UNIVERSITE DE LAUSANNE – FACULTE DE BIOLOGIE ET DE MEDECINE
Département des services de chirurgie et d'anesthésiologie
Service de chirurgie thoracique et vasculaire

Infrainguinal Bypass for Peripheral Arterial Occlusive Disease : When arms Save Legs

THESE

préparée sous la direction du Professeur Corpataux Jean-Marc
(avec la collaboration du Docteur Saucy François)
et présentée à la Faculté de Biologie et de Médecine de
l'Université de Lausanne pour l'obtention du grade de

DOCTEUR EN MEDECINE

par

Frédéric VAUCLAIR

Médecin diplômé de la Confédération Suisse
Originaire de Bonfol (Jura)

Lausanne

2011

UNIL | Université de Lausanne
Faculté de biologie
et de médecine

Ecole Doctorale
Doctorat en médecine

Imprimatur

Vu le rapport présenté par le jury d'examen, composé de

Directeur de thèse	*Monsieur le Professeur Jean-Marc Corpataux*
Co-Directeur de thèse	
Expert	*Madame le Professeur Lucia Mazzolai*
Directrice de l'Ecole doctorale	*Madame le Professeur Stephanie Clarke*

la Commission MD de l'Ecole doctorale autorise l'impression de la thèse de

Monsieur Frédéric Vauclair

intitulée

Infrainguinal Bypass for Peripheral Arterial Occlusive Disease: When arms Save Legs

Lausanne, le 9 février 2012

pour Le Doyen
de la Faculté de Biologie et de Médecine

Madame le Professeur Stephanie Clarke
Directrice de l'Ecole doctorale

Pontages infra-inguinaux dans les artériopathies occlusives périphériques : Quand les bras viennent au secours des jambes.

Les progrès de la médecine ont permis d'améliorer aussi bien la qualité que l'espérance de vie. A ce jour, ceux-ci n'ont malheureusement pas révolutionné la chirurgie vasculaire périphérique. En effet, malgré l'apport de la bio-ingénieurie, les veines restent plus performantes en termes de longévité que les conduits synthétiques dans les interventions de revascularisation réalisées dans le contexte d'une ischémie chronique. Malheureusement, le nombre de veines couramment utilisées et reconnu comme premier choix (veine saphène) et limité.

L'étude rétrospective réalisée avait pour but de démontrer que les veines des membres supérieurs constituaient plus qu'un dernier choix, plutôt une alternative chez des patients qui ne disposaient plus de veines saphènes ou si celles-ci étaient de mauvaise qualité.

Nous avons donc revu une série consécutive de patients ayant bénéficié de pontage avec des veines de bras (céphalique, basilique ou mixte) entre 2001 et 2006. L'âge, les commorbidités, les symptômes, ainsi que les rapports angiologiques de ces patients ont également été analysés.

Pendant ces 5 années, 62 pontages chez 56 patients (6 patients opérés des 2 côtés) utilisant des veines de bras ont été réalisés dans notre service de chirurgie thoracique et vasculaire au CHUV.

L'analyse des résultats a permis de démontrer que le taux de perméabilité à 3 ans est tout à fait satisfaisant pour les pontages réalisés avec des veines de bras et même comparable à celui obtenu avec les veines saphènes. De plus, nous avons mis en évidence l'importance de la qualité de la veine choisie, l'influence de son diamètre (une augmentation du diamètre de la veine permet une meilleure survie du pontage).

En conclusion, les veines de bras sont plus qu'un dernier choix dans la revascularisation des membres inférieurs. On devrait prendre en considération leur utilisation à chaque fois qu'elles sont de bonne qualité et d'un diamètre correcte chez les patients qui ne disposent plus de veine saphène, ou même si celles-ci sont présentes, mais de mauvaise qualité. Ceci augmente le nombre de segments veineux à disposition, ce qui permettra d'utiliser encore moins souvent les conduits synthétiques.

