Türk Göğüs Kalp Damar Cerrahisi Dergisi 2012;20(4):768-773
doi: 10.5606/tgkdc.dergisi.2012.152

***Original Article** / Özgün Makale*

Surgical treatment alternatives for occlusive disease of the subclavian artery based on our clinical experience

Klinik deneyimlerimiz eşliğinde subklaviyan arterin tıkayıcı hastalığında cerrahi tedavi alternatifleri

Faik Fevzi Okur,[1] Veysel Şahin,[2] İhsan Sami Uyar,[1] Feyzi Abacılar,[1] Beşir Akpınar,[2] Volkan Yurtman,[2] Emin Alp Alayunt,[1] Mehmet Ateş[1]

[1]Department of Cardiovascular Surgery, Medical Faculty Şifa University, İzmir, Turkey;
[2]Department of Cardiovascular Surgery, Şifa Medical Center, İzmir, Turkey

Background: In this study, we described the outcomes of the procedures including subclavian carotid transposition (SCT), carotid subclavian bypass (CSB) and subclavian-subclavian bypass (SSB).

Methods: Between January 1999 and December 2009, the medical records of 20 patients (19 males, 1 female; mean age 58.5 years; range 46 to 73 years) undergoing surgical intervention for symptomatic occlusive subclavian artery disease in our clinic were retrospectively analyzed. Ten of these patients underwent SCT, six underwent CSB and four underwent SSB. All patients had symptoms of severe subclavian artery insufficiency and a significant decrease of >50 mmHg in systolic blood pressure on the affected side. The mean follow-up was 7.1±2.1 years (range, 2-10 years).

Results: Immediate relief of symptoms was achieved in 100% of patients, with an early graft success (30-day patency) of 95%. As noted primary patency rates at 1, 5, and 10 years in SCT series were %100, %100, %90, in CSB series %100, %83.3, % 66.7, in SSB series %100, %50, %50 respectively.

Conclusion: The comparison of the early and late postoperative results show that transposition of subclavian artery to carotid artery is a safe, effective and durable procedure in eligible patients.

Key words: Subclavian artery stenosis; subclavian steal syndrome; supraaortic reconstruction.

Amaç: Çalışmamızda, subklaviyan karotis transpozisyon (SKT), karotis subklaviyan baypas (KSB) ve subklaviyan-subklaviyan baypas (SSB) işlemlerinin sonuçları tanımlandı.

Çalışma planı: Ocak 1999 - Aralık 2009 tarihleri arasında kliniğimizde semptomatik tıkayıcı subklaviyan arter hastalığı tanısıyla cerrahi tedavi uygulanan 20 hastanın (19 erkek, 1 kadın; ort. yaş 58.5 yıl; dağılım 46-73 yıl) tıbbi kayıtları retrospektif olarak incelendi. On hastaya SKT, altı hastaya KSB, dört hastaya da SSB ameliyatı uygulandı. Bütün hastalarda ciddi subklaviyan arter yetersizliği semptomları vardı ve etkilenen taraftaki sistolik kan basıncı diğer tarafa göre en az 50 mmHg daha düşük idi. Ortalama takip süresi 7.1±2.1 yıl (dağılım 2-10 yıl) idi.

Bulgular: Yüzde doksan beş erken greft başarı oranı (30 günlük açık kalma) ile hastaların %100'ünde semptomların düzeldiği görüldü. Bir, beş ve 10 yıllık not edilen primer açıklık oranları sırasıyla SKT serisinde %100, %100, %90, KSB serisinde, %100, %83.3, %66.7, ve SSB serisinde %100, %50, %50 idi.

Sonuç: Erken ve geç dönem ameliyat sonrası sonuçlar karşılaştırıldığında, uygun olan hastalarda subklaviyan arterin karotis artere transpozisyonunun güvenli, etkin ve kalıcı bir işlem olduğu görülmektedir.

Anahtar sözcükler: Subklaviyan arter darlığı; subklaviyan çalma sendromu; supraaortik düzeltme.

