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Mid- and long-term outcomes of extra-anatomic bypass procedures

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ABSTRACT

Objectives: In this study, we report our mid- and long-term results of extra-anatomic bypass surgery.

Patients and methods: Between January 2005 and December 2011, a total of 65 patients (54 males, 11 females; mean age: 54.3±4.2 years; range, 20 to 82 years) with extra-anatomic bypass surgery with complete follow-up data were retrospectively analyzed. Extra-anatomic bypass surgery was performed to the lower extremity in 36 (55.3%) and the upper extremity in 29 (44.7%) patients. Additional distal bypass surgery was done in 18 of 36 patients with lower extremity disease.

Results: The median follow-up time was 3.6 years (range, 3 months to 6 years). There was no early mortality, while there were five reoperations due to graft thrombosis and two amputations due to insufficient arterial flow in the postoperative period. There were two reoperations due to graft thrombosis and graft infection as late morbidity. In the long-term, the mortality rate was 6% (n=4) related to the malignancy in two patients, pulmonary embolism in one patient, and aortoduodenal fistula in one patient.

Conclusion: An extra-anatomic bypass procedure is a surgical approach that can still be performed with low mortality and morbidity rates and acceptable patency rates in high-risk patients.

Keywords: Axillofemoral, extra-anatomic bypass, femorofemoral, subclavian-subclavian.

Although the first choice in the surgical treatment of peripheral arterial diseases is anatomical correction, the techniques of extra-anatomic arterial reconstruction, which reduce the risk of surgery and anesthesia in high-risk and elderly patients with comorbid factors, may reduce the risk of perioperative morbidity and mortality.[1] The first procedure of extra-anatomic bypass began in 1952, when Freeman and Leeds[2] freed the superficial femoral artery and anastomosed it subcutaneously to the contralateral femoral artery.

Providing long-term graft patency in these patients who have the chance of surgical operation is still the most important problem. Intimal hyperplasia is often determined by the formation of graft patency in the mid- and long-term. Currently, extra-anatomical bypass procedures are still successfully performed to improve the quality of life of patients. Long-term patency rates of extra-anatomical artery reconstruction with the use of externally supported grafts have encouraged surgeons to perform extra-anatomical bypass in elective cases, as well. In the present study, we aimed to investigate graft patency, morbidity, and mortality rates in the mid- and long-term follow-ups of patients who underwent extra-anatomical bypass in our clinic.

PATIENTS AND METHODS

This retrospective study was conducted at Haydarpasa Training Hospital, Department of Cardiovascular Surgery between January

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2005 and December 2011. A total of 65 patients (54 males, 11 females; mean age: 54.3±4.2 years; range, 20 to 82 years) with complete follow-up data who underwent extra-anatomic arterial reconstruction were included. Patients without follow-up results were excluded from the study. A written informed consent was obtained from each patient. The study protocol was approved by the Haydarpasa Numune Training and Research Hospital Ethics Committee (17.05.2021-145-3376). The study was conducted in accordance with the principles of the Declaration of Helsinki.

During the follow-up of the patients, heparin perfusion was routinely used for 6 h in the intensive care unit in the postoperative period. The patients treated with low-molecular-weight heparin (LMWH) for three days were discharged with dual antiaggregant therapy (clopidogrel 75 mg/day and acetylsalicylic acid 300 mg/day). Graft patency was routinely checked at one week, one month, six months, and biannually, thereafter. Data were obtained through clinical health records, hospital automation system, and telephone interviews. The three-month and six-year follow-up data were recorded. The patients were evaluated based on physical examination, arterial Doppler ultrasonography and peripheral arterial angiography, when necessary.

Surgical technique

The patients were operated under general anesthesia. Synthetic grafts were used in all patients, except for one in whom the saphenous vein was used during caroticosubclavian operation.