European Journal of Vascular and Endovascular Surgery 43 (2012) 48–53

Contents lists available at SciVerse ScienceDirect

European Journal of Vascular and Endovascular Surgery

journal homepage: www.ejves.com

Infrainguinal Bypass for Peripheral Arterial Occlusive Disease: When Arms Save Legs CME

F. Vauclair [a,*], C. Haller [a], P. Marques-Vidal [b], S. Déglise [a], E. Haesler [c], J.-M. Corpataux [a], F. Saucy [a]

[a] Department of Thoracic and Vascular Surgery, Lausanne University Hospital, Rue du Bugnon 21, 1011 Lausanne, Switzerland
[b] Institute of Social and Preventive Medicine, Lausanne University Hospital, Lausanne, Switzerland
[c] Department of Vascular Medicine, Lausanne University Hospital, Lausanne, Switzerland

ARTICLE INFO

Article history:
Received 22 March 2011
Accepted 6 August 2011
Available online 3 September 2011

Keywords:
Limb salvage
Distal bypass
Vein conduits
Infrainguinal revascularisation
Arm vein

ABSTRACT

Objectives: Determine if arm veins are good conduits for infrainguinal revascularisation and should be used when good quality saphenous vein is not available.
Design: Retrospective study.
Materials and methods: We evaluated a consecutive series of infrainguinal bypass (IB) using arm vein conduits from March 2001 to December 2006.We selected arm vein by preoperative ultrasound mapping to identify suitable veins. We measured vein diameter and assessed vein wall quality. We followed patients with systematic duplex imaging at 1 week, 1, 3, 6 and 12 months, and annually thereafter. We treated significative stenoses found during the follow-up.
Results: We performed 56 infrainguinal revascularisation using arm vein conduits in 56 patients. Primary patency rates at 1, 2 and 3 years were 65%, 51% and 47%. Primary assisted patencies at 1, 2 and 3 years were 96%, 96% and 82%. Secondary patency rates at 1, 2 and 3 years were 92%, 88% and 88%. The three-year limb salvage rate was 88%.
Conclusions: We conclude that infrainguinal bypass using arm vein for conduits gives good patency rates, if selected by a preoperative US mapping to use the best autogenous conduit available.

With the improvement in the quality of life and medical therapies, there is an increase in both life expectancy and the patient's expectations. Medicine has to cope with older patients and their growing lists of comorbidities,[1] thereby complicating the framework conditions for vascular surgery.

In fact, the ageing patient is apt to benefit from a bypass (be it cardiac or leg), and surgical options are now considered even for elderly patients. Nevertheless, the fundamental problem of a limited number of great saphenous veins (GSVs) available per patient still remains.

Bioengineering has already tried to solve this lack of conduit, but without success.[2] Veins are still considered superior to prostheses in terms of long-term patency,[3–14] and the GSV remains the conduit of choice.[6–12] However, other surgeons or pathologies may have laid claim first to this valued vein.

Based on numerous studies,[3,6,15] vascular surgery teams still advocate an all-autogenous policy for infrainguinal bypass (IB). What remains unclear is which vein should be used.

We decided to work in the 'do the best operation first' fashion and this series reflects consecutive IB where the arm vein was the best alternative conduit for lower extremity revascularisations based on systematic preoperative duplex mapping.

The aim of this study was to evaluate the arm veins as conduits for IB and to look for factors that could influence the survival and the patency rates.

Materials and Methods

Between March 2001 and December 2006, all patients undergoing infrainguinal arterial revascularisation at the Lausanne University Hospital (Centre Hospitalier Universitaire Vaudois-CHUV) were recorded prospectively in a computerised database. Retrospectively, we selected a consecutive series of IB where the arm vein served as graft. Operative reports were then coordinated with patients' demographics, comorbidities, presenting symptoms and angiographic reports. Staging of arteriopathy was done using

CME To access continuing medical education questions on this paper, please go to www.vasculareducation.com and click on 'CME'

* Corresponding author. Tel.: +41 76 563 37 33.
E-mail address: Frederic.Vauclair@chuv.ch (F. Vauclair).

1078-5884/$ – see front matter © 2011 European Society for Vascular Surgery. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.ejvs.2011.08.007

Rutherford categories. Patients were stratified using ASA anaesthesiologic scoring.[16,17]

During this 5-year period, 62 lower extremity revascularisations using arm vein conduits were performed in 56 patients (six patients were operated on both legs). This represents approximately 7% of all IBs done during this period at our department. To simplify demographic and statistical analysis, we choose to exclude the second operation performed on six patients.

