State of the Art

Which Stent for Which Lesion in Peripheral Interventions?

Michel Henry, MD
Christos Klonaris, MD
Max Amor, MD
Isabelle Henry, MD
Kiril Tzvetanov, MD

Applications of endovascular procedures have been expanded dramatically throughout the human body for both occlusive and aneurysmal disease; arteries at the aortoiliac and femoropopliteal levels are no exception. Currently, interventional procedures are the 1st treatment option for most patients who have peripheral artery disease. Although balloon angioplasty alone offers good immediate and long-term results, the addition of stents has been proposed to improve the procedural success of angioplasty and extend its application to more patients with vascular disease. Stenting, however, is controversial. Its use is considered acceptable in the aortoiliac vessels but is more in dispute for the femoropopliteal vessels. Moreover, the rapid development of endovascular stents for peripheral applications has made stent selection a complicated task for clinical practitioners. Many factors influence the type of stent selected; therefore, knowledge of the stents available—including various designs and individual properties—is mandatory. Appropriate selection depends on adequate preprocedural evaluation of the lesion; the choice of approach; the choice of primary versus selective stent placement; the location and characteristics of the lesion; the availability of stents in the intervention suite; and the experience of the operator.

Several stents are now available, but they are not equivalent; it is important to select the stent that is best suited to the lesion. On the basis of our experience using different types of stents, as well as our review of the world medical literature, we summarize the properties of various stents and specific indications for their application. This report is intended for use as a practical guide to stent selection. ***(Tex Heart Inst J 2000;27:119-26)***

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From: *Department of Interventional Cardiology, U.C.C.I. Polyclinique d'Essey, 54270 Essey-les-Nancy, France*

Address for reprints:
Michel Henry, MD, U.C.C.I. Polyclinique d'Essey, 7 rue Parmentier, 54270 Essey-les-Nancy, France

The number of patients who have peripheral artery occlusive disease is steadily increasing worldwide, primarily as a result of the aging of the population. It is estimated that 10% to 20% of individuals more than 70 years of age sustain some degree of chronic, lower-extremity ischemia. This percentage is greater in some subgroups of patients, such as those having diabetes or end-stage renal failure.

Types of peripheral vascular disease are generally classified as claudication or critical limb-threatening ischemia. The distinction is made because the natural history and progression of the 2 types are different. The prognoses are different as well: better for patients with claudication and worse for those with more advanced stages of ischemia. In addition, this classification serves as a guide for decisions that must be made concerning the best treatment option. Patients who have severe, lifestyle-limiting claudication, rest pain, or tissue necrosis should be offered relatively aggressive therapy.

During the past 40 years, surgery has been established as a reliable treatment for arterial occlusive disease in all peripheral regions. Endovascular therapy, inspired by the work of Dotter and Judkins[1] in the United States in the mid-1970s and Grüntzig and Hopff[2] in Europe in the mid-1980s, is, however, a relatively new field of vascular medicine. Only within the last decade has this new concept of treatment become widely recognized and accepted. During that time, the applications of endovascular therapy have been broadened dramatically in all vessels, including those at the aortoiliac and femoropopliteal levels. Currently, interventional procedures are the 1st treatments to be proposed for most patients who have peripheral artery disease. Balloon angioplasty alone may offer good immediate and long-term results; however, the addition of stents has been proposed in order to increase the procedural success of angioplasty and extend its application to more

types of lesions. Nevertheless, stenting is controversial. Although it is well accepted at the aortoiliac level, it is less so at the femoropopliteal level.[3-25] Moreover, the rapid development of endovascular stents for peripheral applications, the different designs, the unique properties, and even name changes as a result of corporate mergers have made stent selection a confusing issue in everyday clinical practice. Therefore, an overview of currently available stents and their characteristics is necessary before the indications and proper stent selection in different clinical settings can be considered.