In patients who underwent femorofemoral bypass, the graft was passed through tunnel formed in the suprapubic area and anastomosed to the femoral arteries in an end-to-side fashion. A polytetrafluoroethylene (PTFE) graft was used in 18 patients and a Dacron® graft (DuPont, Wilmington, DE, USA) was used in four patients.

For axillofemoral bypass, the right axillary artery was accessed via an infraclavicular approach. After an 8-mm ringed PTFE graft was anastomosed to the axillary artery in an end-to-side fashion, it was extended from the subcutaneous distance to the inguinal area through a tunnel formed from the back of the pectoralis major muscle toward the distal part. In patients who underwent axillobifemoral bypass, the graft was jumped to the left femoral region by femorofemoral bypass.

After both subclavian arteries were explored by a supraclavicular incision for subclavian-subclavian bypass in five patients with type 3 aortic dissection, the graft was passed down through the tunnel created under the skin with anastomosis lines. The contralateral subclavian artery was preferred, as there was a carotid plaque on the same side. The Dacron® graft was used in all patients.

In patients with type 3 aortic dissection, caroticosubclavian bypass anastomoses were performed between the common carotid artery and the subclavian artery. The Dacron® graft was used in all patients, except for one patient in whom a saphenous vein was used.

Statistical analysis

Statistical analysis was performed using the Microsoft Excel software (version 2013; Microsoft Inc., Redmond, WA, USA). Continuous variables were expressed in mean ± standard deviation (SD) or median (min-max), while categorical variables were expressed in number and frequency.

RESULTS

Of the patients, 44 (67.6%) were smokers. Diabetes in 30.7% (n=20), hypertension in 56.9% (n=37),

Table 1. Demographic characteristics of patients and comorbid risk factors

	n	%
Sex		
Female	11	16.93
Male	54	87.07
Smoking	44	67.6
Diabetes mellitus	20	30.7
Hypertension	37	56.9
COPD	9	13.8
CKD	2	3.07
CAD	19	29.2

COPD: Chronic obstructive pulmonary disease; CKD: Chronic kidney disease; CAD: Coronary artery disease.

Table 2. Revascularization techniques

Extra-anatomic bypass method	Number of surgical procedures (n)
Caroticosubclavian	22
Subclavian-subclavian	5
Axillobifemoral	4
Axillounifemoral	1
Femorofemoral	27
Descending aortofemoral	4
Aorta-subclavian	2
Total	65

Table 3. Simultaneous interventions with extra-anatomic bypass

Extra-anatomic bypass	CABG	Unilateral femoropopliteal	Bilateral femoropopliteal	Endarterectomy	Stent
Femorofemoral	3	4	2	-	-
Axillobifemoral	-	1	-	-	-
Axillounifemoral	-	1	-	-	-
Caroticosubclavian	2	3	-	4	6
Descending aortofemoral	1	-	1	-	-
Total	6	9	3	4	6

CABG: Coronary artery bypass grafting.

Table 4. Mortality after extra-anatomic bypass

Extra-anatomic bypass	Age	Sex	Comorbid conditions
Femorofemoral	69	Male	Malignancy, coronary artery disease
Femorofemoral	74	Male	Malignancy
Femorofemoral	76	Male	Pulmonary embolism, coronary artery disease
Axillobifemoral	76	Male	Aortoenteric fistula, coronary artery disease

chronic obstructive pulmonary disease (COPD) in 13.8% (n=9), and coronary artery disease 29.2% (n=19) were the most common accompanying pathologies (Table 1). Revascularization was performed for the lower extremity in 36 (55.3%) and the upper extremity in 29 (44.7%) patients. The main symptoms of the cases in which we performed extra-anatomic bypass operation on the lower extremity were claudication at short distances (50 meters and below), pain at rest, and necrosis.

Axillobifemoral bypass was performed in four patients, axillounifemoral in one patient, femorofemoral in 27 patients, aorta-subclavian in two patients, caroticosubclavian in 22 patients, subclavian-subclavian in five patients, and descending aortic-femoral bypass in four patients (Table 2).

