Crural Bypass Surgery in Case of Critical Ischemia: Technical Aspects and Results

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ABSTRACT

Background

Crural bypass surgery is one of the last options to salvage the leg. Compared to arterial reconstructions of more proximal localization patency rates are generally less good. The aim of this retrospective study was to answer the question if crural bypass surgery is justified. For that we focused on different technicalities, bypass material, recipient vessel and anticoagulation regimes.

Objective

To know outcome of crural bypass in terms of patency rates, survival rates, amputation. The difference in outcome is compared in different stages of peripheral arterial disease and various bypass materials and sites.

Method

Between 07/2013 and 06/2018 we performed 102 crural bypasses (27 female, 75 male; age 44-90 (70) years). Reasons for the bypasses were a critical peripheral arterial diseases (PAD) (stage III [pain at rest] and IV [necrosis/gangrene] according to Fontaine). End point of the study was major amputation or death. All patients were operated on in the same department by two experienced vascular surgeons.

Result

Amputation-free time was 78% after sixmonths and 70% after 24 and 60 months. Six, 12 and 40 months survival was 83%, 78% and 59%, respectively. Patency rates were affected by the severity of the disease (stage III vs. stage IV) and so was major amputation. Autologous bypasses were not associated with a better patency rate. Minor amputation or the anticoagulation scheme did not influence the long term results.

Conclusion

The long term survival after crural bypass is good and amputation rates are low, independent of the vessel of the lower leg used as recipient outflow. Accordingly, if a bypass is technically feasible, there is no limitation regarding the choice of the recipient vessel. If possible, autologous vein should be used, but a graft prosthesis can lead to equally good results. As patients with stage III PAD have better outcomes, early intervention is recommended in order to avoid deterioration to stage IV.

KEY WORDS

Anticoagulation, Crural bypass, Limb salvage, Recipient vessel

INTRODUCTION

Crural bypass surgery (distal anastomosis below the popliteal segment) is necessary in case of critical ischemia due to long segment obstruction including the popliteal artery. Accordingly usually it is one of the last options to salvage the leg. Compared to arterial reconstructions of more proximal localization patency rates are generally less good.[1,2] This is because of technical aspects (small outflow vessels, short outflow distance, length of the bypass, smaller caliber of the bypass) as well as for patient related reasons (high age, comorbidities, critical ischemia with permanent pain). As first choice autologous bypasses (mainly greater saphenuous vein) are propagated, but in cases without useable vein graft prosthesises have to be used instead with different outcomes.[1-6] Due to accompanying diseases 30 days mortality has been reported to be 3-5%.[1,4,7] Apart from that, costs for operation and a long hospital stay can become overwhelming in some world`s regions. In summary, ever since crural bypasses have been operated there has been the problem of not knowing beforehand which patient gains profit of such an operation and who does not.

In our department of vascular surgery, between 2013 and 2017 we have performed 102 crural bypasses. The aim of this retrospective study was to answer the question if crural bypass surgery is justified in terms of input (potential perioperative risk, long hospital stay, uncertain long term results) and profit for the patient (major amputation-free survival). Ascrural bypass surgery very much depends on differenttechnicalities, we focused on aspects: bypass material, recipient vessel and the widely discussed topic of anticoagulation regimes.

METHODS

This is a retrospective study of patients who underwent crural bypass surgery in the department of vascular surgery of the Carl-von-Basedow Hospital Merseburg, Germany. All operations were done by two different surgeons, each being highly skilled in bypass surgery. Reason for the bypasses were a critical peripheral arterial disease (PAD) (stage III [pain at rest] and IV [necrosis/gangrene] according to Fontaine) in 95 cases (two cases: symptomatic popliteal aneurysm; three cases: PAD stage II with very short walking distance). Every patient had been discussed in our interdisciplinary vascular board beforehand; whenever possible we perform interventional therapy first.

As imaging we either use CT scan, MRI or regular angiography. As bypass material we always try to go for autologous material first but we also use graft bypasses (Dacron thin wall (Vascutek®) or PTFE distaflo® (Bard®)) if there are no veins (insufficient caliber, veins otherwise used, alterations such as varicose veins etc.). Technically, for the anastomoses we generally create end-to-side reconstructions using running sutures (Prolene 6.0). Intraoperative angiography is performed to check the distal anastomosis/outflow vessel. Before cross-clamping the arteries, 50 iU Heparin/kg body weight are administered intravenously. Postoperatively a continuous anticoagulation with heparin is started (clotting time 60-80 sec). In the long term, we put the patients on Antiplatelets (Aspirin or Clopidogrel) or/and coumarins.

