Tips and tricks in open vascular surgery
Tips and tricks in open vascular surgery
Preface

Vascular surgeons are living an exciting era all over the world. Especially in the last two decades, so many things have been changing in our discipline due to a deeper knowledge of the pathophysiology of vascular disease and to remarkable technological advancements. Generations of vascular surgeons have been prompted to radically evolve their daily clinical practice in this new scenario. Such a change has led to significant improvements for today’s vascular patients in terms of both perioperative outcomes and life expectancy, with an enhanced quality of life.

Endovascular approaches are among the driving forces of this revolution, bridging most of the gap in the surgical options available in the past. Not unexpectedly, today endovascular techniques and devices are often the main focus of most meetings and publishing events in the field of vascular specialties. Unfortunately, more and more often, the education and the training of the new generations of surgeons are biased towards endovascular procedures to the detriment of the acquisition of a sound background knowledge of open surgery. This trend must be strongly counteracted.

Continuous education, training and updating in open vascular surgery should be the main target in universities, teaching hospitals, dedicated meetings and symposia. Furthermore, open surgery keeps growing and evolving: innovative materials and facilities, investigational perfusion substrates, updated methods of monitoring tissue function and vitality, new drugs and anesthesia strategies, and new technical tips and tricks have been leading to continuous improvement in the outcomes of open surgical procedures.

In keeping with this spirit, for the 7th International Congress of Aortic and Peripheral Surgery – “HOW TO DO IT” 2016, we want to buck the mainstream trend and write a book that is entirely dedicated to open vascular surgery.

This volume pragmatically describes the tools (indications, techniques, materials and devices) required to deal with the most complex situations that vascular specialists must face nowadays in the various fields of conventional surgery, including complications and failure of endovascular procedures.

The legacy of knowledge which has been kept alive over the years by the most skilled Italian vascular surgeons is a priceless baton to hand over to future generations.

We want to warmly thank all of the authors who accepted to contribute their expertise and mastery of surgical techniques to this book.

Milan, December 15th-17th, 2016
Roberto Chiesa, Carlo Setacci, Patrizio M. Castelli
Authors

Vittorio Alberti
Department of Vascular Surgery,
San Filippo Neri Hospital,
Rome, Italy

Michele Antonello
Department of Vascular and Endovascular Surgery Clinic, Padua University,
School of Medicine, Padua, Italy

Luca Apruzzi
Unit of Vascular Surgery,
San Raffaele Scientific Institute,
Milan, Italy

Angelo Argenteri
Department of Vascular Surgery,
University of Pavia,
Teaching Hospital IRCCS Policlinico San Matteo – Pavia, Italy

Stefano Atique Gabriel
Unit of Vascular Surgery,
San Raffaele Scientific Institute,
Milan, Italy

Domenico Baccellieri
Unit of Vascular Surgery,
San Raffaele Scientific Institute,
Milan, Italy

Domenico Benevento
Department of Vascular and Endovascular Surgery Unit,
Department of Medicine, Surgery and Neuroscience, University of Siena, Italy

Giuseppe Berardi
Vascular Surgery Unit,
Maturiziano Umberto I Hospital,
Turin, Italy

Luca Bertoglio
Unit of Vascular Surgery,
San Raffaele Scientific Institute,
Milan, Italy

Maria Pia Borrelli
Vascular and Endovascular Surgery Unit,
Department of Medicine, Surgery and Neuroscience, University of Siena, Italy

Marco Caldana
Department of Vascular Surgery,
University of Pavia,
Teaching Hospital IRCCS Policlinico San Matteo, Pavia, Italy

Laura Capoccia
Vascular and Endovascular Surgery Unit,
Department of Surgery “P. Stefanini”, Policlinico Umberto I, “Sapienza” University of Rome, Italy

Matteo Castagnola
Thoracic, Cardiovascular and Multi Specialist Surgery Department,
Angiology, Vascular and Endovascular Surgery Unit, Aosta Valley Regional Hospital “U. Parini”, Aosta, Italy

Renata Castellano
Unit of Vascular Surgery,
San Raffaele Scientific Institute,
Milan, Italy

Patrizio M. Castelli
Vascular Surgery Unit,
Department of Surgery and Morphological Sciences,
University of Insubria School of Medicine, Circolo University Teaching Hospital, Varese, Italy

Roberto Chiesa
Vita-Salute San Raffaele University,
Milan, Italy;
Unit of Vascular Surgery,
San Raffaele Scientific Institute,
Milan, Italy

