Role of Crossover Bypasses in the Treatment of Ischemia of the Lower Extremity
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Aim. To evaluate the role of crossover bypasses in the treatment of the lower extremity ischemia.

Methods. A retrospective study (1978-1997) included 51 patients with 52 femoro- or iliofemoral crossover bypasses. The most frequent indication for crossover bypass was unilateral thrombotic occlusion of the bifurcated graft or unilateral pelvic occlusion (49.0%) and the rest pain (40.4%). The main type of crossover reconstruction was "U" shaped, subcutaneous femorofemoral bypass. The first, third, and fifth year primary patency rates were evaluated using the life table analysis method.

Results. The cumulative patency rates were 91.3%, 73.9%, and 54.5% at 1, 3, and 5 years, respectively. Limb amputation had to be performed in five (9.6%) failed reconstructions. In four (7.7%) cases, thrombosis of reconstruction, and in one (1.9%) case, graft infection, caused the bypass occlusion. One patient (1.9%) died within 30 days after surgery from an acute myocardial attack.

Conclusion. Crossover bypass is an attractive method because of its technical simplicity, low morbidity, and good long-term results.

Key words: aneurysm; bypass; ischemia; leg; thrombosis; vascular patency; vascular surgical procedures

There are several possibilities for the treatment of unilateral iliac artery or bypass occlusion. Vascular surgeon can decide to carry out unilateral or bilateral iliac reconstruction, percutaneous transluminal angioplasty that could be supplemented by a stent implantation, an endoluminal implantation of vascular prosthesis, an axillofemoral reconstruction, or a crossover bypass. The choice of performing one or another reconstruction is not entirely free. Each of them has its own strictly defined criteria. This is also true for an extra-anatomic crossover bypass. With this respect, we evaluated the role of crossover bypasses in the arterial reconstructive surgery for lower extremity ischemia in a twenty-year retrospective study.

Patients and Methods
A total of 51 patients were operated on at the Department of Surgery, University Hospital in Plzeň, between January 1, 1978, and December 1, 1997. Fifty-two extra-anatomic crossover type reconstructions were performed in those patients. There were 38 men and 13 women, with the average age of 53.3 years (range 45-80 years). Forty-four femorofemoral reconstructions, six iliofemoral, and two femoropopliteal crossover reconstructions were performed. A thrombotic occlusion of a pelvic arterial reconstruction (in most cases, this involved one branch of a bifurcation bypass) was the reason for performing crossover reconstructions in 25 cases. In 22 cases, the reason for reconstruction was an unilateral thrombosis of the iliac artery, in two other cases ligature of the iliac arteries associated with an aneurysm, and in two further cases it was an injury to the iliac artery during gynecological or urological surgery, respectively. Sixteen patients (30.8%) suffered from claudications (<100 m), 21 patients (40.4%) had rest pain, and 15 patients (28.8%) had a trophic defect on the limb periphery (Table 1). Seventeen patients (32.7%) had a serious cardiac pathology, 9 patients (17.3%) had undergone repeated laparotomies for other reasons, 3 patients (5.8%) had suffered a cerebral vascular attack, and 3 (5.8%) had received treatment for a carcinoma. Nine patients (17.3%) suffered from other serious diseases (end-stage renal disease, respiratory insufficiency, hepatopathy). In the remaining 11 patients, we chose this type of reconstruction after a complete assessment of the clinical, prognostic, and angiographic features (Table 2).

All patients had indications for vascular reconstruction after an examination at our vascular outpatient clinic, and in accordance with their clinical and angiographic findings. Percutaneous transluminal angioplasty of a stenosis of the donor side iliac artery was performed in six patients (11.5%) before performing the reconstruction. In three cases, percutaneous transluminal angioplasty was supplemented by a stent implantation. Thirty-six patients (69.2%) had clinically and angiographically confirmed femoropopliteal occlusion on the recipient side. None of the patients had claudications or rest pain of the limb on the donor side, although 28 patients (53.8%) had an angiographically
confirmed femoropopliteal occlusion bridged with a strong collateral system on the donor side. Most frequently, we chose a subcutaneous bypass in the shape of an inverted letter U during femorofemoral reconstruction procedure, and in iliofemoral reconstructions we selected an S-shape type. A crimped, collagen-coated 7-8 mm graft of Czech production (Výzkumný Ústav Pletaøský, Brno, The Czech Republic) was used almost exclusively. Long-term results were statistically evaluated using the life table analysis method.