According to the anatomical situation (remaining main vessel of the lower leg as recipient vessel):

1. Anterior tibial artery (fig. 1)

Recipient vessel is the proximal/mid-part of the anterior tibial artery. Main steps are the incision of the fascia to get into the anterior compartment; afterwards the anterior muscle has to be divided. At the dorsal aspect we find the artery, accompanied by venous vessels which have to be divided to isolate the artery. The course of the bypass is, different from the other bypasses, along the lateral aspect of the thigh.

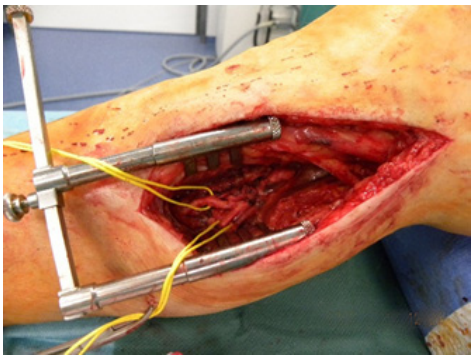

Figure 1. Exposure of the tibiofibular trunc, fibular artery, proximal posterior artery

2. Tibiofibular trunc (fig. 2)

Recipient vessel is the short part of the tibiofibular trunc. This is the most demanding vessel to be dissected. Incision line is the medial region of the lower leg. The compartments need to be divided and the gastrocnemic muscle has to be dissected from the tibial bone. The crossrunning veins have to be ligated separately and meticuously, otherwise severe bleeding might occur. The course of the bypass is anatomically in the deep compartment.

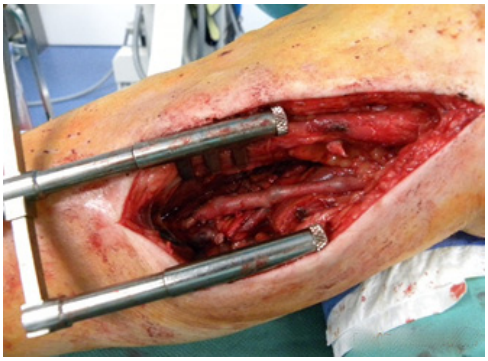

Figure 2. Bypass to the fibular artery

3. Posterior tibial artery (fig. 3)

The posterior artery can be used as a recipient vessel in its whole length but usually the distal half is used for anastomosis. At this location the artery lies more superficial compared to the fibular artery and the tibiofibular trunc such being easier to find and dissect.

Figure 3. **Bypass to the distal tibial posterior artery**

4. Fibular artery (fig. 4)

The fibular artery can only be used along the proximal part (from the tibiofibular trunc downwards over estimated 5 centimeters (individual differences) as from there on it runs behind the fibular bone with reduced caliber. The fibular artery does not reach the foot-region eventually divides into collaterals from the posterior and anterior arteries. Still it can be sufficient as a recipient vessel. The course of the bypass is anatomically.

Figure 4. **Bypass to the anterior artery**

5. Pedal arteries (fig. 5)

Very rarely the recipient vessel is as distal as the joint-region (tibial posterior- or tibial anterior-dorsalis pedis). Preparation of these arteries is usually not very complicated as they are located superficially, but the length of the bypass distance as well as the short run-off (only foot-vessels) can be hampering the results.

Statistical calculations were done with Excell and SPSS for windows including Kaplan Meier survival calculations and Chi-square-testings. Statistical significance was defined at a p-level <0.05.

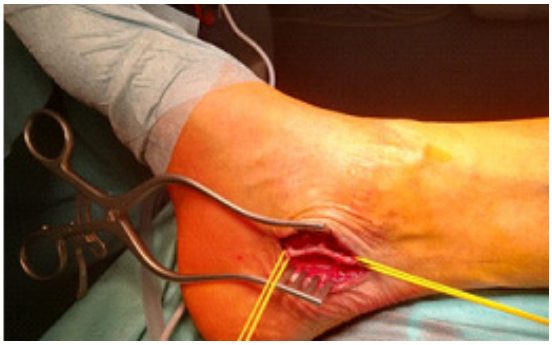

Figure 5. **Bypass to the distal tibial posterior artery**

RESULTS

Between 07/2013 and 06/2018 we performed 102 crural bypasses (27 female, 75 male; age 44-90 (70) years). Overall primary patency was 60% (6 months) and 50% after 22 months. Amputation-free timewas 75% after 22 months and 65% after five years. Eighty two patients had stage IV-PAD; in 36 cases minor amputation had to be performed after bypass implantation. Perioperative mortality was 7.8% (8/102); 6, 12 and 40 months survival were 83%, 78% and 59%, respectively. There were no statistical differences between men and women.