Giuseppe Cilli
Vita-Salute San Raffaele University,
Milan, Italy

Hector W.L. de Beaufort
Thoracic Aortic Research Center,
Policlinico San Donato IRCCS,
University of Milan,
San Donato Milanese, Italy

Gianmarco de Donato
Vascular and Endovascular Surgery Unit,
Department of Medicine, Surgery and Neuroscience,
University of Siena, Italy

Ester de Marco
Vascular Surgery and Organ Transplant Unit,
University Hospital of Catania, Department of Surgical Specialties, University of Catania, Italy

Domenico Diaco
Department of Vascular Surgery,
University of Pavia,
Teaching Hospital IRCCS Policlinico San Matteo – Pavia, Italy

Walter Dorigo
Department of Vascular Surgery,
University of Florence, Italy

Aaron Fargion
Department of Vascular Surgery,
University of Florence, Italy
Authors

Stefano Fazzini  
Department of Vascular Surgery,  
San Filippo Neri Hospital,  
Rome, Italy

Stefania Ferraro  
Vascular Surgery Unit,  
Department of Surgery and  
Morphological Sciences,  
University of Insubria School of  
Medicine, Circolo University Teaching  
Hospital, Varese, Italy

Ilaria Figarelli  
Vascular Surgery Unit, “A. Cardarelli”  
Hospital, Naples, Italy

Martina Formiconi  
Vascular and Endovascular Surgery  
Unit, Department of Surgery “P.  
Stefanini”, Policlinico Umberto I,  
“Sapienza” University of Rome,  
Italy

Marco Franchin  
Vascular Surgery Unit,  
Department of Surgery and  
Morphological Sciences,  
University of Insubria School of  
Medicine, Circolo University Teaching  
Hospital, Varese, Italy

Giuseppe Galzerano  
Vascular and Endovascular Surgery  
Unit, Department of Medicine,  
Surgery and Neuroscience,  
University of Siena, Italy

Elena Giacomelli  
Department of Vascular Surgery,  
University of Florence, Italy

AleSSiA giAquinta  
Vascular Surgery and Organ  
Transplant Unit, University Hospital  
of Catania, Department of Surgical  
Specialities, University of Catania,  
Italy

Franco Grego  
Vascular and Endovascular Surgery  
Clinic, Padua University,  
School of Medicine, Padua, Italy

Massimiliano W. Guerrieri  
Vascular and Endovascular Surgery  
Unit, Department of Medicine,  
Surgery and Neuroscience,  
University of Siena, Italy

Andrea Kahlberg  
Vita-Salute San Raffaele University,  
Milan, Italy;  
Unit of Vascular Surgery,  
San Raffaele Scientific Institute,  
Milan, Italy

Arnoud V. Kamman  
Thoracic Aortic Research Center,  
Policlinico San Donato IRCCS,  
University of Milan,  
San Donato Milanese, Italy

Sebastiano Laddagna  
Vascular Surgery Unit,  
Department of Surgery  
and Morphological Sciences,  
University of Insubria School of  
Medicine, Circolo University Teaching  
Hospital, Varese, Italy

Jessica Lanza  
Department of Vascular Surgery,  
University of Pavia,  
Teaching Hospital IRCCS Policlinico  
San Matteo – Pavia, Italy

Simone Mambrini  
Vascular and Endovascular Surgery  
Unit, University Hospital IRCCS San  
Martino IST, University of Genoa,  
Italy

Nicola Mangialardi  
Department of Vascular Surgery,  
San Filippo Neri Hospital, Rome, Italy

Wassim Mansour  
Vascular and Endovascular Surgery  
Unit, Department of Surgery “P.  
Stefanini”, Policlinico Umberto I,  
“Sapienza” University of Rome,  
Italy

Enrico Maria Marone  
Department of Vascular Surgery,  
University of Pavia,  
Teaching Hospital IRCCS Policlinico  
San Matteo – Pavia, Italy

Daniele Mascia  
Unit of Vascular Surgery,  
San Raffaele Scientific Institute,  
Milan, Italy

Mariagnese Mele  
Vascular and Endovascular Surgery  
Unit, Department of Medicine,  
Surgery and Neuroscience,  
University of Siena, Siena, Italy

Germano Melissano  
Vita-Salute San Raffaele University,  
Milan, Italy;  
Unit of Vascular Surgery,  
San Raffaele Scientific Institute,  
Milan, Italy