All patients underwent preoperative clinical examination, angiography or angio-CT, as well as both arterial and venous ultrasound (US) scanning. When lower limbs did not provide enough venous material to perform the planned bypass, upper limbs were likewise examined. After inspection and palpation with and without application of a tourniquet, deep veins were scanned using B-mode sonography to rule out a deep vein thrombosis. Then the superficial veins, the great and short saphenous veins or the cephalic and basilic veins, as well as their main branches, were located and scanned throughout their courses, also using B-mode. Diameters were assessed at several levels, and alterations, such as thrombosis, aneurysm, focal wall thickening or calcifications and intraluminal webs were sought. 'Any patent venous segment showing a straight course, an even and thin wall and a minimal luminal diameter of 2.5 mm was regarded as suitable for use as a conduit' (we defined vein of poor quality when one or more criteria were observed, such as diameter <2.5 mm, thrombosis, aneurysm, focal wall thickening or calcifications and intraluminal webs). When the diameter was less than 2.5 mm, measurements were repeated after heating the limb and asking the patient to perform movements with his foot or hand while wearing a cuff inflated to 80 mmHg proximally on the limb. All ultrasound studies were performed using linear 5–12 MHz transducers (Envisor and HDI 5000, Philips Medical Systems Switzerland, Gland, Switzerland; Vingmed System V, GE Medical Systems Switzerland, Glattbrugg, Switzerland).

Then, based on preoperative US mapping findings (Fig. 1), selected veins were isolated and harvested after ligation of the collaterals (Fig. 2). When a single segment of suitable length was not present, we performed spliced vein bypasses (composite) using venous-to-venous and end-to-end anastomosis done with single stitches (polypropylene 7.0).

Before arterial flow interruption and arteriotomy, we used a single dose (50 UI/Kg) of intravenous heparin.

At the end of the procedure, the flow was measured using a transit time principle probe (Medistim, Oslo, Norway) placed around the venous conduit just distal to the proximal anastomosis. When blood flow was under 25 ml/min, an intraoperative digital subtraction angiography (DSA) was performed in order to detect and correct any stenosis or other bypass problem. If nothing was found, we assumed that low flow was due to poor run-off.

In order to reduce operative time, the operation was performed using a two-team approach.

For below-the-knee bypasses, anticoagulation therapy with intravenous heparin was started 6 h post-op and then the patient was later switched to an oral anticoagulant on day seven (to minimise haemorrhagic complications and to delay oral

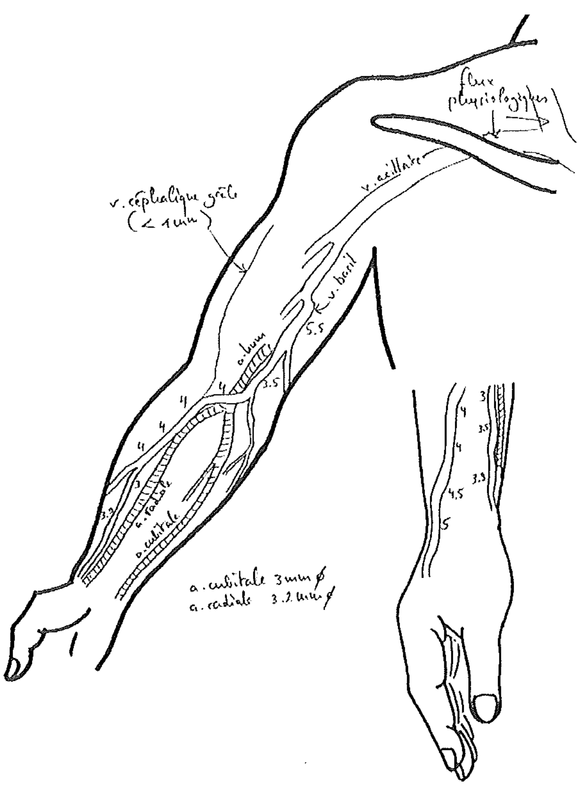


Figure 1. Pre-operative duplex mapping.