Stent Types

The following are properties of an ideal intravascular stent:

- High radiopacity for clear visualization, which facilitates accurate placement
- High hoop strength to resist arterial recoil
- Minimal or no foreshortening in deployment, for precise placement
- Simple and easy-to-use delivery system
- Longitudinal flexibility to cross tortuous vessels and aortic bifurcation with the contralateral approach
- Radial elasticity to resist external compression without permanent deformation, especially at flexion sites
- High expansion ratio and low profile for passage through small introducers or guiding catheters or through tight stenoses
- Retrievability in case of faulty deployment
- Side branch accessibility
- Minimal induction of intimal hyperplasia
- Resistance to thrombosis and corrosion
- Durability
- Low price

Unfortunately, no currently available endoprosthesis combines all of the above properties. However, many of these properties can be found in the various stent designs, which can be divided into 3 main categories: 1) balloon-expandable, 2) self-expandable, and 3) covered. A brief description of the stents currently available for clinical use is presented.

Balloon-Expandable Stents

The Strecker™ Stent (Boston Scientific Corp.; Natick, Mass)*. The Strecker stent is made of a tubular wire mesh knitted from a single electropolished tantalum filament. It has a premounted balloon, and it has good radiopacity. The flexibility of this stent is a valuable feature. It is available in diameters from 4 to 12 mm with lengths of 20, 40, 60, and 80 mm.

*The Palmaz® Stents** (Cordis Corporation, a Johnson & Johnson company; Warren, NJ).* The classic Palmaz stents are made of rigid stainless steel and can be dilated to various diameters, depending on the size of the balloon chosen for deployment. These stents range from to 4 to 9 mm in diameter and from 10 to 39 mm in length. They can be implanted precisely because of their minimal foreshortening and good radiopacity. These characteristics are of particular value for treating lesions situated at or near a bifurcation. The large Palmaz stents have diameters from 8 to 12 mm and lengths up to 30 mm, and they are available for iliac and transhepatic use. In addition, extra-large stents are available for aortic applications.

*The newer Palmaz Stents** (Cordis).* The Palmaz-Schatz® Long Medium Stent is articulated and is thus more flexible and can be easily implanted using the contralateral approach. Diameters range from 6 to 10 mm and lengths from 41.8 to 77.8 mm. The new Palmaz® Corinthian™ Stent** also has improved flexibility. Its short length (12 to 18 mm) is useful for focal tight lesions in the iliac and femoral arteries. Diameters range from 5 to 8 mm.

*The Perflex™ Stent** (Cordis).* The flexibility of the Perflex stent is important, and the use of this stent is indicated for iliac artery lesions, even through the contralateral approach. The diameters vary between 7 and 10 mm and the lengths between 22 and 88 mm.

The Medtronic AVE Stents (Medtronic AVE; Santa Rosa, Calif). The Medtronic AVE stents comprise both rigid and flexible types, ranging from 6 to 10 mm in diameter and from 20 to 60 mm in length. They combine the minimal foreshortening and good radiopacity of the Palmaz stent and the flexibility of the new nitinol stents, even though they are made of stainless steel.

*The MegaLink™ Stent** (Guidant France S.A.; Rueil Malmaison, France).* The MegaLink stents are stainless steel, flexible stents with satisfactory radial strength and minimum recoil. They are available in diameters of 6 to 10 mm and in lengths of 18 to 38 mm. The MegaLink is available in the United States for biliary applications only.

Self-Expandable Stents

The Wallstent® Endoprosthesis (Boston Scientific). The Wallstent is made of a stainless steel alloy mesh and is soft and flexible along its longitudinal axis. Its radial strength enables a progressive dilation of the artery. The radiopacity of this stent is rather poor.

* Not available in the United States

** A transhepatic biliary stent

The main disadvantage of this stent is shortening, which makes precise placement difficult. With the new Easy Wallstent™*, repositioning of the stent is possible even after partial deployment.

Nitinol Stents. Nitinol alloys are known as shape-memory alloys. Nitinol prostheses recover their predetermined diameters at body temperature. They are resistant to arterial wall radial strength; however, most of them are not well suited for use with hard, calcified plaques. The nitinol stents can be divided into 3 types:

- Laser-cut stents (Symphony® Nitinol Stent with Radiopaque Markers*, Boston Scientific; Optimed Sinustent®, Optimed Medizinische Instrumente GmbH, Ettlingen, Germany; Optimed Sinus Slex® [formerly Amadeus], Optimed; S.M.A.R.T.™ Stent**, Cordis; Memotherm™ Nitinol Stent, Bard Peripheral Technologies, Covington, Ga)
- Braided stents (Expander™*, Medicorp S.A., Villers les Nancy, France)
- Coil stents (VascuCoil® Intravascular Stent [now IntraCoil™], IntraTherapeutics, St. Paul, Minn; and Medtronic AVE).