Mirko Menegolo  
Vascular and Endovascular Surgery  
Clinic, Padua University,  
School of Medicine, Padua, Italy

Nunzio Montelione  
Vascular and Endovascular Surgery  
Unit, Department of Surgery “P.  
Stefanini”, Policlinico Umberto I,  
“Sapienza” University of Rome,  
Italy

Federico Navarretta  
Thoracic, Cardiovascular and Multi  
Specialist Surgery Department,  
Angiology, Vascular and Endovascular  
Surgery Unit, Aosta Valley Regional  
Hospital “U. Parini”, Aosta, Italy

Franco Nesli  
Vascular Surgery Unit,  
Mauriziano Umberto I Hospital,  
Turin, Italy

Matteo Orrico  
Department of Vascular Surgery,  
San Filippo Neri Hospital, Rome, Italy

Domenico Palombo  
Vascular and Endovascular Surgery  
Unit, University Hospital IRCCS San  
Martino IST, University of Genoa,  
Italy

Alberto Pecchio  
Vascular Surgery Unit,  
Mauriziano Umberto I Hospital,  
Turin, Italy

Flavio Peinetti  
Thoracic, Cardiovascular and Multi  
Specialist Surgery Department,  
Angiology, Vascular and Endovascular  
Surgery Unit, Aosta Valley Regional  
Hospital “U. Parini”, Aosta, Italy

Daniele Pennica  
Vascular Surgery Unit,  
Mauriziano Umberto I Hospital,  
Turin, Italy
# Contents

1. Popliteal artery aneurysm open repair: indications and technique ...................................................... 1  

2. Complex open carotid surgery: high bifurcation, carotid restenosis and surgery after carotid stenting .......................................................... 7  

3. Surgery of carotid body tumors .......................................................................................................... 16  
   F. Grego, M. Piazza, F. Squizzato, M. Menegolo, M. Antonello

4. Surgery of vertebral and subclavian arteries ........................................................................................ 22  
   A. Argenteri, E. M. Marone, D. Diaco, M. Caldana, J. Lanza, M. Rota

5. Complex abdominal aortic aneurysm open repair: giant aneurysm, venous anomalies and renal arteries anatomical variants  .......................................................... 34  
   P. M. Castelli, G. Piffaretti, S. Laddaga, S. Ferraro, M. Franchin

6. Open conversion after EVAR ............................................................................................................. 42  
   N. Mangialardi, M. Orrico, S. Ronchey, B. Praquin, V. Alberti, S. Fazzini

7. Inflammatory abdominal aortic aneurysm open repair ....................................................................... 46  
   A. Pecchio, G. Berardi, D. Pennica, F. Nessi

8. Surgical options in Leriche syndrome ................................................................................................. 54  
   C. Ruotolo, I. Ficarelli

9. Thoracoabdominal aortic aneurysms open repair: technique and adjuncts for organ protection ........ 66  

10. Malperfusion syndromes during acute type B aortic dissection: surgical options ............................. 76  
    H. W. L. de Beaufort, A. V. Kamman, S. Trimarchi

11. Arterial re-routing in hybrid surgery: indications and technique ......................................................... 81  
    R. Chiesa, A. Kahlberg, E. Rinaldi, L. Bertoglio, R. Castellano, G. Cilli, G. Melissano

12. Surgery for renal arteries .................................................................................................................... 93  
    P. Veroux, A. Giaquinta, D. Zerbo, E. De Marco, A. Sanzone, M. Veroux

13. Graft infection in aortic surgery: diagnosis and operative management .......................................... 100  
    F. Speziale, E. Sharigia, L. Capoccia, P. Sirignano, W. Mansour, N. Montelione, C. Pranteda, M. Formiconi

    F. Peinetti, M. Castagnoval, F. Navarretta

15. Vascular implication in surgical oncology ........................................................................................... 120  
    S. Mambrini, M. C. Perfumo, D. Palombo
Introduction

Popliteal artery represents the second most frequent localization of arterial aneurysms. Popliteal artery aneurysm (PAA) is a multifactorial disease, even if atherosclerosis seems to be the main cause in elderly patients, while in younger ones other causes have been hypothesized, such as popliteal artery entrapment syndrome, cystic adventitial degeneration, osteochondroma and trauma. If the PAA remains untreated, the risk of complications increases with time. The main complications of PAA include rupture, distal embolization and thrombosis; acute leg ischemia due to thrombosis of PAA represents a dangerous complication of this pathological feature, often being the first clinical manifestation.