Table 1: Diagnosis and symptomatology in 52 patients treated with crossover bypass of lower extremity arteries. [view this table]
Table 2: Accompanying diagnosis in 52 patients treated with crossover bypass of lower extremity arteries. [view this table]
Table 3: Results of the treatment of lower extremity ischemia by crossover bypass in 51 patients (52 bypasses) [view this table]

Results
One, three, and five year cumulative primary patency rate of the crossover reconstruction was 91.3%, 73.9%, and 54.5%, respectively (Table 3). A high-level amputation had to be performed in 5 failed reconstructions (9.6%). In 4 cases (7.7%), thrombosis of reconstruction and in 1 case (1.9%), graft infection were the causes of the bypass occlusion. One patient (1.9%) died of an acute myocardial attack within 30 days after surgery.

Discussion
Almost half a century ago, Oudot and Beaconsfield (1) were the first to use an arterial allograft for iliofemoral crossover reconstruction in order to save a second limb affected by a serious ischemia. In 1952, Freeman and Leeds (2) successfully used an endarteromized superficial femoral artery for revascularization of the second limb affected by ischemia. Artificial material (Dacron) was used for the first time by Mc Caughan and Kahn (3) in 1958 for performing an iliofemoral crossover reconstruction. In 1962, Vetto (4) described for the first time the use of femorofemoral crossover bypass for the treatment of unilateral iliac artery occlusion.

Femorofemoral and iliofemoral crossover reconstructions quickly gained many supporters because of their technical simplicity. Although the first wave of enthusiasm was overshadowed by a temporary freeze, mostly on account of deteriorating long-term results, we have recently witnessed an increase in this procedure in peripheral vascular surgery (5-7). The reason for such an increase is predominantly in the achievement of greater precision in the criteria of indication, leading to an improvement in long-term results comparable with unilateral iliac reconstructions (8-10). Technical simplicity and minimal surgical burden on the patient are undoubted advantages of crossover reconstructions. For these reasons, they are indicated particularly in cases where the risk of an intraabdominal approach for pelvic arterial reconstruction is high. This concerns mostly the patients with a low cardiac reserve, serious broncho- pulmonal obstructive disease, and patients with renal insufficiency or those who have suffered from cerebral vascular attack with permanent neurological consequences. Another indication for this type of reconstruction is represented by patients who have undergone repeated laparotomies for other reasons, or who have had radiation treatment of the pelvis for gynecological reasons, where there is a presumption of extensive intra-abdominal adhesions. In addition, crossover reconstruction is indicated in elderly patients with a wide range of associated internal diseases. In such cases, a very short period of confinement in bed with the possibility of immediate active rehabilitation is very important. In patients with colostomy or jejunostomy, this type of extra-anatomic reconstruction is also more advantageous than the intraabdominal or retroperitoneal approach from the point of view of a possible graft infection (11,12). Moreover, in patients with a generally poor condition and with a limb threatened by ischemia, where surgery under general anesthesia would be hazardous, this type of reconstruction can be performed under local anesthesia. Apart from the above-mentioned indications, femorofemoral reconstruction can be used in cases of occlusion of a branch of aortofemoral graft (13), where the occlusion is caused by neointimal proliferation in the distal bypass anastomosis. The free branch of the bifurcated graft represents the inflow tract (donor side), and the femorofemoral reconstruction is supplemented with a profundo- plasty at the place of the occlusion. In cases of unfavorable conditions in the outflow tract in the inguinal area, and if the superficial femoral artery is occluded, a crossover femoropopliteal bypass can be used, particularly in patients suffering from critical limb ischemia.

Long-term results of femorofemoral and ilio- femoral crossover bypasses are encouraging. The advantages of these reconstructions may be characterized by uncomplicated postoperative course, short hospitalization of the patients, and a quick return to everyday life, as well as considerable
financial savings.