Available online at
www.tgkdc.dergisi.org
doi: 10.5606/tgkdc.dergisi.2012.152
QR (Quick Response) Code

Received: December 2, 2011 *Accepted*: January 12, 2012

Correspondence: Veysel Şahin, M.D. Şifa Tıp Merkezi Kalp ve Damar Cerrahisi Kliniği, 35240 Basmane, İzmir, Turkey.
Tel: +90 232 - 446 08 80 e-mail: veyselkvc@gmail.com

High-grade stenosis or occlusion of the subclavian artery proximal to the origin of the vertebral artery can cause symptoms of vertebrobasilar or coronary insufficiency should there be an anastomosis between the coronary artery and the left internal mammary artery (LIMA) along with ischemia of the ipsilateral upper extremity from hypoperfusion. In addition, a reversal of cerebral or coronary blood flow circulation can also be at fault. This blockage reverses the normal direction of blood flow in the vertebral or coronary artery in which blood is drawn from the contralateral vertebral, basilar, carotid, or coronary artery regions into the low-pressure ipsilateral upper limb vessels.[1]

The management of subclavian artery occlusive disease has evolved a great deal over the years, and a variety of therapeutic options are available, including transthoracic bypass grafting or an endarterectomy,[2-3] subclavian-carotid transposition (SCT)[4] and extrathoracic bypass grafting, carotid-subclavian bypass (CSB), carotid-axillary bypass (CAB), axillary-axillary bypass (AAB), or subclavian-subclavian bypass (SSB).[5] The transthoracic approach is invasive and is rarely used in elderly populations because of the high incidence of complications.[3] Subclavian-carotid transposition, CSB, and SSB are the interventions used by most surgeons.

Percutaneous transluminal angioplasty (PTA), with or without stenting of the subclavian artery, provides another tool for those treating patients who have stenosis or occlusion. Subclavian artery PTA/stenting is now commonly used by some for treating subclavian artery stenosis, and certain authorities advocate it as the first line of therapy or treatment of choice for this disease.[6,7]

In this study, we analyze the early and long-term efficacy of CSB, SCT, and SSB for severe subclavian artery occlusive disease.

PATIENTS AND METHODS

Twenty patients (19 males and 1 female; mean age 58.5 years; range 46 to 73 years) in whom SCT, CSB, or SSB grafts were used to correct symptomatic occlusive disease of the subclavian arteries between January 1999 and December 2009 were included in this study. The mean follow-up of this series was 7.1±2.1 years (range, 2-10 years) and included 20 patients. The ethics committee approved the study, and written informed consent was obtained from all patients. Ten of these patients had isolated occluded lesions of the subclavian artery and underwent SCT, six had heavily calcified proximal subclavian artery occluded lesions and underwent CSB, and four had isolated occluded lesions of the subclavian and the common carotid artery and underwent SSB. Many patients had more than one risk factor for atherosclerotic disease. Seventeen patients (85%) were cigarette smokers, and 16 (80%) had a history of hypertension and/or diabetes mellitus (DM). Peripheral vascular occlusive disease (PVOD) was present in 11 patients (55%), and hyperlipidemia was present in six (30%). No patient with vasculitis was included in this study. The demographic characteristics of the patients are shown in Table 1.

Carotid-subclavian bypass

For this procedure, a skin incision was made 1 cm above the clavicle, extending from the sternoclavicular joint to the lateral portion of the supraclavicular region for about 6 to 8 cm. Exposure of the carotid artery and subclavian artery was then carried out. Next, the carotid artery was isolated and surrounded with vessel loops. After systemic heparinization was achieved, carotid artery occlusion was performed via cross-clamping. Implantation of a polytetrafluorethylene (PTFE) (Goretex, W.L. Gore & Associates, Flagstaff, Arizona) tube graft 6 mm in diameter was first carried out in the subclavian artery through an end-to-side anastomosis using No. 5-0 polypropylene suture material. After this was completed, the graft was tunneled toward the carotid artery. The carotid graft anastomosis was similarly carried out by end-to-side anastomosis using the same suture material.

