The Results of Carotid-Subclavian Bypass in a Single Institute

Karotis-Subklaviyan Baypas Klinik Sonuçlarımız

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ABSTRACT Objective: We present our patients who underwent carotico-subclavian bypass operation either for subclavian steal syndrome or for subclavian artery revascularization prior to thoracic endovascular aneursym repair procedures. **Material and Methods:** We performed 16 carotico-subclavian bypass operations between August 2009-November 2013 in our department. Nine patients were operated for subclavian steal syndrome with subclavian artery occlusion and 7 patients were operated before thoracic endovascular stent grafting for type III aortic dissection or the thoracic aneursym necessitating left subclavian artery occlusion. Fourteen male (87.5%) and 2 female (12.5%) patients with their ages ranging between 55-74 (mean 66.3) years were operated. All operations were performed under general anesthesia with a supraclavicular incision. In 14 patients, 8-mm Dacron grafts were used and in 2 patients 8 mm polytetrafluoroethylene grafts were used. Anastomoses were done in end-to-side fashion. **Results:** Radial artery pulses were palpable in all the patients after the operation, and their complaints like left arm pain or dizziness were resolved. Early 30-day morbidity was 6.2 % with one patient experiencing puffiness and pain at the left shoulder two weeks after the operation, due to seroma which was drained percutaneously under ultrasonography guidance after diagnosis. No perioperative stroke or minor cerebrovascular events were observed. One patient who had a native carotid artery tortuosity and cerebral artery aneurysm suffered from carotid-subclavian bypass graft thrombosis 2 days after the operation, with an early graft thrombosis rate of 6.2 %. No carotid-subclavian procedure related mortalities were observed. Patients to have thoracic endovascular aortic repair (TEVAR) procedures with a requirement of intentional left subclavian artery (LSA) coverage were primarily operated for carotico-subclavian graft interposition to provide LSA revascularization, and subsequently TEVAR procedure was performed. **Conclusion:** Carotico-subclavian bypass is a safe procedure with good surgical results.

Key Words: Carotico-subclavian bypass; subclavian steal syndrome; vertebrobasilar insufficiency

ÖZET Amaç: Subklaviyan çalma sendromu nedeniyle veya torasik endovasküler girişimlere ek olarak uyguladığımız karotis-subklaviyan baypas ameliyatı sonuçlarımızı sunmaktayız. **Gereç ve Yöntemler:** Ağustos 2009-Kasım 2013 tarihleri arasında kliniğimizde 16 hastada karotis-subklaviyan baypas ameliyatı yapıldı. Dokuz hastada subklaviyan arter stenozu sonucu subklaviyan çalma sendromu olması nedeniyle, 7 hastada da tip III aort diseksiyonu ve anevrizması sebebiyle torasik endovasküler stent greftleme prosedüründe sol subklaviyan arterin kapatılması gereksinimi sebebiyle karotis-subklaviyan baypas ameliyatı yaptık. Hastaların 2'si kadın (%12,5) ve 14'ü erkek (%87,5) idi ve yaşları 55-74 (ortalama 66,3) yıl arasında değişiyordu. Tüm ameliyatlar genel anestezi altında supraklaviküler insizyonla yapıldı. On dört hastada 8 mm Dacron greft, 2 hastada 8 mm politetrafloroetilen greft kullanıldı. Anastomozlar uç-yan şeklinde yapıldı. **Bulgular:** Tüm hastalarda radial arter nabızları ameliyat sonrası palpabl oldu ve hastaların sol kolda ağrı ve baş dönmesi gibi şikayetleri, ameliyat sonrasında geçti. Erken 30 günlük morbidite oranı 1 hastada görülen seroma ile %6,2 olarak saptandı; ameliyattan 2 hafta sonrasında sol omzunda ağrı ve şişkinlik şikayeti ile başvuran hastada tespit edilen seroma, ultrasonografi eşliğinde perkutan olarak boşaltıldı. Hiçbir hastada perioperatif stroke veya minor serebrovasküler olay gözlenmedi. Erken greft trombozu oranı %6,2 idi; nativ karotis arterinde tortiyozite ve serebral arter anevrizması olan 1 hastada ameliyattan iki gün sonra greft trombozu gelişti. Karotis-subklaviyan baypas prosedürüne bağlı hiç mortalite gözlenmedi. Torasik endovasküler aorta onarımı (TEVAR) yapılacak ve sol subklaviyan arterin kapatılması gereken hastalarda, öncelikle karotis-subklaviyan baypas ile subklaviyan arter revaskülarizasyonu sağlanarak, sonrasında TEVAR prosedürü uygulandı. **Sonuç:** Karotis-subklaviyan baypas ameliyatının, iyi cerrahi sonuçlar ve teknik olarak kolay uygulanabilirliği sebebiyle güvenli bir cerrahi yaklaşım olduğunu düşünüyoruz.

