	-	Right occluded, Left 75%	-
4	70	f	-	DM, HT, HL	+	Right occluded, Left 90%	Amourosis fugax
5	74	m	+	HT	-	Left occluded, Right 85%	Amourosis fugax
6	84	m	+	HT	-	Left occluded, Right 80%	-

(m, male; f, female; HT, hypertension; DM, diabetes mellitus; HL, hyperlipidemia; IHD, ischemic heart disease;)

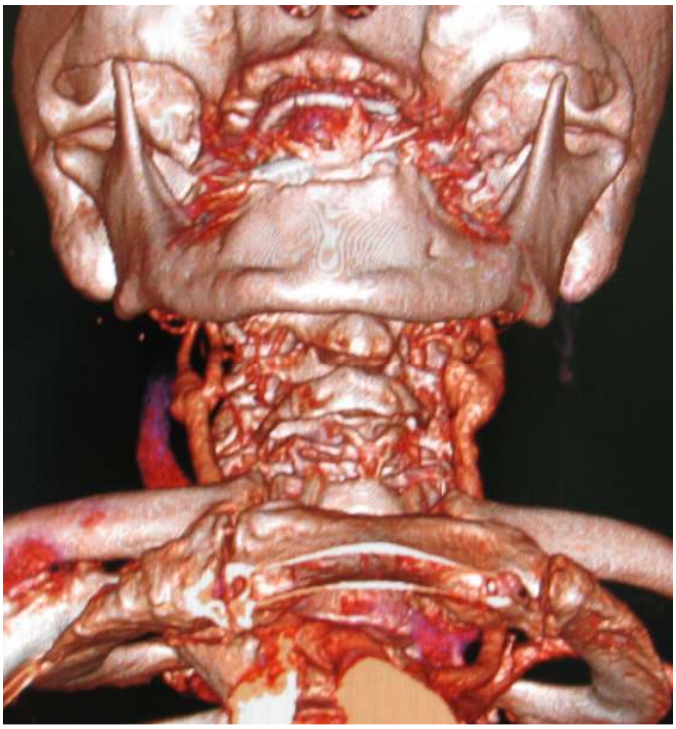

Fig. 3. Postoperative control computerized tomography angiography of one of the patients

A controversy exists regarding the treatment of cases with chronic total occlusion of the internal carotid artery. Among the physicians, it is sometimes wrongly believed that chronic total occlusion of internal carotid artery does not lead to ischemic cerebral symptoms. However, indeed chronic total occlusion may cause symptoms and internal carotid artery occlusion is a major predictor of the neurologic mortality and morbidity in the presence of stroke. The clinical spectrum of internal carotid artery occlusion varies between being asymptomatic to leading to severe strokes [13]. The pathophysiology of the ischemia depends on both cerebral hypoperfusion and distal embolization from an occluded internal carotid artery [9]. The phenomenon is called carotid stump syndrome and the thrombus material in the totally occluded internal carotid artery acts as the major source of intracranial emboli [14-17]. Additionally, the degree of stenosis including occlusion is directly related with the risk of ipsilateral stroke [18-21].

The risk of stroke or transient ischemic attacks in patients with occlusion of the internal carotid artery is complex. Sacquegna et al. [22] indicate recurrent stroke rates of 4.8% in 1 year, 12.2% in 3 years and 17.1% in 5 years. Atherosclerosis is a multivessel disorder and contralateral side carotid artery may be affected to various extents. A meta-analysis of 20 follow up studies show annual 5.5% risk of stroke with 2.1% ipsilateral stroke [23] with increased risk when both carotid arteries are affected [13].

Internal carotid artery total occlusion may cause cerebral and retinal ischemic symptoms by two main mechanisms. The distal stump of the atherosclerotic plaque in the internal carotid artery may act as the source of embolizing particle. The other mechanism concerns the retrograde collateral pathways through external carotid artery and the ophthalmic artery. The plaque in the common carotid artery or the proximal stump may transverse and enter into the cerebral circulation [13,14]. Embolism is accepted as the most common mechanism for the cerebral ischemic symptoms [13,24].