Additional surgical procedures were performed in addition to the extra-anatomic bypass in 28 patients. Nine patients underwent unilateral femoropopliteal, three patients underwent bilateral femoropopliteal, four patients underwent carotid endarterectomy, six patients underwent aortocoronary, five patients underwent thoracic aortic endovascular stent implantation, and one patient underwent abdominal aorta endovascular stent implantation (Table 3). Four patients were reoperated, and three of them were reoperated due to the graft occlusion. The other was a patient who underwent femorofemoral bypass, as the left iliac leg of the aortobifemoral graft was occluded. In this patient, the left leg of the old axillobifemoral bypass graft was excised due to infection. One of the cases was reoperated for graft occlusion and underwent endovascular aortic replacement (EVAR) for an abdominal aortic aneurysm and developed occlusion in one leg of the graft.

There was no mortality in the perioperative period. In the early postoperative period, five patients who

Figure 1. Control (at the postoperative fifth year) arterial phase computed tomography image showing the aortofemoral polytetrafluoroethylene graft (long arrow). Note the stenosis of the left femoropopliteal bypass graft (short arrow).

underwent femorofemoral bypass due to critical leg ischemia underwent revision due to thrombosis, and thrombectomy was performed in four, and anastomosis was renewed in one patient. In addition, amputation was performed in one of the patients with femorofemoral bypass and axillofemoral bypass due to distal extremity flow insufficiency in the early postoperative period. The patients were discharged on the second day at the earliest, the 16th day at the latest, and the fourth day on average after the operation.

During the long-term follow-up, graft thrombosis developed in two patients who underwent femorofemoral bypass, and graft infection developed in one patient who underwent right femoro left popliteal bypass. This patient died two years later due to aortoduodenal fistula. In addition, late mortality developed in one patient due to pulmonary embolism and two patients due to malignancy, four patients (6%) in total (Table 4). In a patient who underwent femoropopliteal bypass operation after aortofemoral bypass, reoperation was performed at the postoperative fifth year due to femoropopliteal graft occlusion, despite a patent aortofemoral bypass graft (Figure 1).

DISCUSSION

Anatomical correction is the first choice in peripheral arterial diseases. The extra-anatomic bypass method is usually performed according to the patient's overall condition and the surgeon's preference. Axillofemoral bypass is preferred in cases where aortofemoral bypass is relatively contraindicated, multiple previous abdominal surgeries, radiation, stoma, advanced age, heart or lung disease.[1,2] Duration of surgery is shorter in extra-anatomic bypass. Accordingly, the duration of anesthesia and complications related to anesthesia are lower. Therefore, extra-anatomic bypass can be used safely in high-risk patients, particularly in those with lung disease. Significant postoperative complications (lung failure, renal failure, stroke) are more common in patients undergoing aortofemoral surgery.[3,4]

A transthoracic approach is required for anatomical correction in subclavian artery stenosis. The mortality rate in the transthoracic approach was found to be 14.7%.[5] However, when the extra-anatomic technique is used in these patients, the rate of graft patency yields similar results. Perioperative mortality is very rare, and the morbidity rate is 6%.[6] Since there is no significant difference in the patency between anatomic correction and extra-anatomic bypass in subclavian artery surgery, the extra-anatomic bypass has become the first choice currently owing to the shorter operation time and lower perioperative mortality and morbidity rates. Caroticosubclavian, subclavian-subclavian, and axilloaxillary bypass are the preferred methods in subclavian stenosis. If carotid artery stenosis on the same side is present, the contralateral carotid artery can be used as the inflow. In our series, three of five patients who underwent subclavian-subclavian bypass had ipsilateral carotid stenosis. Two patients had a previous history of radiotherapy to the neck area.