Anahtar Kelimeler: Karotiko-subklavyen baypas; subklavyen çalma sendromu; vertebrobaziller yetmezlik

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Subclavian artery lesions requiring arterial reconstruction are relatively uncommon. Symptomatic subclavian artery atherosclerosis should be treated since it can cause significant morbidity. Patients can be asymptomatic or various symptoms can be seen due to posterior cerebral or upper extremity ischemia. The left subclavian artery (LSA) is said to be more often atherosclerotic compared to the right, and it is involved in approximately 70% of symptomatic cases.[1] Extra-thoracic revascularization (carotid-subclavian bypass grafting, subclavian-carotid transposition, carotid-carotid bypass, subclavian-subclavian bypass, axillo-axillary bypass grafting) and percutaneous balloon angioplasty (PTA) or stenting are the primary treatment options for subclavian artery stenosis or occlusion. Arm ischemia causing claudication, rest pain or trophic changes, symptomatic subclavian steal or symptoms of vertebrobasillar insufficiency (VBI) may compose the indications for surgery.[2] VBI on arm exertion and retrograde vertebral flow documented with duplex ultrasound scanning and angiography are useful for the diagnosis. In the previous years, subclavian arterial atherosclerosis used to be the only indication for carotid-subclavian bypass, but recently, with the advancing techniques of endovascular procedures for aortic pathologies, carotico-subclavian bypass has become a preferred approach for LSA revascularization in patients necessitating LSA salvage in thoracic endovascular aortic repair (TEVAR) procedures. We present our surgical experience with carotico-subclavian bypass procedure for both indications.

MATERIAL AND METHODS

We performed 16 carotico-subclavian bypass operations in a four-year time interval between August 2009-November 2013, in our department. We analyzed the patients' records retrospectively. The patients were analyzed in two different groups, according to the indication for carotico-subclavian bypass procedure (Group I and Group II). Group I included 9 patients who were operated for subclavian steal syndrome with subclavian artery occlusion or stenosis. Group II included 7 patients who were operated adjunctive to thoracic endovascular stent grafting for type III aortic dissection and thoracic aneurysm necessitating left subclavian artery sacrifice. Fourteen male (87.5%) and 2 female (12.5%) patients (one had subclavian artery occlusion and the other undergoing a TEVAR procedure) with the ages between 55-74 (mean 66.3) years underwent carotico-subclavian bypass in our institution. In Group I, 7 of the patients had subclavian artery occlusion and 2 had significant stenosis. All of the patients in our series had a left sided atherosclerotic lesion. Demographic variables of the patients are summarized in Table 1. All patients in Group I had an initial carotid artery Doppler ultrasonography and subsequent computerized tomographic (CT) or digital subtraction angiographic (DSA) evaluation to assess subclavian artery stenosis or occlusion prior to surgery. All patients in Group II had already been evaluated for a TEVAR procedure with a computerized angiography, and no other examinations were required.

All operations were performed under general anesthesia with a supraclavicular incision approximately 1 cm above and parallel to clavicle (Figure 1A). A meticulous dissection of subclavian and common carotid arteries is performed (Figure 1B). A 8 mm Dacron graft was used for 14 patients, and a 8 mm polytetrafluoroethylene (PTFE) graft was used for two patients. Anastomoses were done in end-to-side fashion. Both carotid and subclavian artery anastomoses were done with vascular clamps providing total occlusion of the both vessels as seen in Figure 2, after intravenous administration of 5000 unites of standart heparin. In the intensive care unit, low molecular weight heparin was ordered until discharge, combined with an antiaggregant therapy with acetylsalicylic acid.

TABLE 1: Demographic variables.

	n= 15	Percentage (%)
Female	2	13.3
Male	13	86.6
Hypertension	9	60
Diabetes mellitus	3	20
Coronary artery disease	3	20

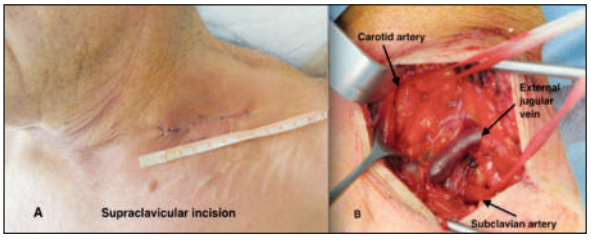

FIGURE 1: A) Supraclavicular incision 1 cm parallel and above clavicle, sternal segment. **B)** Exposure of the common carotid artery and subclavian artery.