About one third of PAAs are asymptomatic when diagnosed, while, among the remaining two thirds, up to 30% rupture and cause compression of vascular and nervous adjacent structures and about 70% have chronic or acute leg ischemia as the symptom of presentation.

While chronic ischemia is often due to progressive chronic thrombosis of the PAA or to chronic embolization into the tibial vessels, acute ischemia is caused in the majority of the cases by an acute aneurysmal thrombosis. The relationship between the occurrence of ischemic complications and the dimensions of the PAA is still controversial; even if the increase of risk with the growing diameter of the PAA is well established, several cases have been reported with limb ischemia in the presence of small PAAs, with a maximum diameter <2 cm.

Indications

The definition of morphological criteria to identify asymptomatic lesions at high risk of developing complications is particularly important, due to the dramatic impact of clinical presentation on the results of surgical treatment. In 1983, Reilly et al. reported an amputation rate of 51% in 66 patients with acutely thrombosed PAA, with perioperative mortality rates up to 5%. Similar results were recently obtained in large European and North American experiences, showing significantly better results for elective interventions in asymptomatic patients than in urgent interventions for acute symptomatic PAAs. Graft patency and limb preservation in most series are affected by the presence of symptoms, by the presence of aneurysmal thrombosis and by the status of the run-off vessels. Symptomatic patients, with poor run-off status and the need for distal tibial revascularization have significantly worse results in the perioperative and long term setting.

As a consequence, a surgical approach to asymptomatic PAAs is justified by both the unfavorable natural history of untreated lesions and the high risk of failure of the intervention performed in chronic or acute symptomatic patients.

Even in the lack of comparative randomized studies between surveillance and operative management in asymptomatic lesions, most authors and the most recent guidelines suggest the indication for surgical treatment in the presence of >2 cm PAA, particularly when a large amount of intraluminal thrombus is present and concomitant tibial disease is detected, suggesting the occurrence of previous episodes of distal embolization.

However, while such a threshold value is useful in the identification of aneurysms at high risk of rupture, more recent studies suggest that smaller lesions cannot have a benign course and that other factors exist which affect the risk of developing large mural thrombosis and consequent thrombosis or embolization. Among them, one must remember the rate of PAA enlargement, its morphology, the quality of the run-off vessels and the presence of a hypercoagulable state.

Therefore, in the absence of strong evidence, the main criterion for the indication to treatment is the presence of a >2 cm PAA; when smaller lesions are present, surgical intervention can be considered in the presence of one or more factors possibly predicting late complications.

On the other hand, the operative treatment is mandatory regardless of the diameter when PAA becomes symptomatic, particularly when rupture or leg ischemia occur.
The introduction in clinical practice of intra-arterial thrombolysis has somewhat modified the management of patients with acute limb ischemia due to a thrombosed PAA. Its rationale lies in the attempt to partially or completely restore the patency of the popliteal artery and of the tibial vessels, to solve the acute ischemic condition and improve the status of the run-off, which represents one of the crucial issues for a successful surgical revascularization.

Many authors suggested intra-arterial thrombolysis as an effective alternative to emergent surgical intervention in patients with mild to moderate ischemia. Also in our experience, preoperative intra-arterial thrombolysis in selected patients with acute limb ischemia due to aneurysmal thrombosis allowed partial or complete recanalization of thrombosed PAA in about two thirds of cases and, when successful, provided better results that urgent surgery alone, without compromising the results of surgery if unsuccessful. For this reason, and in consideration of the few risks of hemorrhagic complications if careful monitoring of arterial pressure and blood fibrinogen is performed, we adopted a policy of routine intra-arterial thrombolysis in patients with mild-to-moderate acute limb ischemia due to thrombosis of PAA. On the other hand, the risk of amputation and graft thrombosis in patients undergoing immediate intervention in emergent conditions exceeds 10% and 45%, respectively.

In the presence of severe ischemia with neurological impairment, thrombolysis is not feasible due to the immediate risk of limb loss and a primary surgical attempt is mandatory; in such circumstances, aggressive intraoperative thrombolysis methods (high-dose thrombolysis, pulse-spray thrombolysis) can be used in the attempt to restore a satisfactory distal vascular bed to perform a successful surgical revascularization. A common occurrence during thrombolysis is secondary distal embolization, reported in up to 10-12% of cases.