All nitinol stents are not equivalent. Some are very flexible (for example, IntraCoil, Sinus Slex, Expander and S.M.A.R.T. Stent) and can be implanted at locations where there is an angulation. Others, such as the Symphony, are more rigid. Some may even break when they are bent or placed in a flexion site (for example, Sinustent and Memotherm).

Covered Stents

The Cragg Endopro System 1 and the Passager™ Stent Graft (Boston Scientific).* The Cragg/Passager stent was the 1st covered stent. Made of nitinol, it is self-expandable, and it is covered with ultra-thin 0.1-mm woven polyester fabric (Dacron). The rigidity of the stent makes contralateral implantation difficult. The Cragg delivery system is available in the United States; however, the Passager graft is not.

The Corvita Endoluminal Graft (Boston Scientific). The 2 principal characteristics of the Corvita stent are its self-expanding cylindrical wire structure and its highly porous coating of polycarbonate polyurethane. It can be cut with scissors by the user to adapt its length to the length of the lesion.

The Hemobahn™ Endoprosthesis (W. L. Gore & Associates, Inc.; Flagstaff, Ariz).* The Hemobahn stent is a self-expanding endovascular stent graft. The inner wall surface is composed of ultra-thin polytetrafluoroethylene (PTFE) graft material; on the exterior is a self-expanding nitinol stent. It is well suited to the contralateral approach.

The Wallgraft™ Endoprosthesis (Boston Scientific).* The Wallgraft is a flexible, self-expanding, covered stent made of cobalt and titanium and covered with polyethylene teryltolate (PET) graft material.

The Jostent® Coronary Stent Graft (Jomed® France SARL, Voisins le Bretonneux, France). The Jostent graft is the only balloon-expandable, covered-tube stent with radial strength. It is composed of stainless steel and ultra-thin PTFE graft material. In the United States, the Jostent graft is available only for preapproved humanitarian use.

Proper Stent Selection

Many factors must be considered during stent selection for patients in different clinical situations. Knowledge of the various stent types and their individual properties is a necessity. In addition, selection depends on: adequate preprocedural evaluation of the lesion; the access site; the use of primary or selective stent placement; the lesion location and characteristics; stent availability; and the experience of the operator.

Preprocedural Evaluation of the Lesion

During preprocedural evaluation of the lesion, the segment of the vessel to be treated and the total vasculature of the lower extremities must be evaluated thoroughly. Preprocedural arteriography is indispensable for analyzing the lesion (exact location, percentage, and length of the stenosis; and diameter of the artery); for collecting information about the nature of the lesion (eccentric, ulcerated, or calcified), the inflow vessels, the runoff, and the collateral circulation; and for choosing the best approach. Duplex ultrasonography is also performed before the procedure to characterize the lesion and to provide a baseline study. In cases of arterial occlusions, a computed tomographic scan is performed to exclude the presence of aneurysms. Angioscopy and intravascular ultrasound provide valuable information for making decisions about the appropriate treatment, as well; however, they are not part of our routine diagnostic workup, mainly because the cost is prohibitive.

Direct, Primary, and Selective Stent Placement

The medical literature reveals some inconsistencies in the use of the term "primary stenting." The 1st usage refers to stent placement before predilation of the lesion with balloon angioplasty.[7,26] We prefer the term *direct stenting* to refer to this procedure. Others[24,25,27] use *primary stenting* to describe procedures in which stents are predetermined to be inserted after balloon predilation regardless of angioplasty results. We agree

with this usage and will apply it accordingly. A 3rd usage[24,25,27] pertains to procedures in which selective stent deployment is performed only after suboptimal angioplasty results. We will refer to this as *selective stent placement*.

Advantages of Direct Stenting. Direct stenting has the advantage of shortening the duration of both the procedure and the radiation exposure. Moreover, direct stenting may decrease the restenosis rate due to diminution of arterial wall damage. It is as yet unknown whether this procedure will be cost-effective in the long term. Some authors[7] have advocated the use of this technique to prevent peripheral embolism when treating occlusions. (In our series of patients with iliac occlusions,[13] however, we did not see an increased rate of peripheral embolism when stents were placed after lesion predilation.) Covered stents can be implanted directly in cases of aneurysm, arterial trauma or rupture, and arteriovenous fistulas.