Clinical follow up was obtained with routine physical examination and arm Doppler ultrasound assessments in some patients. Resolution of symptoms was also checked. Presence of peripheral arterial pulses in the ipsilateral arm confirmed by Doppler ultrasound was considered as a graft patency. Further imaging modalities like CT/magnetic resonance angiography or DSA were not required. In cases whom carotico-subclavian bypass operation was performed prior to TEVAR procedure, postoperative routine CT angiography control for evaluating endovascular leaks confirmed the carotico-subclavian bypass graft patency as well. Angiographic image of a carotico-subclavian bypass graft during TEVAR procedure is shown in Figure 3.

In our patient cohort, all patients operated for subclavian artery stenosis or occlusion had a left sided disease and no right subclavian artery stenosis was detected. The most frequently seen symptom was left arm pain and numbness in 5 patients, vertigo in 2, temporary vision loss in 1 and repetitive syncope attacks in 1 patient. All patients scheduled for a TEVAR procedure underwent a left carotico-subclavian bypass operation two days before the planned TEVAR procedure except 1 patient in whom both procedures were performed at the same stage (carotico-subclavian bypass procedure and a subsequent TEVAR).

RESULTS

Radial artery pulses were palpable in all patients after the operation with resolved complaints as left arm pain or dizziness. All had one- night stay in the intensive care unit. No major or minor neurological complications were observed. One patient in Group I with a native carotid artery tortuosity and cerebral artery aneurysm (he could not be anticoagulated) suffered from carotid-subclavian bypass graft thrombosis two days after the operation. He underwent a re-operation, and the graft was cut near the carotid anastomosis. After removing the trombotic material and providing flow inside the graft, the graft was re-anastomozed to the carotid artery to a more distal and straight segment. The graft flow was patent after the procedure. The patient did not experience any neurologic events. Early graft thrombosis was observed in 1 (6.2%) patient.

Another patient suffered from puffiness and pain at the left shoulder two weeks after the operation because of seroma, which was drained percutaneously under ultrasonographic guidance. Early 30 day morbidity was 6.2% with seroma be-

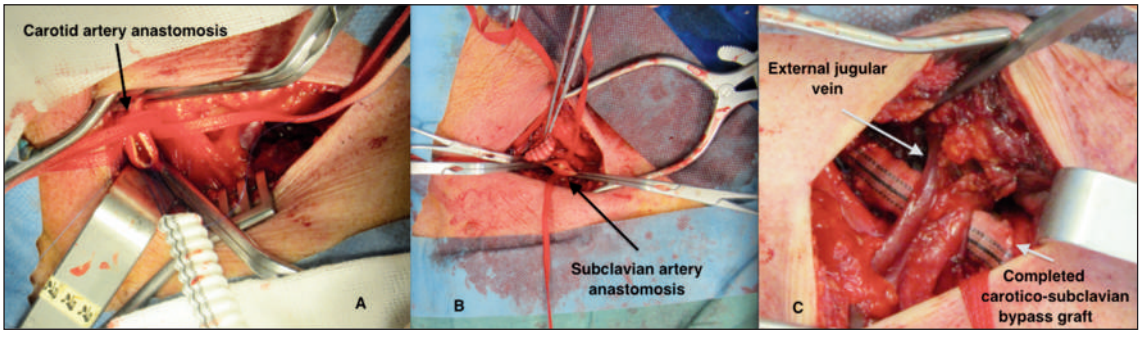

FIGURE 2: A, B) Anastomosis of Dacron graft to common carotid artery and subclavian artery with vascular clamping **C)** Image of completed carotico-subclavian bypass graft.

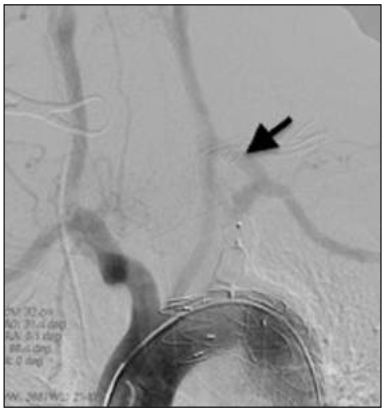

FIGURE 3: Angiographic image of carotico-subclavian bypass graft during thoracic endovascular aortic repair procedure.

ing the only morbidity seen. One patient with a previous coronary bypass operation history with concomitant LSA stenosis had angina due to coronary steal syndrome. After the carotid-subclavian bypass procedure, his cardiac complaints resolved as well. Patients to have TEVAR procedures were primarily operated for carotico-subclavian bypass procedure and a subsequent TEVAR procedure was performed afterwards.