In the majority of cases, this complication can be successfully managed by increasing the delivery rate of the thrombolytic drug. However, in a limited number of patients, distal embolization of old thrombotic material can cause an impairment of foot ischemia even in the presence of a restored patency of popliteal and tibial arteries.

Also, recent Italian guidelines confirm that in patients with mild to moderate acute ischemia due to thrombosis or embolization, intra-arterial thrombolysis is the first line therapy, followed by the elective surgical intervention if successful. In patients with severe ischemia or with rupture, urgent surgical intervention is mandatory. In such circumstances, the kind of intervention depends upon the extent of the thrombosis. In the case of limited thrombosis involving only the aneurysmal sac without involvement of the tibial vessels, aneurysmectomy with graft interposition (see later) can be safely performed (Figure 1.1A). When thrombosis incompletely involves the tibial vessels, bypass grafting on the patent vessel with proximal and distal ligation is suggested; finally, when complete tibial occlusion occurs, thromboembolectomy of the run-off vessels eventually associated with intraoperative stop-flow thrombolysis is necessary to restore run-off flow, followed by the adequate arterial reconstruction (Figure 1.1B).

In recent years, with the worldwide diffusion of endovascular procedures, the endovascular approach to PAA has been gaining popularity and interest, due to the easy deployment of stent-grafts and to the low invasiveness of the procedure. Many authors in recent years reported satisfactory early and mid-term results with the use of endografts in the exclusion of a PAA. Also in our daily practice, the endovascular approach represents our first line choice in patients at high surgical risk and with suitable anatomy; even if patients operated on with open or endovascular techniques have substantially different clinical and anatomical patterns, it is however possible to achieve good early and mid-term results with both techniques, providing that a correct selection of the patients and of the lesions is carried out. There are however very few data about randomized studies comparing the two treatments and most single-center series rarely reported a follow-up duration exceeding 5 years.

Open repair: technique and results

Open surgical repair of PAAs aims at exclusion of the lesion from the blood circulation, in order to eliminate the risk of rupture and thrombosis, while preserving an
adequate blood supply to the leg and foot. The choice of surgical strategy (arterial access, kind of reconstruction, graft material) depends upon several factors: the extension and the morphology of the aneurysm, the status of the outflow and inflow vessels, and the need to evacuate the aneurysmal sac when it is left in situ.

As far as access to the popliteal artery is concerned, it can be achieved with a medial or a posterior approach. The medial approach with supine patients is preferred by the majority of the authors in the presence of large aneurysms with significant proximal and distal extension (Figures 1.2A, 1.2B).

This kind of access makes the dissection and eventually the harvesting of the ipsilateral greater saphenous vein simple and allows a wide exposure of the anatomical structures, with a relatively easy approach to the popliteal trifurcation and to the femoral axis.

On the other hand, it is anatomically complex and technically demanding and requires the resection of muscles and tendons at the knee level, mainly in the presence of large aneurysms.

The posterior approach to the popliteal artery with prone patients using an S-shaped incision (Figure 1.3) is usually carried out in the presence of aneurysms not extending beyond the popliteal fossa and has several limits: exposure of the superficial femoral artery and of tibial vessels is limited, which makes such an approach useful only in the presence of small lesions without proximal or distal extension (Figure 1.4). Moreover, harvesting of the greater saphenous vein is difficult and an adjunctive incision is usually necessary, which can be avoided by using the smaller saphenous vein, whose dissection is easy and safe with this approach. Other advantages of the posterior access are the easy isolation of the aneurysm and the reduced risk of neurological and venous injuries. In the presence of fast growing PAA, the majority of the surgeons suggest, when possible, a posterior approach, which allows the control and ligation of all collaterals arising from the aneurysm, with a reduced risk of sac expansion and subsequent compression of vessels and nerves of the popliteal fossa.

On the contrary, when rupture occurs and hemodynamic instability is present, medial access with fast cross clamping of the popliteal artery represents the first choice treatment to stabilize the hemorrhage before the arterial reconstruction.

Looking at the kind of arterial reconstruction, the possible options include bypass with proximal and distal ligature of the aneurysm (Figure 1.5), aneurysmectomy with end-to-end anastomosis (Figure 1.6) or with graft interposition (Figure 1.7), endoaneurysmectomy and graft interposition (Figure 1.8). Also in this case, the preferred method depends upon anatomical considerations, as well as the preferences and habits of the operating surgeon.