Other symptoms secondary to carotid occlusion may be due to hemodynamic compromise such as sudden decrease in cerebral blood flow as rising from lying or sitting position regarded as orthostatic transient ischemic attack, postprandial hypotension, dehydration, fluid or blood loss, exercise, and cardiac failure [13]. Some ptaients may manifest involuntary limb movements or shaking [13,25] which may be misdiagosed as seizure; however, simultaneous electroencephalogram does not indicate epileptic activity [13,26,27]. Retinal claudication is regarded as monocular blindness occuring especially when looking at bright light and may be seen in the presence of internal carotid artery occlusion presumably resulting from increased metabolic demand in the retina [13,28,29]. Internal carotid artery occlusion may rarely lead to syncope [13,30] and dementia [13,31].

Adequate collateral blood flow and various compensatory mechanisms prevent cerebral ischemia and infarction in case of internal carotid artery occulusion. The most important collateral blood flow is through the Willis polygone from the contralateral internal carotid artery. Other sources of the collateral flow include the orbital branhes of the ipsilateral external carotid artery, mainly cross circulation between the ophthalmic artery and the maxillary, facial, frontal and leptomeningeal branches of the external carotid artery. Less common, the vertebrobasilar system and the cortical surface branches exhibit collateral circulation. On the other hand, when the collateral circulation is inadequate the cerebral autoregulation leads to dilatation of the arterioles [13]. The other intrinsic mechanism is through the oxygen extraction fraction of the affected brain tissue to maintain normal cerbral metabolism when the vasodilation fails to provide adequate cerebral blood flow [13,32]. The patients with one side chronic total occlusion and contralateral side internal carotid artery stenosis are at increased risks for the aforementioned cerebral ischemic events.

The treatment of chronically occluded internal carotid artery is controversial. However, evidence indicates occlusion of internal carotid artery is associated with increased ipsilateral recurrent stroke rates of 6-20% per year [9,33-35]. Moreover, the risk of cerebral ischemia is further increased in the setting of contralateral carotid artery stenosis. The aims of treatment of the chronically occluded internal carotid artery are to prevent future strokes and improve cerebral perfusion [13]. However, in order to perform treatment, either endovascular [36] or surgical, a residual lumen has to be present [13] and endarterectomy is only possible if the occlusion is limited to the extracranial internal carotid artery [9,37]. Additionally, the viability of the brain tissue at ischemic insult is the other prequisite for a successful surgical outcome [9].

A residual lumen can easily be detected with doppler ultrasonography, computerized tomography angiography, magnetic resonance angiography or the gold standard by conventional angiography [38]. Another important factor regarding chronic total occlusion is the presence and propagation characteristic of thrombus, if present, inside the internal carotid artery. In time, the thrombus becomes stiffer and tightly attaches to the walls of the internal carotid artery as well as propagation ascends inside the cranium ending up with string internal carotid artery in which endarterectomy or bypass is not possible [9].

Our cohort comprised of patients with one side chronic total occlusion exhibiting recanalization in the cervical region and serious stenosis on the contralateral side. Four patients had symptoms confined to the totally occluded segment and none had symptoms related with the contralateral stenosed internal carotid artery. We treated the totally occluded side first with local anesthesia

followed by the treatment of the contralateral internal carotid artery. Bilateral endarterectomy at the same surgical session was not performed in any patients.

The importance of treatment of total carotid occlusion in the presence of symptoms and/or contralateral internal carotid artery stenosis was stressed years ago [39,40]. Recurrent symptoms or reversible perfusion defect were generally accepted indications for revascularization in case of total/subtotal carotid occlusions [41]. On the other hand Baracchini et al. [42] and Gonzales et al. [43] performed endarterectomy and angioplasty, respectively to the stenosed carotid side in patients with contralateral internal carotid artery occlusion with promising outcomes. However, literature lacks larger series assessing the efficacy and safety of both methods [13].