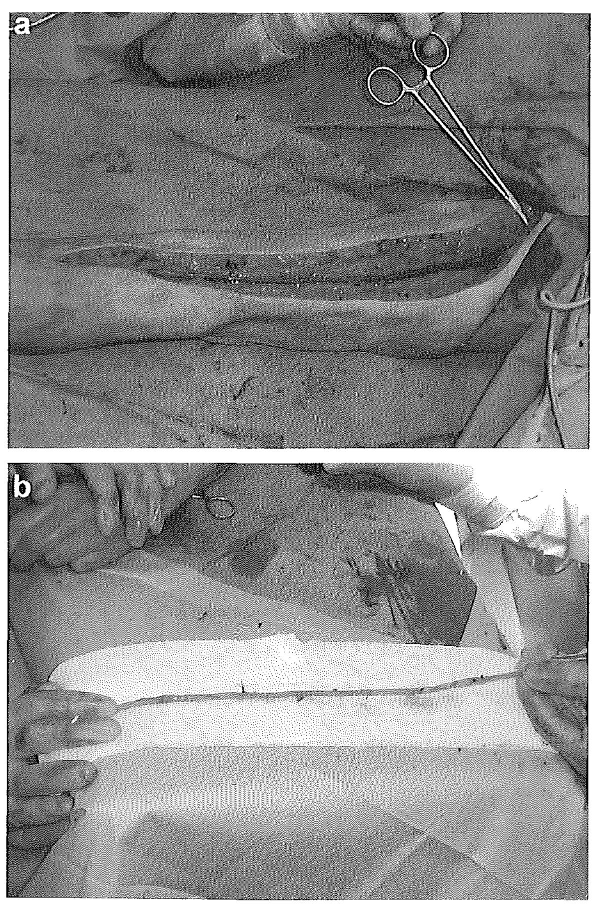


Figure 2. Preparation of arm vein with ligation of collaterals.

anticoagulation if any bypass abnormality was found on day seven duplex imaging).

After surgery, patients underwent periodic systematic evaluations at 1 week, 1, 3, 6 and 12 months, and annually thereafter. These included history and lower limb inspection looking for progression of ischaemic symptoms. We performed ankle and toe pressure measurements, and duplex imaging of the entire length of the bypass, as well as of the feeding artery and the main outflow vessel. Variations in the diameter, thrombus and location of the anastomoses were assessed by B-mode and stenoses were sought using colour Doppler. Spectral Doppler with an angle of 60° was used to assess velocity waves and peak systolic velocities (PSVs) proximal to, at and distal to sites of stenosis. Velocity ratios were recorded across all lesions and were calculated by dividing the maximal PSV at the stenosis site by the PSV proximal to the stenosis. The severity of a stenosis was considered to be about 50% when the PSV ratio was 2.2–2.5, and at least 70% when the systolic wave was dampened distal to the stenosis and the PSV ratio was 3.5 or more. Then all stenoses were carefully scanned using B-mode to assess their minimal luminal diameter, length and cause (valve, thrombus, conduit stricture, dissection or plaque). Stenoses of 50% were monitored closely, whereas stenoses of 70% or more were treated using either common percutaneous balloon angioplasty or surgically with a venous patch.[20–23]

Definitions

All terms used to report patencies and bypass characteristics are based on Rutherford's[24] recommendations.

Statistical analysis

Statistical analysis was performed using SAS v.9.2 (SAS Inc, Cary, NC, USA). Results were expressed as the number of subjects and (percentage) or as the mean ± standard deviation, unless otherwise stated. Patency rates were assessed by the life table method using 2-month intervals and the results were expressed as 1, 2 or 3-year patency rates and [95% confidence interval]. Factors significantly related to patency rates were assessed using the log-Rank test. Statistical significance was set at $p < 0.05$.

Results

Data from 56 patients aged 75.7 ± 10.5 years ((mean ± SD) range: 48–93 years) were collected. The male/female ratio was 1/1 (28 M/28 F). The main clinical characteristics of the patients at baseline are summarised in Table 1. Staging of arteriopathy shows that two-thirds of the procedures were performed for Rutherford categories 5 or 6 (Table 1).

The GSV was missing in 53.6% (30/56), present but too short or of poor quality in 46.4% (26/56). Table 2 shows the principal bypass characteristics. Here, it is important to mention that the rate of redo operations reached 48% and that infrapopliteal bypasses, at 50%, were the most commonly performed.

Six patients have been operated on both legs. Data from the second contralateral intervention were excluded from the analysis and are reported separately.

Survival and complication rates

There was no in-hospital death. Local complications were observed in four patients (7.1%), corresponding to three haematomas in the arm (requiring evacuation) and one transient paraesthesia of the fourth and fifth digits after cephalic harvesting.

Table 1
Patients' characteristics at the time of bypass and staging of Arteriopathy.[24] Category 0: asymptomatic; 1: mild claudication; 2: moderate claudication; 3: severe claudication; 4: ischaemic rest pain; 5: minor tissue loss-nonhealing ulcer, focal gangrene with diffuse pedal ischaemia; 6: major tissue loss-extending above transmetatarsal level, functional foot no longer salvageable. Results are expressed as number of subjects and (percentage).