Bypass surgery with proximal and distal ligature of the aneurysm via medial access is the most commonly
used intervention in the literature; after isolation of the inflow and outflow vessel, a autologous or prosthetic graft is placed with a termino-lateral anastomosis to both proximal and distal anastomotic sites. The aneurysm is then sutured both just beyond the proximal anastomosis and just proximal to the distal anastomosis, to prevent distal embolization and further sac enlargement. However, such a technique does not completely eliminate the risk of this occurrence through collateral feeding vessels. Moreover, the aneurysm, mainly when completely thrombosed, can become infected causing colliquation and eventually cutaneous fistulas.

For this reason, resection of the aneurysm is the most effective means of preventing continued expansion, mainly in the presence of large saccular aneurysms causing compression of the surrounding structures; if the aneurysm involves a short portion of the popliteal artery or the artery is redundant, an end-to-end anastomosis can be performed, while graft placement with termino-terminal anastomoses is necessary in the presence of a longer lesion. The risk of venous and nervous injuries with such a technique is substantial, however, particularly when the excision of large compressing PAAs is required.

An alternative to this kind of reconstruction is endoaneurysmectomy and graft interposition: after arterial clamping, the aneurysm is opened and a graft is placed inside the aneurysm in a fashion similar to that used to repair aortic aneurysms, with proximal and distal termino-terminal anastomoses; this technique is advantageous particularly when a posterior access is used.

Finally, in the presence of saccular aneurysm, aneurysmorraphy with primary closure or patch closure can represent a safe and effective option (Figure 1.9).

As far as graft materials are concerned, both inverted and in situ autologous saphenous vein bypass is classically the material of choice for revascularization, due to the fact that the distal anastomosis is frequently performed at a below-knee or tibial level; early and long-term results are excellent, with high rates of graft patency and limb preservation. Good results are also reported with the use of the smaller saphenous vein in patients without a suitable greater saphenous vein or during posterior access. Bypass graft with autologous veins provides long-term
results that are significantly better than those obtained in below-knee interventions performed for chronic obstructive disease, with reported patency rates of more than 90% at 5 years compared with 60% in patients operated on for obstructive disease.

The use of prosthetic grafts is unavoidable in the absence of good quality autologous material; however, the results of prosthetic grafts, mainly expanded polytetrafluoroethylene (ePTFE), have been excellent in several published series, and their use has been suggested in the presence of a suitable saphenous vein in anatomically selected patients. This approach could preserve the autologous veins for further revascularizations and reduce the complexity and the duration of the intervention. This is also our everyday strategy: we tend to use an ePTFE graft more frequently in shorter, more direct reconstructions, while we prefer an autologous vein for longer bypasses or when a distal tibial anastomosis is required.

In recent years, excellent results have been obtained with the use of heparin-bonded ePTFE grafts, which represent the material of choice when a prosthetic graft is required.

Local perioperative complications include bleeding and graft thrombosis; the former is common in the presence of large aneurysms, particularly when a medial approach is used and can be impaire by the need for graft tunneling, with consequent venous injuries, and by the aggressive pre- and intraoperative anticoagulation. Early graft thrombosis can be influenced by the preoperative status of run-off vessels, the presence of symptoms and the kind of intervention (elective or urgent). Thirty-day amputation rate remains high when the patient is symptomatic; in patients with acute severe limb ischemia due to aneurysmal thrombosis, amputation rates range from 16% to 43%, and this is also confirmed in our experience, with rates of 16.6% and 20% for amputations in patients with preoperative acute limb ischemia or aneurysm rupture, respectively.4

Perioperative mortality and systemic complications are usually low; in the main published studies, early mortality rates are lower than 2%; however, again the presence of symptoms and limb ischemia can significantly impair mortality, which has been reported to be up to 5.5% in such conditions. The long-term results of open surgery are quite good: recently, Dorweiler et al.27 reported their 12-year excellent results on 206 interventions performed between 1998 and 2010, with a primary patency of about 88% and a secondary patency of more than 96.5%. Slightly poorer results at 10 years were reported by Davies et al., who described a primary graft patency of about 63% in 48 patients operated on between 1988 and 2006; however, in that series, the rate of secondary patency was good, too, with a percentage of about 95%. Few other studies reported results at 10-years, with similar outcomes to those cited above but with a relatively low number of followed-up patients. Also in our recent experience, we found very good results at 13 years, with a primary patency of more than 75%, a secondary patency of about 70% and a limb preservation rate of 86%. Also, survival and amputation-free survival rates were excellent, with similar results to those obtained in the general population.