Subclavian-subclavian bypass

Subclavian-subclavian bypasswas carried out through bilateral supraclavicular incisions. The operative exposure was achieved through a 6 cm incision, one fingerbreadth above the clavicle and extending posteriorly from the sternocleidomastoid muscle. After systemic heparinization was achieved, one subclavian artery was cross-clamped, and a PTFE (Goretex) tube 6 mm in diameter was anastomosed to the vessels with

Table 1. Demographic characteristics of 20 patients

Characteristics	No. of patients	Percentage of patients
Male	19	95
Female	1	5
Mean age (year)	58.5	
Age range (year)	46-73	
Risk factors		
Hypertension	13	65
Diabetes mellitus	7	35
PVOD	11	55
Tobacco use	17	85
Hyperlipidemia	6	30
COPD	5	25

PVOD: Peripheral vascular occlusive disease; COPD: Chronic obstructive pulmonary disease.

running fine No. 5-0 polypropylene sutures. After the graft was anastomosed to the recipient vessel, it was tunneled subcutaneously into the anterior tissues of the neck, and the donor anastomosis was carried out.

Subclavian-carotid transposition

To perform this procedure, the common carotid and subclavian arteries were exposed and mobilized as previously described. The subclavian artery was well mobilized proximal to the vertebral artery and IMAs, both of which had been carefully preserved. The subclavian artery was then divided proximally, and the proximal stump was oversewn. Next, the distal end, proximal to the vertebral artery, was sutured end-to-side to the common carotid artery with running fine No. 5-0 polypropylene sutures.

The patients were anticoagulated postoperatively, and low-molecular-weight heparin was initiated six hours after their arrival in the intensive care unit (ICU). After one day, this was replaced by warfarin sodium and aspirin (300 mg/d) for the next three months, thus maintaining an international normalized ratio of 2.0 to 2.5. After the three months, the aspirin (300 mg/d) was continued indefinitely.

Follow-up

After the operation, the patients were closely monitored for neurological and cardiovascular symptoms. After being discharged from the hospital, all patients were examined at the three-, six-, and twelve-month post-procedure follow-ups and annually thereafter. Patients had physical examinations, and bilateral brachial pressures and noninvasive vascular tests were also performed. Graft patency was determined by using duplex ultrasonography. Angiography was also carried out to confirm stenosis and the steal phenomenon.

Statistical methods

Means and standard errors (SE) were calculated. The Kaplan-Meier survival method was used to calculate the patency rates and symptom-free survival rates were obtained using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, Illinois, USA) version 17.0 statistical software program.

RESULTS

All patients had symptomatic disease and a significant decrease of >50 mmHg in systolic blood pressure on the affected side. Preoperative angiography confirmed the steal phenomenon in 15 patients (75%), and 12 (60%) had complete occlusion of the subclavian artery. Symptoms of upper extremity ischemia (claudication, weakness, paresthesia, coldness, and cyanosis) occurred in 14 patients (70%), and symptoms of vertebrobasilar insufficiency (dizziness, vertigo, diplopia, and syncope) occurred in 12 patients (60%). Unstable angina pectoris was present in five patients (20%). The incidence for symptoms is shown in Table 2.

Early (30-day) results

The 30-day morbidity rate was 10% (2 of 20 patients), with no perioperative mortality. Three patients had early perioperative complications, which included one perioperative cerebrovascular accident during the CSB procedure. One patient had phrenic nerve palsy during the SSB procedure, but recovery occurred within three to six months. The one graft in the patient with early graft thrombosis was excised and revised. The mean postoperative ICU and hospital stays were one and three days, respectively. Immediate relief of symptoms was achieved in 100% of patients, with an early graft success (30-day patency) of 95%.

Table 2. Indications for surgery in 20 patients

	SCT		CSB		SSB		*Total*	
	n	%	n	%	n	%	n	%
Cladication	2	10	5	25	2	10	9	45
Weakness	2	10	5	25	3	15	12	60
Paresthesia	3	15	3	15	1	5	8	40
Coldness	1	5	2	10	1	5	4	20
Cyanosis	1	5	2	10	0	0	3	15
Dizziness	2	10	1	5	2	10	5	25
Vertigo	3	15	4	20	1	5	8	40
Diplopia	2	10	2	10	1	5	5	25
Syncope	1	5	1	5	0	0	2	10
Transient ischemic attack	0	0	1	5	0	0	1	5
Angina	1	5	4	20	0	0	5	20

SCT: Subclavian carotid transposition; CSB: Carotid subclavian bypass; SSB: Subclavian-subclavian bypass.