Advantages of Primary Stenting. Generally, stents are implanted after predilation. Primary stenting can be considered for use in some lesions that have a high risk of restenosis (such as eccentric, ulcerated, diffuse, and long lesions), in occlusions, in cases of restenosis, or in specific locations (such as the external iliac artery). This approach facilitates proper stent selection because predilation provides important information about the lesion (soft, fibrous, or calcified plaques), its length, the correct pressure to use for balloon inflation, and the exact diameter of the artery.

Technical Notes. With the direct, primary, or selective technique, the stent should cover the entire lesion. The diameter of the stent must precisely match the size of the vessel. When occlusion makes the exact diameter of the artery difficult to measure, it is helpful to refer to the contralateral site. In cases of direct stenting, the use of a long introducer enables crossing of the lesion; therefore, the stent is placed at the appropriate level while protected by the introducer. After progressive withdrawal of the introducer, the stent is deployed. This avoids problems of stent and balloon progression over the wire in the presence of very tight or severely calcified lesions. Moreover, if they are unprotected, balloon-expandable stents can slide over the balloon, leading to incorrect placement.

In addition to appropriate sizing of the stent, we emphasize gradual and gentle dilation during deployment in order to avoid complications such as adjacent dissection, perforation, or rupture of the arterial wall. Self-expandable nitinol stents take several hours or even days after their deployment to expand fully. By that time, acute in-stent thrombosis may have occurred. For this reason, these stents should be dilated immediately after placement rather than waiting for the stent to expand on its own. Distal embolism and vessel occlusion might be eliminated by continuous blood flow and saline perfusion through the introducer and by appropriate antiplatelet therapy. If this protocol is followed, the procedure may have to be delayed until the full antiplatelet effect is achieved. The guidewire should be placed in the largest distal artery. Thus, if the target vessel should become occluded, it would be easier to treat the distal artery.

The Access Site

One of 4 possible access sites can be used for stenting, depending on the location of the lesion, the morphological status of inflow and run-off vessels, the type of endoprosthesis to be inserted, and the level of operator experience. Each site has advantages and limitations.

The *femoral access site*, antegrade or retrograde, is the most frequently used site. It enables the use of large introducers and implantation of most stents.

The *contralateral access site* enables the use of large introducers and is particularly helpful for treating iliac occlusions. It is also chosen frequently for use in femoropopliteal lesions, because it does not block blood flow or compress the ipsilateral femoral artery after withdrawal of the introducer. Rigid stents cannot be implanted through this approach.

The *brachial access site* is used in cases of failure of deployment through another site or when other sites are inaccessible. This approach requires the use of long devices such as guidewires and introducers, which is a limiting factor.

In patients in whom the contralateral approach is not possible, the *popliteal artery* becomes the access site of choice for the treatment of superficial femoral artery lesions. The diameter of the artery requires the use of small-diameter stents.

Lesion Location and Characteristics

Isolated Abdominal Aortic and Aortoiliac Bifurcation Occlusive Disease. Isolated aortic lesions are relatively rare, and the indications for stent placement have not been established. In 3 recent series comprising a total of 45 patients,[28-30] the technical success rate in patients with isolated abdominal aortic occlusive disease was 100%. Sheeran and colleagues[28] reported an 88% patency rate at 18 months, and Diethrich's group[29] reported a 100% patency at 10 months. However, other authors[31-33] have achieved similar results with angioplasty alone. In 10 patients who had isolated aortic lesions (1 occlusion), we performed angioplasty alone in 6 and inserted stents after angioplasty for residual stenosis in 4.[34] We noted no restenosis; patency was 100% in all 10 patients at 24 months of mean follow-up (maximum follow-up, 103 months). Currently, there is no evidence to justify primary stenting at the abdominal aortic level. In our series[35] of 72 pa-

tients with aortoiliac bifurcation occlusive disease (162 arteries), 69 patients were treated with stents (Palmaz, 74%; nitinol, 14%; and other, 12%). Long-term results were encouraging and comparable to those achieved with surgery. At the 5-year follow-up, the primary patency rate (PI) was 75.8% and the secondary patency rate (PII) was 91.1%. The choice of stents at this level may be difficult. We generally use Palmaz-type stents in cases of calcified or eccentric lesions. The new, self-expandable nitinol stents are also well suited both to a small abdominal aorta and to vessels at the level of the aortoiliac bifurcation. The level of operator experience must also be considered.