No perioperative stroke or minor cerebrovascular events were observed. No mortality was observed due to the carotico subclavian bypass procedure. Nevertheless, mortality was seen in two patients who underwent additional cardiac and endovascular procedures after an uneventful carotico-subclavian bypass operation. Both patients were scheduled for TEVAR procedure. Among these patients, one with a thoracic aneurysm (together with Parkinson's disease and other systemic comorbidities) suffered chest pain in the cardiovascular surgery ward during an uneventful postoperative follow up. He underwent a coronary angiography, and a left main coronary artery stenosis was detected. The planned TEVAR procedure was postponed, and he underwent coronary bypass operation, but he had neurologic sequelae in the intensive care unit. He had pulmonary problems leading to cardiopulmonary failure in postoperative ninth day. The other patient was a 74-year-old man with chronic renal failure and additional comorbidities who underwent an EVAR+TEVAR procedure for Crawford type II aortic aneurysm two days after the carotico-subclavian bypass operation. In the intensive care unit follow up, renal and pulmonary failures occurred and the patient died on postoperative 11th day. Both te patients had descendant aortic aneurysms and preoperative systemic risk factors as old age, chronic obstructive pulmonary dysfunction and chronic compensated renal failure.

Early 30 day graft patency was 93.75% (1 patient experienced graft thrombosis). After the re-operation of this patient, the graft was reanastomozed providing flow patency. Late graft patency at about 18 months was 100% in the 5 patients who came for hospital visits at the follow up in Group I and in all the patients who underwent TEVAR procedures; all had postoperative computerized tomography controls routinely done for endoleak search showing that the grafts were patent in Group II. Immediate relief of symptoms was achieved in 100% of patients with none of the patients suffering late recurrent symptoms.

DISCUSSION

Isolated stenotic or occlusive lesions of the subclavian artery are usually asymptomatic because of the rich arterial collateral supply of the head, neck and shoulder. These lesions can cause symptoms due to the ischemia of either upper extremity or posterior cerebral circulation.[1] In 1960, Contorni described subclavian steal as reversal of flow in the ipsilateral vertebral artery distal to a proximal lesion for the first time.[3] Movement of the upper extremity increases demand for blood and causes a steal from the cerebral circulation through the ipsilateral vertebral artery which is distal to the subclavian artery stenosis or occlusion. This is the reason of posterior cerebral ischemia symptoms. Dizziness, unilateral limb weakness, dysarthria, headache and nausea or vomiting are the most frequent symptoms related to posterior circulation region.[4] Vertebrobasillar insufficiency symptoms like dizziness, drop attacks, blackout spells, blurred vision, diplopia, ataxia and vertigo may also be seen due to subclavian artery lesions since symptomatic subclavian artery lesions are associated with concomitant lesions of the contralateral vertebral artery or one or both carotid arteries in 35% to 85% of patients.[1,2]

Hand claudication and digital embolization may be seen due to upper extremity ischemia. Angina may also be the presentative symptom in patients with a left internal mammary artery graft having a coronary steal syndrome. Briefly, the most common presenting symptoms include vertebrobasillar insufficiency, upper extremity ischemia and transient ischemic attacks We believe that it is important to underline that all symptomatic patients are recommended to undergo treatment.[5]

The prevalence of subclavian steal syndrome is reported to range between 0.6-6.4%.[6] It is reported that incidence of proximal subclavian stenosis in patients undergoing coronary artery bypass grafting ranges from 0.5% to 15%.[7] More than 90% of patients undergoing treatment for subclavian artery stenosis are said to be symptomatic.[5] Cardiac disease affects >50% of patients presenting with symptomatic subclavian artery stenosis.[5,8] Males are affected by the atherosclerotic subclavian steal phenomenon more than females, with a ratio of about 2:1.[6] Physical examination may reveal diminished pulse and a systolic blood pressure difference of greater than 20 mmHg between the arms.[6,9] Labropoulos et al. showed that an arm blood pressure difference >40 mmHg was associated with an increased prevalence of complete steal and the occurrence of symptoms.[10]

Subclavian artery atherosclerosis therapy has developed in years. DeBakey et al. first reported successful revascularization of innominate and subclavian arteries via transthoracic approach in 1958.[11] Dietrich and colleagues reported first extrathoracic approach as carotid-subclavian bypass in 1967.[12] Subclavian artery PTA or stenting has become more assertive since Bachman and Kim reported first subclavian artery angioplasty in 1980.[13] Subclavian artery PTA or stenting has been subscribed as one of the main treatment modalities for this relatively uncommon disease in the current medical literature.