	$N = 56$
Male sex	28 (50.0)
Age (years)	75.7 ± 10.6
Hypertension	47 (83.9)
Hypercholesterolaemia	21 (37.5)
Diabetes mellitus	21 (37.5)
Current smoker	30 (53.6)
Renal insufficiency	31 (55.4)
Glomerular filtration rate (ml/min)	37.1 ± 12.7
Coronary disease	37 (66.1)
Rutherford's category	
3	6 (10.7)
4	12 (21.4)
5	23 (41.1)
6	15 (26.8)

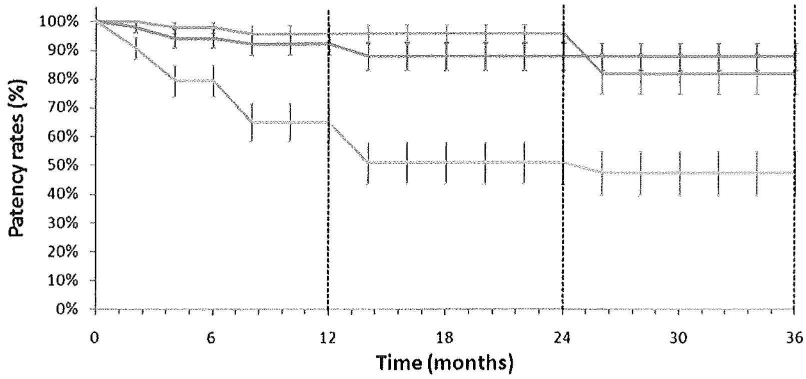
Survival rates were 85%, 72% and 50% at 12, 24 and 36 months, respectively.

Patency and limb salvage

Primary patency rates at 1, 2 and 3 years were 65 ± 6.7%, 51 ± 7.3% and 47 ± 7.6%. Primary assisted patency rates at 1, 2 and 3 years were 96 ± 3.0%, 96 ± 3.0% and 82 ± 6.9%. Secondary patency rates at 1, 2 and 3 years were 92 ± 3.7%, 88 ± 4.7% and 88 ± 4.7% (Fig. 3).

Table 2
Bypass characteristics. Results are expressed as number of bypass procedures and (percentage) or as mean ± standard deviation. *Distal anastomosis is beneath the trifurcation (corresponding to anterior/posterior tibial or peroneal artery or pedal arch).

	$N = 56$
Vein diameter (mm)	4.1 ± 1.1 4 [3–5]; (2–8)
Venous conduit characteristics	
Single vessel (cephalic, basilic or brachial)	30 (53.6)
Spliced arm–leg (saphenous and arm veins)	18 (32.1)
Spliced arm–arm (basilic and cephalic)	8 (14.3)
Type of revascularization	
Above-knee bypass	17 (30.4)
Below-knee bypass	11 (19.6)
Distal bypass*	28 (50.0)
Elective surgery	46 (82.1)
Redo surgery	27 (48.2)
Take-off vessel	
Common femoral artery (CFA)	11 (19.6)
Superficial femoral artery	18 (32.1)
Profound femoral artery (PFA)	14 (25.0)
Suprageniculate popliteal artery (SPA)	6 (10.7)
Infrageniculate popliteal artery	4 (7.1)
Aortic–PFA bypass	1 (1.8)
SFA–ATA bypass (proximal part)	1 (1.8)
CFA–SPA bypass	1 (1.8)
Landing vessels	
Suprageniculate popliteal artery	11 (19.6)
Geniculate popliteal artery (GPA)	5 (8.9)
Infrageniculate popliteal artery	12 (21.4)
Peroneal artery (PA)	11 (19.6)
Anterior tibial artery	8 (14.6)
Posterior tibial artery	3 (5.4)
Dorsalis pedis artery (DPA)	4 (7.1)
SFA–PA bypass	1 (1.8)
GPA–DPA bypass	1 (1.8)



n= patients at risk

Primary patency	41	29	20	20	8	4
Secondary patency	48	42	37	37	19	11
Primary assisted patency	47	38	33	33	18	14

Primary assisted — Secondary — Primary

Figure 3. Kaplan-Meier survival curves.

Amputations were performed in 12 patients (21.4%) at a median time of 41 [range 17–167] days, corresponding to six minor and six major amputations. At the end of the follow-up, the limb salvage rate was 88.0% (44 from the 50 patients with critical limb ischaemia).

Factors related to survival and patency

We used the Log Rank test to assess the variables significantly related to patency rates.

