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Original Article

Complex Reconstruction of Supraaortic Branches

Masoud Mirzaie, MD, PhD, Sheila Fatehpur, MD, Martin Friedrich, MD, Samuel Sossalla, MD, PhD, Christian Sohns, MD, Friedrich A. Schoendube, MD, PhD, and Jan D. Schmitto, MD, PhD

Objective: The present paper exemplary describes several severe stenoses of supraaortic branches with its symptoms and operative treatments.
Methods: Eight patients, two female (68 ± 5 y), six male (73 ± 4 y), were retrospectively evaluated. Patients showed neurological signs as followed: recurring attacks of vertigo (80%), temporary paresis of extremity (20%), speech disorders (20%) and subclavian and/or carotic-steel-syndrome (15%). Seven patients have already been previously treated with revascularization of the supraaortic branches in the past. The surgical techniques used were thrombendarterectomy of the internal carotid artery, carotid-subclavian bypass and complex aorto-truncal, aorto-carotid and aorto-subclavian-bypass.
Results: One patient died nine days postoperatively due to myocardial infarction. Mean duration of stay on intensive care unit was 1.5 days. Mean duration of postoperative ventilation was six hours. Average duration of stay on normal ward was nine days.
Conclusion: This study presents several complex reconstructions of supraaortic branches, which were indicated in cases with severe stenoses of supraaortic branches. Even though treatment strategies were complex the peri- and postoperative complication rates are quite low. These therapeutic strategies were necessary to avoid severe neurological complications in these patients.

Key words: aorta, aortic surgery, supraaortic branches, reconstruction

Introduction

Supraaortic branches are less affected by arteriosclerosis than arterial branches of the lower limbs. The most common causes of cerebrovascular insufficiency in descending order are occlusion of the carotid bifurcation(50%–60%), the three big branches of aortic arch (25%) and vertebral arteries (10%–20%).[1–3] Multiple stenoses occur in 50%–75% of these patients. Arteriosclerosis is the most common cause of occlusion processes in patients older than 50 years. In western countries, Arteriitis (Takayasu-Disease) can be disregarded in the pathogenesis of supraaortic occlusions, whereas e.g. in India and Japan arteriosclerosis in patients between 10 and 25 years is a common disease. The most conventional surgical experiences are available for revascularization of the internal carotid artery and the subclavian artery. Good long-term results for elective patients with a risk of operative mortality < 3% are common. Detection of complex stenoses of supraaortic branches through ultrasonography and colour-duplex-sonography is rare. The increasingly used magnetic resonance tomography (MRT)- and computer tomography (CT)- Angiography enhances the diagnosis of stenoses of complex supraaortic branches.

Department of Thoracic-, Cardiac- and Vascular Surgery, University of Goettingen, Goettingen, Germany

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Corresponding author: Jan D. Schmitto. Department of Thoracic-, Cardiac- and Vascular Surgery, University of Goettingen, Goettingen, Germany
Email: schmitto@med.uni-goettingen.de

a | b

Fig. 1 **a**: MRT-angiography: High grade stenosis of both internal carotid arteries, left vertebral artery, output stenosis of the brachiocephalic trunk and the left common artery and the left subclavian artery.
b: Postoperative MRT-angiography of the same patient: Thrombendarterectomy of the right internal carotid artery, implantation of an aorto-common-carotid artery bypass graft of the left side and an aorto-brachiocephalic-trunc bypassgraft

Methods

More than 150 surgical interventions of supraaortic branches are yearly performed at our institution. The present paper exemplary describes eight cases with severe stenoses of supraaortic branches including treatment strategies and presentation of the postoperative results. The majority of these patients got previously already surgical interventions of the supraaortic branches. Preoperative diagnostics and postoperative controls included ultrasonography, colour-duplex-sonography as well as MRT- or CT-Angiography. To perform revascularization of the internal carotid artery, the chosen surgical approach was ahead the sternocleidomastoid muscle. For the carotid-subclavian-bypass, a supraclavicularian incision was performed, and for revascularization of the proximal stenosis of the supraaortic branches, a median sternotomy was done. All revascularizations of the internal carotid artery and the common carotid artery were done with an intraoperative shunt.

Patient 1

Preoperative ultrasonography and colour-duplex-sonography of the supraaortic branches revealed a high-grade stenosis of the left common carotid artery and an occlusion of the left subclavian artery. MRT-angiography confirmed the ultrasonographic findings. The performed surgical procedure was an implantation of a left aorto-common-carotid-bypass-graft combined with an implantation of a bypass-graft from the left common carotid artery to the left subclavian artery.