Type of the graft and surgical management has been evaluated by several studies up to date. Saphenous vein has been shown to perform inferiorly to prosthetic grafts in this location. Ziomek et al. showed a 5-year patency of 94% for prosthetic grafts compared with 58% for vein grafts in patients with carotid-subclavian bypass.[14] Some authorities have documented that ringed PTFE is superior to Dacron or vein in terms of durability. Law et al. reported that PTFE grafts had a patency of 95%, Dacron grafts 84% and saphenous vein grafts 65%, but the differences were not statistically significant, but the small sample size was underlined.[15]

AbuRahma et al. reported the primary patency rates at 1, 3, 5 and 10 years as 100%, 98%, 96% and 92%, respectively, concluding that carotid-subclavian bypass grafting with the use of PTFE grafts was safe, effective and durable, with no perioperative stroke or mortality. Their 30 day morbidity was reported as 6%.[2]

Preference for the type of the surgery may differ with surgeons' practice and experience. Transposition of the subclavian artery to the side of the common carotid artery is the most preferable method. It is said to have three advantages: It is an autogenous reconstruction, has only one anastomosis and carries the best long term patency.[16] Nevertheless, this approach possesses necessity for a more deep dissection to gain proximal control of the subclavian artery stenosis and its associated branches. Aorto-innominate or aorto-subclavian bypass through an extended incision to manubriosternal junction and additional vertical manubriotomy has also been suggested.[9] Carotico-subclavian bypass has been suggested to be advantageous by Aydın et al., whereas subclavian-carotid transposition procedure was emphasized to have superior results compared to other bypass procedures by Aslım and Akay.[17,18] Çınar et al. concluded that carotico-subclavian bypass with a PTFE grafts was a safe and durable procedure.[19] In our experience, in four years, carotid-subclavian bypass grafting has also been our primary surgical approach to avoid more excessive tissue resection. The expanded indications for carotico-subclavian bypass can also be seen in our patient cohort including patients undergoing endovascular procedures necessitating left subclavian artery occlusion more recently, as Aydın et al. stressed.[17]

Studies on endovascular management emphasize that the success rate is lower in subclavian artery occlusion compared to stenotic lesions. The main problem with endovascular procedures seems to be the long term patency rates. Patency rates for surgery have been reported as high as 95% for 10 years.[2,20] De Vries et al. reported that the patency rate at about 3 years follow up after PTA was 93% for subclavian stenosis and 65% for subclavian occlusion.[21] Similarly, Wang et al. reported a 12-month primary patency rate of 98% for angioplasty and stenting procedures whereas a decreased patency rate of 82% at 5 years follow-up.[22]

During TEVAR procedures, thoracic aneurysms close to LSA may necessitate coverage of LSA with the aortic stent-graft. Since a successful stent-graft placement requires a satisfactory landing zone of at least 15 mm in length, LSA coverage serves to provide additional length for the proximal landing zone.[23] LSA revascularization with either transposition or bypass from the carotid artery in such situations is recommended by some authors to prevent complications like left arm ischemia, stroke and spinal cord ischemia.[24,25] In our patient cohort, we performed 7 carotico-subclavian bypass procedures to provide LSA revascularization because of intentional LSA coverage during TEVAR procedures. Criado et al. reported that LSA coverage was apparently safe, but they recommended to ascertain the angiographic patency of the contralateral vertebral artery beforehand, with secondary revascularization being easily achievable if vertebrobasillar or arm ischemia develops after stent-graft placement.[24] In our clinical practice, we perform prophylactic LSA revascularization only under certain conditions like any pathology involving supra-aortic vessels or with the presence of a dominant left vertebral artery. TEVAR patients included in the present study had a dominant left vertebral artery and we preferred LSA revascularization to avoid potential related complications.

In conclusion, we believe that carotico-subclavian bypass grafting with Dacron grafts, as well as PTFE, remains an effective and feasible way in patients with subclavian steal syndrome and as an adjunct to endovascular procedures exhibiting high long-term patency rates.

Conflict of Interest

Authors declared no conflict of interest or financial support.

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