Iliac Occlusive Disease. After performing a meta-analysis of 14 studies that included more than 2,000 patients, Bosch and Hunink[8] summarized the results of percutaneous transluminal angioplasty (PTA) and stenting in patients with aortoiliac occlusive disease. The immediate technical success rate of PTA was 91%, and for PTA combined with stent placement, 96%. The 4-year PI varied, depending on the clinical status (claudication or critical ischemia) and the type of the lesion (stenosis or occlusion). In the PTA-only group, the patency rate for patients with claudication was 65% with stenosis and 54% with occlusion. Among patients with critical ischemia, the patency rate was 53% with stenosis and 44% with occlusion. All rates were 7% to 14% greater in the group of patients treated with stents. Those authors concluded that PTA with stent placement lowered the risk of long-term failure by 39% compared with the risk of PTA alone.[8] However, in a randomized study of patients with iliac artery occlusive disease, Tetteroo and associates[9] failed to prove the superiority of primary stenting over PTA with selective stent placement. Both groups of patients had similar initial hemodynamic success, and the clinical success rates, cumulative patency rates, and reintervention rates showed no substantial differences at 2 years.

Reports of experience with many types of stents at the iliac level are available. Vorwerk and coworkers[10] treated 109 patients with 118 lesions who had iliac artery stenoses (mean length, 3 ± 2 cm) with 142 Wallstent endoprostheses after insufficient balloon angioplasty. At 4 years, the PI was 82% and the PII was 91%. A multicenter study[11] of 486 patients given Palmaz stents revealed a technical success rate of 99% and a 2-year clinical patency of 84%.[11] Strecker and co-authors[6] reported a 3-year patency rate of 95% in patients with the tantalum Strecker stent positioned in the iliac arteries. Our experience[12] with Palmaz stents at the iliac level included 184 patients (230 stents). The technical success rate was 99.7%. The 4-year PI was 86% and the PII was 94%. The patency rates were similar or slightly improved by the use of a shape-memory nitinol prosthesis. In treating 155 iliac lesions (130 stenoses and 25 occlusions), the PI was 89.7% and the PII was 98.7% at 4 years.[12]

Percutaneous transluminal recanalization of chronic iliac occlusions remains controversial. However, results of recent studies have been encouraging, with initial technical success rates greater than 90%, low complication rates, and good long-term results. Vorwerk and colleagues,[7] in 103 patients, reported a 96.1% technical success rate; at 4 years, the PI was 78% and the PII, 88%. We performed PTA in 155 patients (173 iliac occlusions).[36] Our technical success rate was 90%. Stents of various types were inserted in 132 patients. The PI was 73% and the PII was 86% at 8 years.

The use of covered stents has recently been increasing at the iliac level. Dake and associates[14] treated 63 iliac artery lesions with the Hemobahn stent and reported a 6-month patency rate of 98%. Ohki and Veith[15] reported a 3-year PI of 78.7% and a PII of 86.6% in 55 patients. Our experience with the use of covered stents has been satisfactory. Using the Cragg Endopro System 1/Passager device in 64 patients,[37] we achieved a 5-year PI of 88% and a PII of 100%. With placement of the Corvita device in 38 lesions, we had 3-year PI of 87% and a PII of 95%.[37]

Current data concerning the use of different stent types in iliac arteries indicate no obvious differences with regard to technical success rates and follow-up results. All stents can be implanted at the iliac level. The choice of stent depends on other factors, such as location, extent, and nature of the lesion, and the operator's experience and familiarity with specific stent designs. Covered stents do not seem to improve long-term results and should be reserved for such specific indications as aneurysms, arterial rupture, and arteriovenous fistulae.