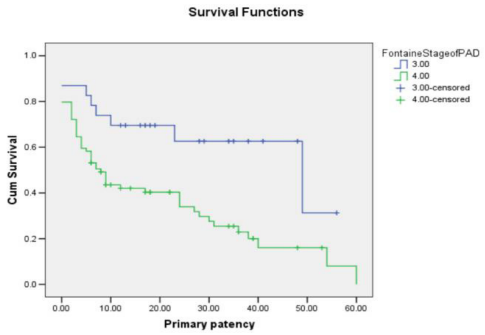

Figure 6. **Primary patency rates and stage of PAD (p< .01)**

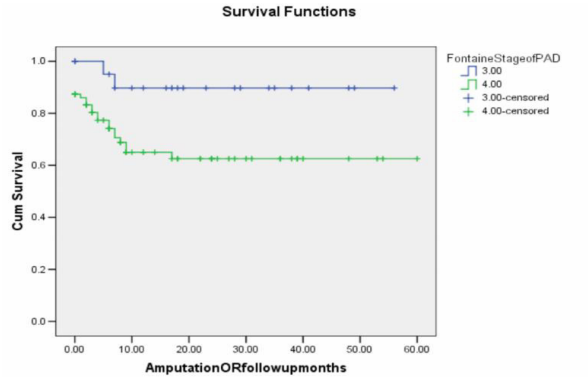

Figure 7. **Major amputation and stage of PAD (p< .05)**

Patency rates were affected by the severity of the disease (stage III vs. stage IV) (fig. 6) and so was major amputation (fig. 7). Autologous bypasses were not associated with a better patency rate; only composite bypasses (spliced graft and vein) were significantly worse in terms of patency rates and amputation compared to pure autologous or graft bypasses. There was no difference between the different grafts (thin wall knitted polyester versus

polytetrafluorethylene [PTFE]) (fig. 8). Minor amputation or the anticoagulation scheme did not influence the long term results, either. The mentioned results are summarized in table 1.

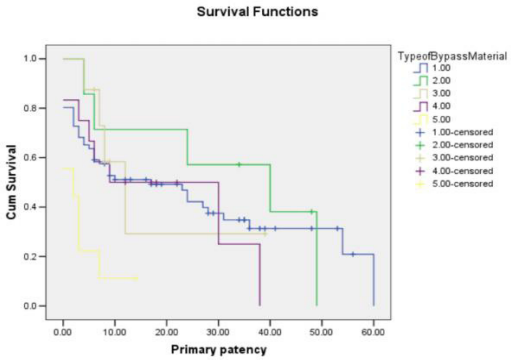

Figure 8. Primary patency and different bypass material (p= .02)

Table 1. Primary patency, major amputation, death correlated with different factors

	Primary patency (months)	Major amputation	Death
Sex	n.s.	n.s.	n.s.
PAD-stage III vs. IV	P< .01	P< .05	n.s.
Recipient vessel*	n.s.	n.s.	p=0.08
Bypass material*	0.02	<0.05	n.s.
Minor amputation**	n.s.	n.s.	n.s.
Anticoagulation***	n.s.	n.s.	n.s.

n.s.= not significant
PAD: Peripheral arterial disease
p-value significant when < .05
* see methods
** Patients who had PAD stage IV who needed minor amputation during the same hospital stay
***Aspirin alone/Warfarin alone/Aspirin+Warfarin/ Aspirin+Clopidogrel/others

DISCUSSION

Crural bypass surgery is a technically demanding surgical intervention and therefore should be applied only in cases of critical ischemia. Crural bypass surgery is among the last options to salvage the limb.[1,8,9] Therefore, besides a very reduced general health state or total immobility, basically no contraindications exist, even though these patients are multimorbid in most of the cases.[10] Still one has to keep in mind that the mortality (due to accompanying diseases such as coronary- and brain-sclerosis) of patients with critical ischemia is 15-20% per year.[7,11] Also, patency rates of the bypass reconstruction are expected to be limited especially in the long term, but results differ very much according to bypass length, bypass material and anticoagulation regime.[1-9] Aim of every surgical intervention should be an amputation free survival as patients who survive the acute episode of acute ischemia will follow the same pattern of mortality as the claudicant.[11]

Many factors influencing bypass function have been discussed during the last decades – bypass material, technical aspects regarding the anastomoses, anticoagulation patterns, vein caliber in case of autologous bypasses, inflow- and outflow issues and others. In this study we concentrated on outcomes of bypass surgery, thus lighting up bypass function, amputation rate and death.