Late results

Overall, 9 of 10 transposition procedures stayed patent (primary patency) in the SCT series, and one underwent a trombectomy. Four of six grafts stayed patent in the CSB series, and two patient grafts were revised to a carotid-axillary artery bypass graft because of significant stenosis at the subclavian site. Two of four grafts stayed patent in the SSB series, two patient grafts were revised to a carotid endarterectomy and a carotid-subclavian artery bypass graft. Figure 1 shows the primary patency rates determined by the Kaplan-Meier life table method. As noted, the primary patency rates at one, five, and 10 years were 100%, 100%, and 90% respectively in the SCT series, 100%, 83.3%, 66.7% respectively in the CSB series, and 100%, 50%, 50% respectively in the SSB series. There were no statistical differences between SSB and CSB ($p>0.05$) concerning the primary patency rates, but there was a statistical difference between SCT and SSB regarding the primary patency rates ($p<0.05$).

Immediate relief of symptoms was achieved in 100% of patients; however, four (20%) had late recurrent symptoms. The preoperative indication for surgery in three of these four patients was vertebrobasillary insufficiency with symptom recurrence at two, five, and six years, and all had patent grafts. The fourth patient had surgery for arm ischemia with recurrence of symptoms and graft failure at seven years. Figure 2 shows symptom-free survival rates by means of the Kaplan Meier life table method.

During the study period, one additional patient (5%) died of lung cancer, which was unrelated to the revascularization procedure.

DISCUSSION

Although symptomatic subclavian artery disease is relatively uncommon,[8,9] it may represent a significant disability and should be treated appropriately to provide favorable and long-lasting results. The procedure should be effective and durable with minimal complications.

Currently, extrathoracic revascularization (CSB, SCT, SSB) and percutaneous balloon angioplasty, both with and without stenting, have been advocated as the primary treatments for symptomatic subclavian artery stenosis or occlusion.[5] However, most studies that have reported angioplasty results indicate that the treatment of stenosis yields results that are significantly different from the treatment of occlusions.[6] It is generally thought that CSB and SCT have emerged as the treatments of choice for symptomatic proximal subclavian artery stenosis or occlusion.[8]

Subclavian carotid transposition offers multiple advantages over CSB and extra-anatomic SSB or axilloaxillary bypasses. Because a direct anastomosis can be performed, no prosthetic materials are needed. Pseudointimal hyperplasia related to compliance mismatch is not a problem, and long-term patency rates are good.[10-13] This procedure, however, is limited to patients with occlusive disease in the proximal carotid artery.[10,11,14] Carotid-subclavian bypass has been used

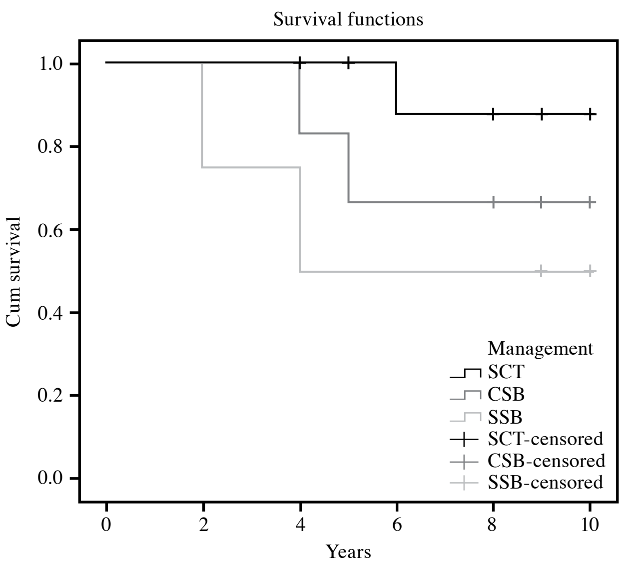

Figure 1. Kaplan-Meier graph showing the time to loss of primary patency. SCT: Subclavian-carotid transposition; CSB: Carotid-subclavian bypass; SSB: Subclavian-subclavian bypass.