In the main series, long-term results are affected by several clinical and anatomical factors: the need for distal tibial anastomosis and an extensive involvement of the crural vessels are independently associated with poorer primary patency, while the presence of preoperative symptoms and

Table 1.1. Primary and secondary results of the main surgical series in treatment of popliteal artery aneurysm (1990-2015).

<table>
<thead>
<tr>
<th>Author</th>
<th>Cases (N.)</th>
<th>Primary patency</th>
<th>Follow-up</th>
<th>Secondary patency</th>
<th>Limb salvage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortell</td>
<td>51</td>
<td>94%</td>
<td>6 years</td>
<td>67%</td>
<td>94%</td>
</tr>
<tr>
<td>Dawson</td>
<td>42</td>
<td>-</td>
<td>5 years</td>
<td>75%</td>
<td>95%</td>
</tr>
<tr>
<td>Sarcina 2</td>
<td>61</td>
<td>97%</td>
<td>10 years</td>
<td>75%</td>
<td>95%</td>
</tr>
<tr>
<td>Davidovic</td>
<td>59</td>
<td>92%</td>
<td>4 years</td>
<td>78%</td>
<td>89%</td>
</tr>
<tr>
<td>D’Addato</td>
<td>107</td>
<td>96%</td>
<td>5 years</td>
<td>77%</td>
<td>91%</td>
</tr>
<tr>
<td>Jones</td>
<td>41</td>
<td>-</td>
<td>5 years</td>
<td>86%</td>
<td>92%</td>
</tr>
<tr>
<td>Mahmood</td>
<td>52</td>
<td>-</td>
<td>5 years</td>
<td>69%</td>
<td>85%</td>
</tr>
<tr>
<td>Blanco</td>
<td>70</td>
<td>95%</td>
<td>10 years</td>
<td>77%</td>
<td>84%</td>
</tr>
<tr>
<td>Laxdal</td>
<td>50</td>
<td>-</td>
<td>5 years</td>
<td>60%</td>
<td>76%</td>
</tr>
<tr>
<td>Martelli</td>
<td>42</td>
<td>90%</td>
<td>4 years</td>
<td>66%</td>
<td>96%</td>
</tr>
<tr>
<td>Aulivola</td>
<td>51</td>
<td>-</td>
<td>5 years</td>
<td>85%</td>
<td>98%</td>
</tr>
<tr>
<td>Pulli</td>
<td>159</td>
<td>95%</td>
<td>5 years</td>
<td>66%</td>
<td>84%</td>
</tr>
<tr>
<td>Huang</td>
<td>358</td>
<td>96%</td>
<td>5 years</td>
<td>76%</td>
<td>97%</td>
</tr>
<tr>
<td>Davies</td>
<td>48</td>
<td>-</td>
<td>10 years</td>
<td>63%</td>
<td>95%</td>
</tr>
<tr>
<td>Zimmerman</td>
<td>56</td>
<td>-</td>
<td>5 years</td>
<td>82%</td>
<td>-</td>
</tr>
<tr>
<td>Pulli</td>
<td>178</td>
<td>97%</td>
<td>4 years</td>
<td>63%</td>
<td>90%</td>
</tr>
<tr>
<td>Huang</td>
<td>107</td>
<td>99%</td>
<td>3 years</td>
<td>80%</td>
<td>99%</td>
</tr>
<tr>
<td>Dorweiler</td>
<td>206</td>
<td>96%</td>
<td>10 years</td>
<td>73%</td>
<td>97%</td>
</tr>
<tr>
<td>Dorigo</td>
<td>234</td>
<td>93%</td>
<td>13 years</td>
<td>55%</td>
<td>86%</td>
</tr>
<tr>
<td>Laeke</td>
<td>186</td>
<td>-</td>
<td>3 years</td>
<td>73%</td>
<td>86%</td>
</tr>
</tbody>
</table>
Conclusions

Open surgical repair of PAAs is a safe procedure, with low rates of perioperative complications, and maintains an excellent durability in the very long term setting, with high patency and limb preservation rates and reasonable risks of reintervention, mainly due to late graft occlusion. These results represent an unavoidable benchmark for alternative techniques, such as endovascular repair, and make it the treatment of choice for such conditions.

References