Recipient vessel

It seems comprehensible that a very long outflow vessel such as the anterior artery which at the same time has a direct flow to the foot (dorsalis pedis) should have best preconditions for good results compared to the fibular artery, which usually is short, small in caliber and ending up in collaterals only. On the other hand, the course of an anterior bypass is extraanatomically, whereas the fibular bypass is placed anatomically. The exposure of the tibiofibular trunc as well as the fibular artery, however, is more demanding and more prone to technical failures than the anterior tibial artery. In this respect the posterior artery seems to be best as recipient vessel (direct flow to the food, easier to dissect than the fibular artery, long vessel). Interestingly, according to our results, there is no difference between the different recipient vessels neither in terms of amputations rates nor in amputation free survival. Even though overall survival times were rather good (80% after 20 months) there only seemed to be a trend towards significance for as shorter survival time in patients with fibular bypasses. As there are no other reports on this question, we can only assume that patients whose main arteries (tibial anterior and –posterior) are occluded must have a more severe general arteriosclerosis resulting in reduced survival time. But overall and compared with other reports we see only little differences in survival in the different types of recipient vessels. In the same way, primary patency rates were not significantly different from each other despite the mentioned technical and anatomical aspects. So we must assume that, taking correct surgical technique as a precondition, these differences between the three arteries seem not to play a role for the bypass-function. Our data assume that technically every vessel (fibular, anterior, posterior) can be used as recipient vessel with good results.

Bypass material

It has been stated that autologous bypasses are best in terms of patency rates.[1,2,5,9,10,12] However, according to our data we cannot support this result in full. Our patient numbers are limited, but as all patients are operated in the same institution by the same two surgeons with the same technique (different from multi-center studies), there is good comparison. According to our results the special grafts we used (precuffed PTFE, thin wall Dacron) were similar with venous bypasses. In the same way, good results were found by several authorsfor PTFE-grafts.[3,6,8] We did not find reports on below-knee-bypasses using Dacron grafts. Accordingly it is difficult to compare our results. However, composite-bypasses had significantly worse outcomes in our series. As main reason we can only assume that caliber

mismatches of spliced bypasses (graft plus vein) influence the blood flow and henceforth the patency rates. In summary we propose the venous first-technique, but graft bypasses can lead to good results, also.

Amputation rates; PAD stage III versus IV

Ourlong term amputation free survival was comparable to other reports.[1-8] The fact that patency rates are usually not as good, clearly shows that if a bypass has a function which leads to wound healing, the long term result can be good even in case of later bypass failure.

We found a significant difference in primary patency as well as major-amputation rate between PAD stage III and IV-patients. This seems comprehensible as critical ischemia with tissue loss (necrosis, gangrene) is at higher risk for amputation. But interestingly, this does not mean that those stage IV patients who needed minor amputation simultaneously, had worse long term results than those patients without. So it seems that lesions of the limb, no matter how severe they are, generally represent a worse health state with higher failure rates of revascularization. But at the same time the need for minor amputation does not necessarily go along with further amputation. There was no "slice by slice" phenomena to be seen. So according to our results patients gain profit of a revascularization even if minor amputation is necessary.

The survival, however, was not significantly different between the two groups (PAD stage III/IV) but there was a trend towards significance. Maybe in a larger collective the result would be significantly different.Interestingly, there are no other reports on these findings.

Anticoagulation

There are very few randomized trials investigating the outcomes of different anticoagulation regimes following bypass surgery. According to the BOA-study warfarin has better results in terms of patency in infragenual vein bypasses compared to Aspirin. As other authors do, we use different combinations but did not find significant differences neither in terms of patency rates nor in bleeding complications.[3] However, there is no general consent about the optimal anticoagulation regime. Generally we prefer coumarins in below-knee bypasses; in most of the cases where patients already received aspirin, we simply added the coumarins. Currently, there are studies under way testing the efficacy of the new oral anticoagulants. This might influence further treatement of patients with crural bypasses.

CONCLUSION

Even though crural bypass surgery is technically demanding and even though we have limited primary patency rates, our results show that the long term survival is good and amputation rates are low. As the prevention of a major amputation is the main goal of any treatment of patients with critical PAD, a crural bypass-operation is justified if the patient is mobile so that he can gain profit from limb-salvage. Even though the three potential recipient vessels are different in size, length and anatomical position, the results are equally good. Accordingly, if a bypass is technically feasible, there is no limitation regarding the choice of the recipient vessel. If possible, autologous vein should be used, but a graft prosthesis can lead to equally good results. As patients with stage III PAD have better outcomes than patients with stage IV, we recommend not to wait until there is tissue loss but to perform the revascularization in an earlier stage.

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