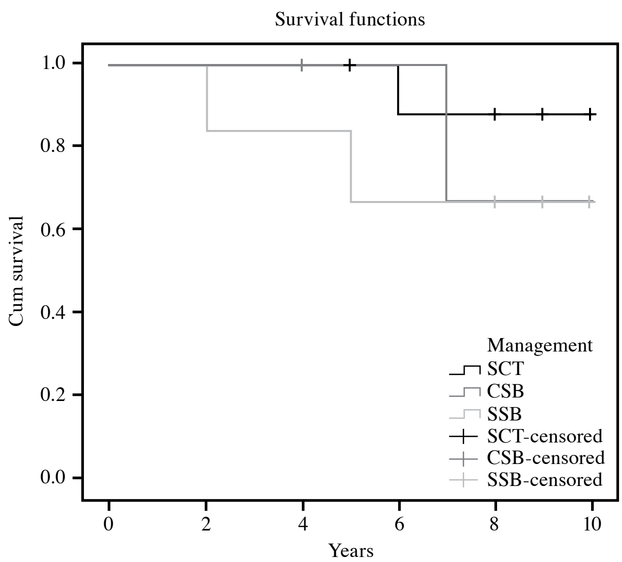

Figure 2. Kaplan-Meier graph showing the time to symptom-free survival. SCT: Subclavian-carotid transposition; CSB: Carotid-subclavian bypass; SSB: Subclavian-subclavian bypass.

by others because a short graft is placed between the ipsilateral high-flow vessels, and the mortality rate is low.[15,16] However, it cannot be used for innominate artery lesions, and patency rates are reported to be lower than with SCTs. A carotid endarterectomy may also be necessary before CSB (or it may be done at the time of this procedure) to prevent a carotid steal.[9] These procedures have yielded excellent results and should be used in patients who have no coexisting severe disease that could increase mortality and morbidity. Higher risk patients should undergo SSB because it has minimal complications and avoids the carotid artery. Others have preferred the SSB procedure over the CSB graft when coexisting ipsilateral carotid artery stenosis is present.[11-17]

If patients had multilevel occlusive disease involving the ipsilateral carotid or the contralateral carotid and the vertebral or subclavian arteries, the symptoms of continued after the surgical procedure unless the graft was occluded.[4]

Although a subclavian carotid steal can occur from SCT in the presence of proximal common carotid stenosis, a subclavian coronary steal can occur when there is proximal subclavian stenosis and a patent IMA coronary graft. Five patients in this study were treated for this problem by either SCT or bypass and had complete resolution of their cardiac symptoms and no postoperative myocardial infarction. Subclavian carotid transposition provides an excellent long-term solution to this problem.[9]

Currently, there is no prospective randomized data comparing angioplasty/stenting of the subclavian artery with surgical bypass grafting in the treatment of subclavian artery disease. However, in a study by Farina et al.,[18] 21 patients who underwent PTA for proximal stenosis of the subclavian artery were compared with 15 patients who underwent carotid-subclavian reconstruction. The incidence of procedural complications was similar. Although better early results were achieved in patients who underwent PTA (actuarial patency: PTA 91%, surgery 87%) after dilatation, the authors[18] observed a continuous deterioration of the hemodynamic status of the artery resulting from a high rate of late restenosis (actuarial patency: PTA 54%, surgery 87%). It should be noted that they excluded patients from their study with long stenoses (>4 cm) and those with complete occlusion of the subclavian artery, which can easily be corrected surgically.[19] The use of PTA for occlusive disease of the subclavian artery is increasing, but open surgical reconstruction remains an effective treatment option with good long-term results.[20,21]

Kretschmer et al.[9] found a statistically significant greater patency rate with transposition over bypass, and the universal experience in the small series of reported transpositions in the literature indicates that patency is almost always 100%.[9] In our study, most patients who underwent SCT enjoyed complete relief from their symptoms, and the primary patency rates at one, five, and 10 years in the SCT series were 100%, 100%, and 90%, respectively.

Limitations of this study were its retrospective design along with the lack of patient numbers; hence, further studies would be beneficial to verify our findings.