Patient 2

Patient two suffered from a high-grade stenosis of the right internal carotid artery and suspicion of complex aortic arch syndrome which was preoperatively diagnosed by sonography. MRT-angiography showed a filiform stenosis of the right internal carotid artery, an output stenosis of the brachiocephalic trunk and the left common carotid artery as well as the left subclavian artery (**Fig. 1a**). Due to high-grade stenosis of the left vertebral artery a clinical and angiographic reference to a subclavian-steel-syndrome on the left side was absent. Intraoperatively, a thrombendarterectomy of the right internal carotid artery, an implantation of an aorto-common-carotid artery-bypass-graft of the left side and an aorto-brachiocephalic-bypass-graft was performed (**Fig. 1b**).

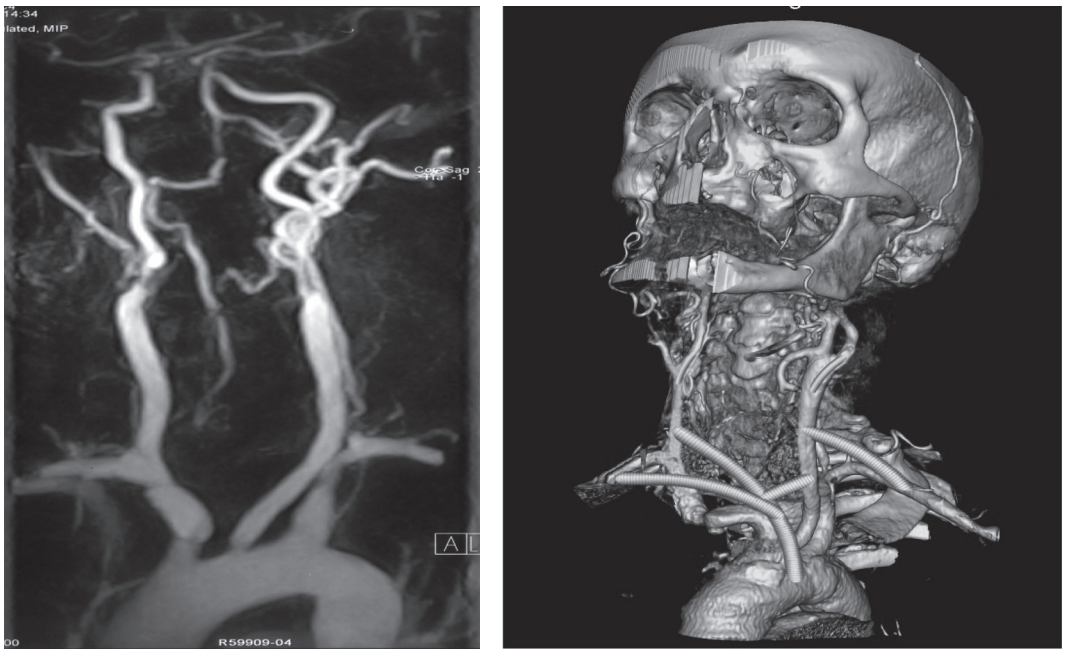

Fig. 2 **a**: MRT-angiography of a patient with filiform stenosis of both internal carotid arteries, stenosis of brachiocephalic trunc, stenosis of both common carotid arteries and occlusion of the left subclavian artery.
b: Postoperative 3-D-reconstruction of the performed operation: Endarterectomy of the right internal carotid artery in combination with coronary artery bypass graft and implantation of both, a right and left sided aorto-carotid-bypass graft and a right sided aorto-subclavian-bypass-graft at the first operative intervention. In the second operation the thrombendarterectomy of the left internal carotid artery and implantation of a left carotid-subclavian-bypass-graft was performed.

Patient 3

Preoperative ultrasonography and colour-duplex-sonography revealed high-grade stenoses of both internal carotid arteries and suspicion of complex aortic arch syndrome. MRT-angiography confirmed these results and showed filiform stenoses of both internal carotid arteries, a stenosis of the brachiocephalic trunk and stenoses of both common carotid arteries and an occlusion of the left subclavian artery with subclavian steel syndrome on both sides (**Fig. 2a**). Two operations were necessary to treat the patient: 1) myocardial revascularization (implantation of five coronary-artery-bypass-grafts), additionally: thrombendarterectomy of the right internal carotid artery, implantation of a right sided aorto-carotid- as well as an aorto-carotid-bypass-graft of the left side and a right sided aorto-subclavian-bypass-graft. 2) thrombendarterectomy of the left internal carotid artery and implantation of a left carotid-subclavian-bypass-graft was followed several weeks later (**Fig. 2b**).

Patient 4

Preoperative sonography showed high-grade stenoses of the left internal carotid artery, brachiocephalic trunk and left common carotid artery. MRT-angiography confirmed these results. First operation: thromboendarterectomy of the left internal carotid artery. Second operation: left aorto-common carotid-bypass-grafting and aorto-brachiocephalic-bypass-grafting. Postoperatively, the patient developed an apoplectic stroke on the left side examined by nuclear resonance scanning. MRT revealed a regular flow in all performed bypasses and the internal carotid artery. The stroke matches most closely with embolisms from the aorta. The patient recovered from the apoplectic stroke during the first postoperative days. Complete regeneration of all neurological symptoms was diagnosed by neurologists four weeks later.