Neither clinical nor surgical variables were associated with *primary patency* rates.

Vein diameter was inversely related to *primary assisted* rates. An increase of 1 mm reduced the risk of occlusion by about 50% (HR = 0.54, 95% confidence interval [0.30–0.98], $p = 0.04$).

For *secondary patency* rates, a significant association was found with spliced vein graft ($p < 0.01$) but it was not possible to assess HR as one group (single vessel) had a 3-year patency rate of 100%, whereas the group which received a spliced graft had a patency rate of 73.1 ± 9.6% (see supplemental Fig. 1).

By contrast, the location of a landing vessel (above/below knee/distal) did not statistically influence the outcome.

Concerning the stage of ischaemia, the patency rates of Rutherford stage 3 versus 4–6 were not statistically different. This lack of difference is probably due to the small number of patients with stage 3.

Discussion

The results of our study suggest that arm veins contribute to satisfying results in terms of patency rates and limb salvage. Indeed, we performed IB with arm veins in 56 patients who were treated mostly for critical limb ischaemia with a limb salvage of 88% at 3 years.

Many studies have highlighted the superiority of venous conduits compared to synthetic ones for infrainguinal revascularisation.[3,7,14] Peirera et al. published in 2006 a meta-analysis of femoropopliteal bypass grafts for lower extremity insufficiency and concluded that GSV performs better than PTFE in femoropopliteal bypass grafting and should be used whenever possible.[25] Mahmood et al. reported that even composite (vein-prosthetic) sequential grafts are not as good as the autologous vein. Interestingly, they found no difference in patency between composite grafts constructed from the arm or leg vein.[26] Several retrospective studies have shown that even alternative veins (other than GSV) have satisfactory patency rates.[3,4,10,11,15,18] Previously, the arm vein was usually used to perform very distal bypass in patients without GSV or as an alternative to preserve the contralateral GSV. In these cases, some studies have achieved secondary patency and limb salvage rates equal to those of GSV.[3,4,11,15,18]

We decided to use arm veins each time as they were the best conduits available even if the GSV was present. This idea is based on the fact that the long-term survival of grafts depends first and foremost on the quality of the conduit.[6–9] During the same study period and with the same policy, Arvela et al. have compared 130 arm vein grafts with 160 prosthetic ones. Their results confirmed the superiority of arm veins over prosthetic conduits, even when spliced (patency is not statistically affected by the number of vein segments).[27]

Vein quality was assessed preoperatively by duplex mapping. We defined a vein to be of poor quality when one or more criteria were observed, such as diameter <2.5 mm, thrombosis, aneurysm, focal or diffuse wall thickening or calcifications and intraluminal webs. We selected arm vein when the diameter was sufficient, the quality was excellent and the length adequate for harvesting. US mapping is crucial due to the numerous vein punctures in hospitalised patients, which is harmful for patency.

As in other studies, it is important to note that arm vein bypass results are not really comparable with GSV bypass because patients' basic vascular status is worse (high rate of redo operations).

Nevertheless, our results of patency and limb salvage at 3 years were quite satisfying and even similar to those using GSV, being comparable to those found in the literature.[4,5,18,19] The endovascular treatment of critical limb ischaemia is increasing all around the world. The Basil trial comparing endovascular and open surgery concluded that patients with life expectancy >2 years and good quality of GSV should be treated by open surgery.[28] Our study supports the fact that vein arms should be explored by US and used when available because they contribute to good results in terms of patency rates. The absence of GSV in the presence of good vein arms should be evoked when an endovascular treatment for long arterial occlusion is considered.

In this analysis, vein diameter was shown to be an important protective factor of assisted patency rates, whereas it exerted no statistically significant effect on secondary patency rates.

Vein diameter is probably not the only factor influencing the occlusion rate which could be more affected by conduit, inflow and outflow qualities. In contrast to vein diameter, spliced vein grafts significantly decreased the secondary patency rates. This is probably related to the number of anastomoses. To minimise the stenosing effect of anastomosis, we made separate simple stitch sutures. We performed systematic duplex scanning of the bypasses to treat significative stenosis before occlusion. The strict follow-up of patients should be accurate during the first 6 months because 50% of the occlusion occurs during the first half-year.[5]

During the study period, the management of significative stenosis was surgical in a majority of cases (85%) because we previously had experiment arm vein rupture during balloon angioplasty. Actually, we carefully performe balloon angioplasty ourselves in the operating room and this is the procedure we prefer for treatment of stenosis.