Femoropopliteal Disease. The use of stents is more controversial in femoropopliteal arteries. With use of the Wallstent in femoropopliteal lesions, Sapoval and co-authors[16] reported an early stent thrombosis rate of 19% and a 1-year PI and PII of 49% and 67%, respectively. Rousseau and coworkers,[17] using the same stent after PTA, found a 17% rate of early thrombosis and a 76% patency rate at 2 years. Liermann's group,[18] using the Strecker stent in a series of 42 patients, reported a 60% patency rate in the treatment of occlusions and 82% in the treatment of stenoses at the 19-month follow-up. With Palmaz stents, Bergeron and colleagues[19] achieved a 2-year PI of 77% and a PII of 89% in 39 patients with 42 superficial femoral artery lesions. However, some less favorable results have also been reported with regard to stent placement in the femoral arteries. Damaraju and associates[20] reported a 41% patency rate 2 years after Wallstent placement. Gray and co-authors[21] reported only 22% of the Wallstents placed in 58 superficial

femoral artery lesions to be patent at 1 year without a secondary procedure.

We used Palmaz stents[12] in 126 patients who had disease at the femoropopliteal level: 85 with stenosis and 41 with occlusion. The mean lesion length was 3.8 ± 2.6 cm (range, 1 to 15 cm). Initial technical success was attained in 99%. The PIs and PIIs at 4 years were 65% and 95% at the femoral level and 50% and 69% at the popliteal level. The patency rates were dependent on the nature of the lesions. The PI was 80% for stenoses but only 39% for occlusions; the PII was 94% for stenoses and 86% for occlusions. Our results with the Long Medium Palmaz-Schatz spiral stent in a series of 68 patients[38] were similar to those achieved with the older Palmaz stents.

We have been using nitinol self-expandable stents selectively for several years: most often the IntraCoil, the Expander, and the Sinustent. In 486 patients with occlusive disease of the lower extremities,[39] 588 lesions were treated. Of these, 328 lesions were located in the femoral artery (225 stenoses and 103 occlusions) and 105 in the popliteal artery (67 stenoses and 38 occlusions). The mean rate of stenosis was 74.2% ± 7.9% at the femoral level and 81.7% ± 8.4% at the popliteal level. The mean lesion length was 63.8 ± 46.1 mm (femoral) and 45.4 ± 23.5 mm (popliteal). Indications for stenting were post-PTA residual stenosis, dissection, and restenosis. Initial technical success was achieved in all but 3 lesions. Restenosis rates were 16.5% at the femoral level and 14.4% at the popliteal level; these rates were similar for all stent types. The 4-year PIs in the femoral artery were 64.2% in the upper third, 85.7% in the middle third, 79.3% in the lower third, and 79.2% overall. The 4-year PIIs in the same positions were 92.3%, 96.3%, 87.1%, and 91.3%. At the popliteal level, the PI was 84.7% and the PII, 94.9%. We found no significant difference between lesions longer than 8 cm and those that were shorter, between stenoses and occlusions, or among the 3 stents used.

All types of lesions can be treated with nitinol stents, but all nitinol stents are not equivalent. For instance, the Sinustent has better radial force than the IntraCoil and seems more suitable for use in fibrous, calcified lesions. The IntraCoil is the most flexible stent and may be the best choice for popliteal use. The Expander is a unique braided stent that will not break (as opposed to the laser-cut stents). We have observed breaking of the Sinustent in the popliteal artery; therefore, we suggest that other nitinol stents be used in that position. In contrast to Palmaz stents, prostheses made of nitinol cannot be compressed. We have observed compression of Palmaz stents in the lower part of the femoral artery and in the popliteal artery; accordingly, we recommend that these stents be avoided at these levels. Recently, we have begun to use other nitinol stents (S.M.A.R.T., Sinus Slex, and Symphony), and the initial results seem encouraging. The Symphony stents are more rigid with good radial force and are indicated for fibrotic, calcified lesions but not for those located at a joint. In these cases, the S.M.A.R.T. and Sinus Slex stents are preferable.

Despite our favorable results with nitinol stent placement at the femoropopliteal level, we should mention that their routine use is not recommended by most investigators.[22-25] None of these stents has been approved for clinical applications in the United States. Two randomized studies[24,25] failed to prove the superiority of stents combined with balloon angioplasty as opposed to angioplasty alone at the femoropopliteal level. However, in both studies, Palmaz stents were used. In our experience, the shape-memory (nitinol) stents yield better results.