Patient 5

Results of ultrasonography and colour-duplex-sonography detected a flow profile only over the left internal

carotid artery with a high-grade branch stenosis and a high-grade branch stenosis of the left common carotid artery. MRT-angiography showed an aortic arch syndrome with occlusion of the brachiocephalic trunk, the right subclavian artery and the right common carotid artery as well as high-grade branch stenoses of the left common carotid artery and the left internal carotid artery, an occlusion of the left subclavian artery and high-grade long-segment stenoses of both vertebral arteries. As surgical treatment, a thrombendarterectomy of the left internal carotid artery, left aorto-carotid bypass grafting, left carotid- subclavian bypass grafting and right aorto-subclavian bypass grafting was performed.

Patient 6

Sonography revealed filiform stenoses of both internal carotid arteries and both subclavian arteries. MRT-angiography showed high-grade stenoses of both internal carotid arteries and an occlusion of the left subclavian artery. First, a thrombendarterectomy of the left internal carotid artery and an implantation of a subclavian-internal carotid artery bypass graft was performed. Secondly followed by a thrombendarterectomy of the right internal carotid artery several weeks later.

Patient 7

Sonography results revealed stenoses of the brachiocephalic trunk and the left subclavian artery, a significant subclavian steel syndrome on the left side and suspicion of a partial aortic arch syndrome. MRT-Angiography revealed high-grade stenosis of the brachiocephalic trunk, high-grade branch-stenosis of the left common carotid artery, occlusion of the left subclavian artery as well as high-grade branch-stenosis of the left internal carotid artery and a subclavian-steel-syndrome on the left side. Therefore, a thrombendarterectomy of the left internal carotid artery, implantation of a left aorto-carotid-, an aorto-brachiocephalic- and a left carotic-subclavian bypass graft was performed.

Patient 8

Preoperative sonography revealed a high-grade stenosis of the left internal carotid artery, suspicion of an occlusion of the right common carotid artery and the right subclavian artery as well as a subclavian-steel-syndrome on the right side. MRT-Angiography showed an occlusion of the brachiocephalic trunk, of the right common carotid artery as well as a high-grade branch-stenosis of the left internal carotid artery. As therapy of choice, a thrombendarterectomy of the left internal carotid artery, implantation of a right aorto-carotid bypass graft and implantation of a right aorto-subclavian bypass graft was performed.

Discussion

Supraaortic branches are less affected by arteriosclerosis than those of the lower limbs. The most common cause of cerebrovascular insufficiency is a process of occlusion of the carotid bifurcation (50%–60%) following by the three big aortic arch branches with 25%. The vertebral arteries are only affected with 10–20% whereas the left side is more common than the right side.[1–4] Round about 50%–75% of the patients have multiple stenoses. Arteriosclerosis is the most common cause for occlusion processes for patients older than 50 years. For western countries Arteriitis (Takayasu-Disease[5–9]) can be disregarded in the pathogenesis of supraaortic occlusions, whereas in India and Japan, arteriosclerosis in patients between 10 and 25 years is a common disease. Other but also rare causes of this disease are iatrogenic occlusions after a subclavian-flap-operation concerning aortic coarctation. Furthermore, after PCA of the subclavian artery, traumatic occlusions particularly of the common and internal carotid artery, compression of subclavian artery caused by cervical ribs as well as elongation and looping of the internal carotid artery, conatal vessel anomaly like hypo- and aplasia of the internal carotid-, subclavian- or lusorian artery can occur. Occlusion processes of the supraaortic branches depending on its localisation can lead to perfusion insufficiency in three different vascular areas: 1. subclavian-brachial artery system, 2. vertebral-basilar artery system and 3. carotid artery system. The symptoms of subclavian stenosis with localization proximal of the vertebral artery express itself in a subclavian steel syndrome. Different vessels are qualified for compensation of a subclavian steel syndrome, whereby four different forms of this disease can be distinguished. The most common, Type I (vertebral-vertebral-type) occurs with 66%, and Type II (carotid-basilar shunt), III (external-basilar-shunt) and IV (carotid-subclavian-shunt) are less frequent. Due to its complex anatomical formation, the symptoms of the vertebral-basilar and carotid system can alternate in such a way that signs of vertebral-basilar insufficiency of a carotid stenosis can dominate.

Conclusion

This study presents several complex reconstructions of supraaortic branches, which were indicated in cases with severe stenoses of supraaortic branches. Even though treatment strategies were complex the peri- and postoperative complication rates are low. These therapeutic strategies were necessary to avoid severe neurological complications in these patients.

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