Regarding the relatively low survival rate, it should be noted that the average age of our patients was older than in most cited publications (where the average ages tend to be <70 y), and that their general health status was relatively bad (mean ASA score of 3.02). According to Swiss statistical reports, more than 30% of patients had reached their life expectancy (mean male/female life expectancy in 2004 was 78.6/83.7 years) at the time of surgery.[29]

Our study has some limitations. Even if all IBs are recorded prospectively in our department, the retrospective analysis has some disadvantage linked to the design of the study. Moreover, the small number of patients did not permit us to generalise the results to every patient waiting for an IB.

In summary, we conclude that arm veins have good primary and secondary patency rates even after 3 years with very few harvesting complications.[18,30] Arm veins selection by preoperative US mapping using defined criteria is essential to get the optimal conduit even if spliced graft is necessary at the end. Its performance should be evaluated by per-op flow measurement using a sterile ultrasound surgical probe, thereby allowing time to react in case of inadequate values. Thereafter, a systematic duplex surveillance programme is recommended to detect and treat the possible stenosis.[3,4,15,18] When these procedures are followed, there is hope for limb salvage in the majority of cases.

Therefore, arm veins quality should always be evaluated when good quality GSV is absent. Spliced vein grafts are effective when no long segment is available.

Acknowledgements

There was no external source of funding or study sponsor.

Ethics Approval

No ethics approval has been obtained for this article because data were analysed retrospectively and anonymously.

Conflict of Interest

The authors had full access to the data and take responsibility for its integrity; read and agree with the manuscript as written; and have no conflict of interest to declare.

Appendix. Supplementary material

Supplementary data related to this article can be found online at doi:10.1016/j.ejvs.2011.08.007.