With the rapid development of endovascular treatment of abdominal aortic aneurysms, many authors (14,15) favor unilateral stent implantation, and occlusion of the contralateral iliac artery followed by femorofemoral crossover reconstruction, all carried out in a single procedure.

Performing a femorofemoral reconstruction is particularly beneficial for men from the point of view of their sexual function. The preparation of the area of the aorta and iliac arteries can be avoided, where the preaortal sympathetic plexus could be damaged, resulting in post-operative sexual dysfunctions. The disadvantage of subcutaneous femoro-femoral crossover reconstruction in the inguinal area is the danger of graft infection. We believe, however, that the risk of such an infection in this localization is the same as in other types of reconstruction with inguinal anastomosis. We had only one (1.9%) infectious complication of the graft. The steal phenomenon, in which ischemia of the donor side occurs, is in fact not a disadvantage of crossover reconstructions but a consequence of an incorrect indication for the reconstruction procedure.

Correct indication is therefore of crucial significance for the immediate and long-term patency of these reconstructions (16-18). Only in the patients for whom the pelvic reconstruction is dangerous for various reasons (see above), and who suffer from trophic defects on the limb periphery, rest pain, or who are limited by short claudications (Fontain IV, III, and IIb) is the crossover reconstruction indicated. We adopted the following procedure: clinical examination, measurement of the patient’s malleolar pressure, and angio-raphy or computer angiography. Non-invasive color flow dopplerometry has recently become more widely used. Its advantage, apart from giving a good morphological picture, is the possibility of assessment of the flow parameters of the “donor” side. The actual condition of the donor artery is the basic premise for carrying out the crossover reconstruction. The donor side arteries must have a normal pulse without rough murmur. Graphic examinations must not show stenosis of the donor artery greater than 50% of the artery or graft lumen. Similarly, the outflow tract of the donor side should ideally be free from occlusions, or without significant stenosis (greater than 50%). This condition is, however, only relative. In our experience, the reconstruction was possible without endangering the donor side with the steal phenomenon even in femoropopliteal occlusion of the donor side (particularly in pelvic reconstruction), which was compensated for by substantial collateral circulation. Some authors (19) also report that, as a result of this type of reconstruction, the flow on the donor side subsequently increases, which in due course limits or arrests the progression of atherosclerotic changes.

Stenosis, or a short occlusion in the donor artery on the basis of atherosclerosis, can be overcome by percutaneous transluminal angioplasty with or without a stent application in a single procedure together with crossover reconstruction, or in two sessions in a quick succession. Endovascular implantation of a vascular prosthesis into the diffusely stenosed iliac artery of the donor side, followed by femorofemoral reconstruction, also seems to be very promising. This procedure places very little burden on the patient. There are, however, certain limitations to its wider use due to the high cost of endoluminal vascular prostheses.

Success of the reconstruction will also depend on the condition of the recipient artery. We evaluate its outflow tract which usually needs to be supplemented with a profundoplasty, sequential venous graft profundal bypass or femoro-popliteal reconstruction.

The technique of crossover reconstruction is simple. We prefer a femorofemoral reconstruction conducted above the symphysis through a subcutaneous tunnel. Vascular prostheses, externally supported by a coil, are particularly useful. Some surgeons prefer placing the vascular prosthesis behind the musculus rectus abdominis in order to reduce the probability of graft infection. Prevention of infection is another possible reason for an iliofemoral crossover bypass which is conducted through the retroperitoneal space. However, since we have had a very low rate of infection complications in simple femorofemoral reconstruction, we do not find justification for a more frequent use of iliofemoral crossover reconstructions.

Long-term results of crossover reconstructions are very good and comparable to unilateral iliac reconstruction. The cumulative primary patency rate of crossover reconstructions in our group of patients was 91.3%, 73.9%, and 54.5% at the first, third, and fifth year after reconstruction, respectively, which is also a good result.

Crossover arterial reconstructions have an established position in the reconstruction surgery of the lower extremity ischemia. Owing to their simplicity, minimal surgical demands on the patient, low morbidity, and good long-term results, they have become a method of the first choice in many cases.

References
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