To avoid the risks of a prosthetic graft, subclavian carotid transposition with an autogenous graft can be performed. In case of transposition, the risk of distal embolism is excluded, as the occluded part is transected from the arterial circulation. This method can be used safely in subclavian stenosis due to its long-term patency and low morbidity.[7] With the widespread use of interventional techniques, atherectomy, percutaneous balloon angioplasty, and stent placement in case of critical ischemia began to be discussed. The five-year patency of subclavian-subclavian bypass is 97%, while the four-year patency of subclavian angioplasty is 82%. Only balloon dilation can be performed for the subclavian artery lesions. In case of stent placement, there is a risk of compression and fracture of the stent with the movement of the arm.[8]

Currently, anatomic correction is the first choice in lower extremity operations. Cross-over femorofemoral bypass is performed in unilateral iliac artery occlusion with a high surgical risk.[9,10] The five-year patency for the femorofemoral bypass is 78%. While the 10-year extremity salvage rate is 91% in femorofemoral bypass, this rate is 95% in endarterectomy and 97% in anatomic bypass. The fact that the 10-year survival rate is less in patients undergoing extra-anatomic bypass indicates that this method is preferred in patients at risk.[11] The low primary patency and extremity salvage rates in patients undergoing extra-anatomic bypass indicate that this surgery is preferred in patients with comorbid factors. Since the distal vascular bed is problematic in critical ischemia cases, graft occlusion is more common, resulting in a relatively low rate of graft patency.[10,11]

The use of autogenous grafts is not preferred in femorofemoral bypass surgery. The ringed prosthetic graft is frequently used. The five- and eight-year survival of the saphenous vein graft (34.3% *vs.* 22.8%, respectively) is lower than that of PTFE

(77.3% *vs.* 50.3%, respectively).[9] As an autogenous graft, the external iliac artery can be dissected from the proximal segment and used as a graft.[12] Critical ischemia was present in 44% of the patients who underwent femorofemoral bypass operation. When we compared the patients with concomitant risk factors and claudication complaints and a good distal vascular bed to those who underwent bypass due to critical ischemia, the patency of the graft was found to be significantly different in the bypass performed due to claudication. Early graft occlusion developed in one and late graft occlusion in one of the patients we operated on for claudication, and patency was found to be 86%. In cases we operated for critical ischemia, the patency rate was found to be 47%.

Axillofemoral bypass, which is another method, may be preferred in cases where the flow on the opposite side of the leg with the lesion is not sufficient as inflow or in bilateral iliac artery lesions. The initial results achieved with axillofemoral bypass were not promising, and its indication was limited to patients with critical ischemia (rest pain, ulcer, and necrosis). However, the results obtained with the introduction of externally supported grafts encourage surgeons for axillofemoral operation. In recent studies, the one-year patency rate is 86% and the five-year patency rate is 58 to 74%. In aortofemoral operations, the five-year patency is 80%.[3,11,13] In a study comparing externally supported and unsupported grafts, the five- and 10-year primary and secondary patency rates in externally supported grafts were 80.1% and 69.6%, respectively, while these rates were 61.1% and 21.1% in unsupported grafts.[13] Although 58% of aortofemorals and 20% of axillofemorals had claudication, there was no significant difference in operative mortality, extremity salvage, and patency rates. The five-year survival was found to be 45% in the axillofemoral and 72% in the aortofemoral procedures.[3] Axillofemoral procedure is performed in patients with a higher risk and mostly critical ischemia and compared to the results of anatomical correction performed in more elective cases. In more homogeneous studies, the patency ratio between the two groups may give more accurate results.

In conclusion, in most studies, the extra-anatomic bypass is compared with elective anatomic approaches in patients with critical ischemia with comorbid factors. However, considering the low amputation rate in patients with critical ischemia and the low perioperative mortality and morbidity rate in high-risk patients, we believe that extra-anatomic bypass techniques can be safely practiced in both lower and upper extremity lesions.

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