Covered stents have also been used at the femoropopliteal level. In 50 femoral artery occlusive lesions, Dake's group[14] used the Hemobahn device and reported a 6-month PI of 83% and a PII of 87%. Diethrich,[40] using a customized PTFE-coated Palmaz device, reported a 9-month PI of 72% and PII of 84%.

We evaluated the Cragg Endopro/Passager grafts[4] in 92 lesions (29 stenoses, 50 occlusions, and 13 aneurysms). The mean lesion length was 10.2 ± 7.7 cm. The respective PIs and PIIs at 5 years were 65% and 73% at the femoral level, 40% and 50% at the popliteal level, 82% and 93% for lesions less than 10 cm, 51% and 59% for lesions 10 cm or longer, 63% and 73% for stenoses, and 61% and 72% for occlusions. Although the results are satisfactory in femoral lesions shorter than 10 cm, they are less favorable in longer lesions, particularly in the popliteal artery.

We also treated 25 femoropopliteal lesions[37] with the Corvita covered stent (8 stenoses, 12 occlusions, and 5 aneurysms). The respective PIs and PIIs at 3 years were 55% and 72% overall, 54% and 82% for lesions less than 10 cm, 55% and 64% for longer lesions, 78% and 78% for stenoses, and 31% and 64% for occlusions.

In our experience, covered stents do not yield better results than those achieved with noncovered stents in the treatment of arterial occlusive disease; therefore, we suggest that it is preferable, in general, to reserve their use for aneurysms, arterial rupture, and arteriovenous fistulae, as in the iliac vessels. Ideally, covered stents developed in the future will enable the performance of a true endoluminal arterial bypass (as an alternative to surgery) to treat long lesions.

Bypass Stenosis. About 20% to 30% of bypass vein grafts and synthetic grafts develop graft-threatening stenosis, especially during the first 12 months after surgery.[41-43] If untreated, the stenosis will lead to graft failure. The therapeutic options are percutaneous

procedures and reoperation for surgical reconstruction. Several series[44-47] have shown that short focal lesions respond well to angioplasty or to angioplasty and stenting in combination. When angioplasty is insufficient, stents with good radial force may be the best option: either balloon-expandable stents (such as Palmaz and Medtronic AVE), or some of the nitinol stents (for example, Sinustent and Symphony).

Infrapopliteal Artery Disease. Although angioplasty in the tibial and peroneal arteries has yielded satisfactory results,[48,49] experience with the use of stents at the infrapopliteal level is insufficient to justify their primary use. Infrapopliteal arteries have a diameter similar to that of the coronary arteries, so in cases when stents are indicated (residual stenosis or dissection after angioplasty), coronary stents should be used.

Stent Availability

It is important to have several types of stents available in an angioplasty laboratory so that placement of the stent best suited to the lesion and the artery will always be an option. All laboratories must have covered stents for emergency treatment of arterial rupture during interventional procedures to avoid serious complications or emergency surgery.

Conclusion

The choice of stent depends on operator experience, the stents available in the catheterization laboratory, the approach used, and the location and characteristics of the lesion. Most stent implantation is performed selectively. Accepted indications are residual stenosis, arterial recoil, poor cosmetic results, dissection, and restenosis. Primary stenting may be considered for lesions in the form of occlusions; lesions at high risk of restenosis; lesions longer than 8 cm; and those that are diffuse, eccentric, or ulcerated.

Stents seem to improve the immediate and long-term results of peripheral interventional procedures and to expand the applicability of such procedures. Because of the variety of stents that are now available, any artery can be implanted with a stent. All stents are not equivalent, however, and it is important to select the best stent for the lesion and vessel to be treated. At the iliac level, all stents can be implanted. Although balloon-expandable stents are still indicated for placement in many situations, the new self-expandable stents seem to achieve better results at the femoropopliteal level. Covered stents do not improve results in peripheral occlusive disease and should be reserved for the treatment of aneurysms, arteriovenous fistulas, and arterial rupture. Restenosis after stenting remains problematic. Nevertheless, forthcoming generations of drug-releasing stents and radioactive treatments promise improved results in interventional procedures.

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