In conclusion, SCT is the safest and most efficient procedure, both in short and long-term patency. We conclude that it should be the treatment of choice for routine subclavian occlusive disease. As surgeons gain more experience and confidence with this approach, it will be practiced more universally.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. AbuRahma AF, Robinson PA, Jennings TG. Carotid-subclavian bypass grafting with polytetrafluoroethylene grafts for symptomatic subclavian artery stenosis or occlusion: a 20-year experience. J Vasc Surg 2000;32:411-8.
2. Takach TJ, Reul GJ Jr, Cooley DA, Livesay JJ, Duncan JM, Ott DA, et al. Concomitant occlusive disease of the coronary arteries and great vessels. Ann Thorac Surg 1998;65:79-84.
3. Courbier R, Jausseran JM, Poyen V. Current status of vascular grafting in supraaortic trunks. Personal experience. Int Surg 1988;73:210-2.
4. Maggisano R, Provan JL. Surgical management of chronic occlusive disease of the aortic arch vessels and vertebral arteries. Can Med Assoc J 1981;124:972-7.
5. Wylie EJ. Surgical treatment of extracranial cerebrovascular disease-introduction. World J Surg 1979;3:145-6.
6. Henry M, Amor M, Henry I, Ethevenot G, Tzvetanov K, Chati Z. Percutaneous transluminal angioplasty of the subclavian arteries. J Endovasc Surg 1999;6:33-41.
7. Selby JB Jr, Matsumoto AH, Tegtmeyer CJ, Hartwell GD, Tribble CG, Daniel TM, et al. Balloon angioplasty above the aortic arch: immediate and long-term results. AJR Am J Roentgenol 1993;160:631-5.
8. Vitti MJ, Thompson BW, Read RC, Gagne PJ, Barone GW, Barnes RW, et al. Carotid-subclavian bypass: a twenty-two-year experience. J Vasc Surg 1994;20:411-7.

9. Kretschmer G, Teleky B, Marosi L, Wagner O, Wunderlich M, Karnel F, et al. Obliterations of the proximal subclavian artery: to bypass or to anastomose? J Cardiovasc Surg (Torino) 1991;32:334-9.
10. Edwards WH Jr, Tapper SS, Edwards WH Sr, Mulherin JL Jr, Martin RS 3rd, Jenkins JM. Subclavian revascularization. A quarter century experience. Ann Surg 1994;219:673-7.
11. Salenius JP, Uurto I. Subclavian steal syndrome. Duodecim 2011;127:2148-54. [Abstract]
12. Salam TA, Lumsden AB, Smith RB 3rd. Subclavian artery revascularization: a decade of experience with extrathoracic bypass procedures. J Surg Res 1994;56:387-92.
13. Branchereau A, Magnan PE, Espinoza H, Bartoli JM. Subclavian artery stenosis: hemodynamic aspects and surgical outcome. J Cardiovasc Surg (Torino) 1991;32:604-12.
14. Mingoli A, Feldhaus RJ, Farina C, Schultz RD, Cavallaro A. Comparative results of carotid-subclavian bypass and axillo-axillary bypass in patients with symptomatic subclavian disease. Eur J Vasc Surg 1992;6:26-30.
15. AbuRahma AF, Robinson PA, Khan MZ, Khan JH, Boland JP. Brachiocephalic revascularization: a comparison between carotid-subclavian artery bypass and axilloaxillary artery bypass. Surgery 1992;112:84-91.
16. Lowell RC, Mills JL. Critical evaluation of axilloaxillary artery bypass for surgical management of symptomatic subclavian and innominate artery occlusive disease. Cardiovasc Surg 1993;1:530-5.
17. Hennerici M, Klemm C, Rautenberg W. The subclavian steal phenomenon: a common vascular disorder with rare neurologic deficits. Neurology 1988;38:669-73.
18. Farina C, Mingoli A, Schultz RD, Castrucci M, Feldhaus RJ, Rossi P, et al. Percutaneous transluminal angioplasty versus surgery for subclavian artery occlusive disease. Am J Surg 1989;158:511-4.
19. Khalil A, Nashef SA. An alternative surgical approach to subclavian and innominate stenosis: a case series. J Cardiothorac Surg 2010;5:73.
20. Al-Jundi W, Saleh A, Lawrence K, Choksy S. A case report of coronary-subclavian steal syndrome treated with carotid to axillary artery bypass. Case Report Med 2009;2009:687982.
21. Linni K, Ugurluoglu A, Mader N, Hitzl W, Magometschnigg H, Hölzenbein TJ. Endovascular management versus surgery for proximal subclavian artery lesions. Ann Vasc Surg 2008;22:769-75.