References

1 Stipa S. The cephalic and basilic veins in peripheral arterial reconstructive surgery. *Ann Surg* 1972;**175**:581–7.
2 Twine CP, McLain AD. Graft type for femoro-popliteal bypass surgery. *Cochrane Database Syst Rev* 2010 May 12;**5**.
3 Curi MA, Skelly CL, Woo DH, Desai TR, Katz D, McKinsey JF, et al. Long-term results of infrageniculate bypass grafting using all-autogenous composite vein. *Ann Vasc Surg* 2002;**16**:618–23.
4 Chew DK, Conte MS, Donaldson MC, Whittemore AD, Mannick JA, Belkin M. Autogenous composite vein bypass graft for infrainguinal arterial reconstruction. *J Vasc Surg* 2001;**33**:259–64.
5 Armstrong PA, Bandyk DF, Wilson JS, Shames ML, Johnson BL, Back MR. Optimizing infrainguinal arm vein bypass patency with duplex ultrasound surveillance and endovascular therapy. *J Vasc Surg* 2004;**40**:724–31.
6 Chew DK, Owens CD, Belkin M, Donaldson MC, Whittemore AD, Mannick JA, et al. Bypass in the absence of ipsilateral greater saphenous vein: safety and superiority of the contralateral greater saphenous vein. *J Vasc Surg* 2002;**35**:1085–92.
7 Faries PL, LoGerfo FW, Arora S, Hook S, Pulling MC, Akbari CM, et al. A comparative study of alternative conduits for lower extremity revascularization: all-autogenous conduit versus prosthetic grafts. *J Vasc Surg* 2000;**32**:1080–90.
8 Landry GJ, Moneta GL, Taylor Jr LM, Edwards JM, Yeager RA, Porter JM. Choice of autogenous conduit for lower extremity vein graft revisions. *J Vasc Surg* 2002;**36**:238–44.
9 Gupta AK, Bandyk DF, Cheanvechai D, Johnson BL. Natural history of infrainguinal vein graft stenosis relative to bypass grafting technique. *J Vasc Surg* 1997;**25**:211–20.
10 Belkin M, Conte MS, Donaldson MC, Mannick JA, Whittemore AD. Preferred strategies for secondary infrainguinal bypass: lessons learned from 300 consecutive reoperations. *J Vasc Surg* 1995;**21**:282–95.
11 Hölzenbein TJ, Pomposelli Jr FB, Miller A, Contreras MA, Gibbons GW, Campbell DR, et al. Results of a policy with arm veins used as the first alternative to an unavailable ipsilateral greater saphenous vein for infrainguinal bypass. *J Vasc Surg* 1996;**23**:130–40.
12 Brochado-Neto FC, Albers M, Pereira CA, Gonzalez J, Cinelli Jr M. Prospective comparison of arm veins and greater saphenous veins as infrageniculate bypass grafts. *Eur J Vasc Endovasc Surg* 2001;**22**:146–51.
13 Harris RW, Andros G, Dulawa LB, Oblath RW, Salles-Cunha SX, Apyan R. Successful long-term limb salvage using cephalic vein bypass grafts. *Ann Surg* 1984;**200**:785–92.
14 Faries PL, Logerfo FW, Arora S, Pulling MC, Rohan DI, Akbari CM, et al. Arm vein conduit is superior to composite prosthetic-autogenous grafts in lower extremity revascularization. *J Vasc Surg* 2000;**31**:1119–27.
15 Varcoe RL, Chee W, Subramaniam P, Roach DM, Benveniste GL, Fitridge RA. Arm vein as a last autogenous option for infrainguinal bypass surgery: it is worth the effort. *Eur J Vasc Endovasc Surg* 2007;**33**:737–41.
16 Saklad M. Grading of patients for surgical procedures. *Anesthesiology* 1941;**2**:281–4.
17 ASA. New classification of physical status. *Anesthesiology*:111. For update: www.asahq.org/clinical/physicalstatus.htm, 1963;**24**.
18 Faries PL, Arora S, Pomposelli Jr FB, Pulling MC, Smakowski P, Rohan DI, et al. The use of arm vein in lower-extremity revascularization: results of 520 procedures performed in eight years. *J Vasc Surg* 2000;**31**:50–9.
19 Probst H, Saucy F, Dusmet M, Ris HB, Ducrey N, Haller C, et al. Clinical results of autologous infrainguinal revascularization using grafts originating distal to the femoral bifurcation in patients with mild inflow disease. *J Cardiovasc Surg (Torino)* 2006;**47**:437–43.
20 Gonsalves C, Bandyk DF, Avino AJ, Johnson BL. Duplex features of vein graft stenosis and the success of percutaneous transluminal angioplasty. *J Endovasc Surg* 1999;**6**:66–72.
21 Nguyen LL, Conte MS, Menard MT, Gravereaux EC, Chew DK, Donaldson MC, et al. Infrainguinal vein bypass graft revision: factors affecting long-term outcome. *J Vasc Surg* 2004;**40**:916–23.
22 Carlson GA, Hoballah JJ, Sharp WJ, Martinasevic M, Maiers Yelden K, Corson JD, et al. Balloon angioplasty as a treatment of failing infrainguinal autologous vein bypass grafts. *J Vasc Surg* 2004;**39**:421–6.
23 Tong Y, Matthews PG, Royle JP. Outcome of endovascular intervention for infrainguinal vein graft stenosis. *Cardiovasc Surg* 2002;**10**:545–50.
24 Rutherford RB, Baker JD, Ernst C, Johnston KW, Porter JM, Ahn S, et al. Recommended standards for reports dealing with lower extremity ischemia: revised version. *J Vasc Surg* 1997 Sep;**26**(3):517–38.
25 Pereira CE, Albers M, Romiti M, Brochado-Neto FC, Pereira CA. Meta-analysis of femoropopliteal bypass grafts for lower extremity arterial insufficiency. *J Vasc Surg* 2006 Sep;**44**(3):510–7.
26 Mahmood A, Garnham A, Sintler M, Smith SR, Vohra RK, Simms MH. Composite sequential grafts for femorocrural bypass reconstruction: experience with a modified technique. *J Vasc Surg* 2002;**36**:772–8.

27 Arvela E, Söderström M, Albäck A, Aho PS, Venermo M, Lepäntalo MJ. Arm vein conduit vs prosthetic graft in infrainguinal revascularization for critical leg ischemia. *Vasc Surg* 2010;**52**(3):616–23.
28 Adam DJ, Beard JD, Cleveland T, Bell J, Bradbury AW, Forbes JF, et al. Bypass versus angioplasty in severe ischaemia of the leg (basil): multicentre, randomised controlled trial. *Lancet* 2005;**366**:1925–34.
29 Seematter-Bagnoud L, Paccaud F, Robine JM. *Le futur de la longévité en Suisse*. Office fédéral de la statistique; 2009.
30 Conte MS, Belkin M, Upchurch GR, Mannick JA, Whittemore AD, Donaldson MC. Impact of increasing comorbidity on infrainguinal reconstruction: a 20-year perspective. *Ann Surg* 2001;**233**:445–52.