The strategy to treat the stenosed side first was accepted as high risk in our patients. Additionally, four patients were ipsilaterally symptomatic to the occluded side, and none had symptoms related with the contralateral stenosed side. Thus surgery was prioritirized and safely performed for the occluded internal carotid artery. The stenosed contralateral side was operated at least after 2 weeks. When the arteries were clamped, neurocognitive functions of the patients did not alter and carotid shunt to proceed with endarterectomy was not required during the treatment of the stenosed side.

Shunts may be used during carotid endarterectomy. The literature lacks conflicting reports regarding the use of carotid shunts. Some authors perform carotid endarterectomy routinely with carotid shunts [44,45] while various others do not indicate evidence to use carotid shunt during carotid endarterectomy [46]. Despite routine shunting or selective shunting was associated with low stroke rates [47], still some authors may be against the insertion of carotid shunts due to the risk of arterial wall injury [44,46,48]. Goodney et al. [48] state that surgeons face with higher rates of stroke and/or death in patients with contralateral carotid artery occlusion despite using shunts. Naturally none of our patients required carotid shunts during the surgery of the occluded internal carotid artery confirmed with stable momentory neurologic status with local anesthesia. Additionally, again shunts were not required during the surgery of the stenosed contralateral side after the treatment of the occluded side providing enough collateral cerabral flow which is also confirmed with unimpaired neurologic functions observed during local anesthesia.

In 1960s extracranial bypass procedures were first employed to treat internal carotid artery occlusions and/or intracranial occlusive lesions, which may still be accepted as an option for the management of totally occluded internal carotid artery [8]. Another option may be angioplasty of the totally occluded carotid artery to be less invasive than attempting an intracranial bypass [18,36,49]. However, carotid endarterectomy is still the gold standard therapeutic option for atherosclerotic carotid artery disease and endovascular treatment may be promoted when there is recanalization of the internal carotid artery inside the cranium [36]. Angioplasty was not the preferred in our patients.

Current evidence indicates treatment for symptomatic patients with carotid total or subtotal occlusion since the best medical treatment with anti-platelet and anticoagulant therapies are only helpful in reducing the propagation of thromboemboli where as persistent cerebral hypoperfusion and atherosclerotic plaques endanger with recurrent strokes [50] Surgical revascularization of chronic totally occluded carotid arteries was studied in patients at a higher risk of stroke [51]. However, there is not a consistent data about the feasibility and safety of interventional measures in patients with chronically occluded carotid arteries [52]. Moreover, it may be risky when compared with the direct vision surgical revascularization as distal embolization despite protection devices, dissection or perforation may occur during penetration of the occluded segment of the carotid artery [52,53]. On the other hand, Jovin et al. [54] showed high successful revascularization rate in acute totally carotid occlusions with stent placement and angioplasty. The patency of the stents or angioplasty is not known in case of chronic chronic total carotid occlusion therapy [52]. When compared with the direct surgical revascularizaion, endovascular treatment, since it is performed with angiography provides the extent of the internal carotid artery occlusion. Additionally, effected intracranial segments can also be treated simultaneously during endovascular revascularization of the occluded carotid artery. Once again, no evidence suggests better results with interventional approaches to treat carotid occlusions [50] than very well established surgical approach [50,55].

6. LIMITATIONS

Major limitation of the study is the modest number of the patients. Unfortunately it burdens the scientific power of the paper. In order to reach an established widely accepted protocol, multicenter studies with increased number of the patients are necessary.

7. CONCLUSION

Carotid artery disease may be bilateral including one sided total/subtoal occlusion. The total occlusion may cause symptoms despite medical therapy and carries certain morbidity rates. Endarterectomy prioritized to the occluded side facilitated the surgery of the contralateral stenosed side in our modest number case series.

ETHICAL APPROVAL

All authors hereby declare that all observations and analysis have been examined and approved and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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